Appendices:

Transportation Transformed: Advancing Eco-Friendly Mobility

Final Report- August 10, 2016

Sponsors: NYSERDA, NYSDOT, UTRC

Appendix 1

PowerPoint Presentations

Climate Change , sustainability and ecomobility

Jamil Ahmad
Deputy Director, UNEP New York Office

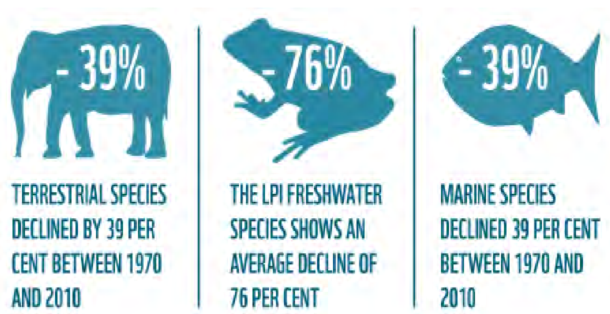
7 April 2016

Saving our planet

“ We are the first generation that can end poverty and the last one that can save our planet ”

- Ban Ki-moon, Secretary-General of the UN

Current global environmental challenges



- **Earth system** provides basis for human societies and their economies
- Current **ecological footprint of 7 billion** already uses bio-capacity of 1.5 Earths
- All the while 1.2 billion live in extreme poverty
- The **great human challenge**: provide all with a life in dignity within Earth's safe operating space
- **Need for sustainable development**: integrating the economic, social and environmental
- **Changes to Earth system unprecedented**: climate change, land use changes and degradation, biodiversity loss

The age of Anthropocene !!!

“

The Anthropocene age, in which the profound human influence on the planet will leave its legacy for millennia”.

Climate change, a major challenge

Photo: Alejandro Laguna

It is real and we are responsible.

Climate Change: a major challenge

- **Global GHG emissions steadily rising**
- Progress in reducing carbon intensity outstripped by increased levels of consumption - **humanity is using up its carbon budget**
- Holding temperature increase below 2C requires **transformative change**
- Climate change as serious **threat to development**:
  - Increase in frequency and intensity of weather events
  - Changes and stress to natural habitats and ecosystems, impacting on and decreasing their services
  - Ocean acidification and sea level rise
  - Health risks
- **World's poorest particularly vulnerable** to and affected by climate change

The Paris Agreement

UNEP

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

The gap

Bridging the gap is a task for the whole world

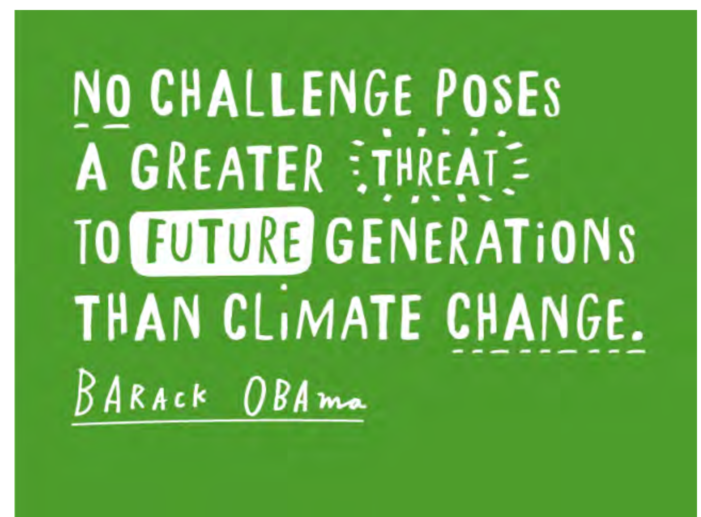
2030 Agenda for Sustainable Development

UNEP

- Embraces **all aspects of sustainable development**: economic, social and environmental
- Guided by **Sustainable Development Goals** (SDGs)
- Builds on progress achieved by Millennium Development Goals (MDGs)
- More **comprehensive** than MDGs, transformative, universal and **addressing inter-linkages**
- **Integration of social, environmental and economic dimensions** is key
- "**5 P's**": **People, Planet, Prosperity, Peace and Partnership**
- Choosing between development and sustainability is a false choice

2030 Agenda for Sustainable Development

- Climate Change is a **threat multiplier**
- **Climate change impacts** directly and/or indirectly **on all SDGs**
- **For SDG 13 to be effective**, we need a **successful COP-21**



The way towards a carbon-neutral future

→ Improving **human well-being and social equity**

→ Significantly **reducing environmental risks** and ecological scarcities

→ **Low-carbon, resource efficient** and **socially inclusive**

Needed transformative changes:

- Strategic green investments
- Efficient, cleaner, safer production
- Sustainable consumption
- Equitable distribution

Changing institutions and **incentives** for individual behaviour

65 countries have embarked on green economy and related strategies, and **48** of them are taking steps to develop national green economy plans.

Huge financing needs to realize the SDGs

Photo: CheapFullCoverageAutoInsurance.com

The UNEP Inquiry

UNEP

Inquiry: Design of a Sustainable Financial System

- **Too little capital is supporting the transition to a sustainable, low-carbon economy**
- Too much continues to be invested in a high-carbon and resource-intensive economy.
- **The UNEP Inquiry contributes to the acceleration of the transition** by identifying best practice, and exploring financial market policy and regulatory innovations that would support the development of a green financial system.

Ecomobility

At least five of the SDGs support the ecomobility agenda.

In particular goal 11 (make cities safe and inclusive) includes the need to:

- provide access to safe, affordable, accessible and sustainable transport systems for all
- improving road safety
- notably by expanding public transport
- with special attention to the needs of those in vulnerable situations.

Urban sustainability as a challenge

Half of humanity – 3.5 billion people – lives in cities today

By 2030, almost 60 per cent of the world's population will live in urban areas

95 per cent of urban expansion in the next decades will take place in developing world

828 million people live in slums today and the number keeps rising

The world's cities occupy just 3 per cent of the Earth's land, but account for 60-80 per cent of energy consumption and 75 per cent of carbon emissions

Rapid urbanization is exerting pressure on fresh water supplies, sewage, the living environment, and public health

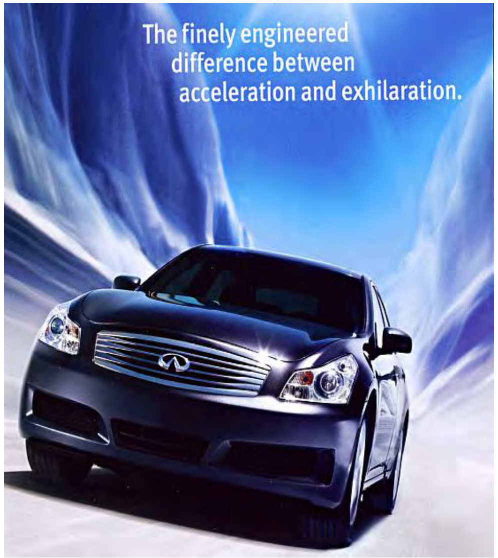
But the high density of cities can bring efficiency gains and technological innovation while reducing resource and energy consumption

Cities, at the core of sustainable development

- 75% of population, GDP, resource use, waste, emissions, will be located at city level within the next 20 to 30 years.
- Resource efficiency in cities will increase economic resilience, mitigate climate change, reduce waste and improving quality of life.

Photo: Bryan & Jeff
https://creativecommons.org/licenses/by-sa/2.0/

The global transport challenge



- Our transport choices determine how our cities grow.
- We need to rethink how we move.
- The 'dream' is different to the reality.

Transport , environment and health

- Road transport accounts for 17% of global CO_2 emissions.
- Over 800,000 deaths occur each year due to urban air pollution.

Transport and road safety

- 1.3 million people killed and 50 million people seriously injured every year on the road.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SURF SHACK
SURF SCHOOL
SURF SHACK


Sustainable Development Goals (SDGs)

It’s about how we do it

It’s not just about how much we develop and how fast we move.

It’s about HOW we develop and at what expense.

The age of Anthropocene shall not be the age of denying the benefits of development to our coming generations.

Thank you!

Contacts:

www.unep.org/newyork

unepnyo@un.org

Reducing GHG Emissions in Transportation and the Role of Eco-Mobility

Gabe Pacyniak
Mitigation Program Manager, Georgetown Climate Center
Adjunct Professor, Georgetown Law

April 7, 2016
Transportation Transformed:
Advancing Eco-Friendly Mobility Conference

GEORGETOWN CLIMATE CENTER
A Leading Resource for State and Federal Policy

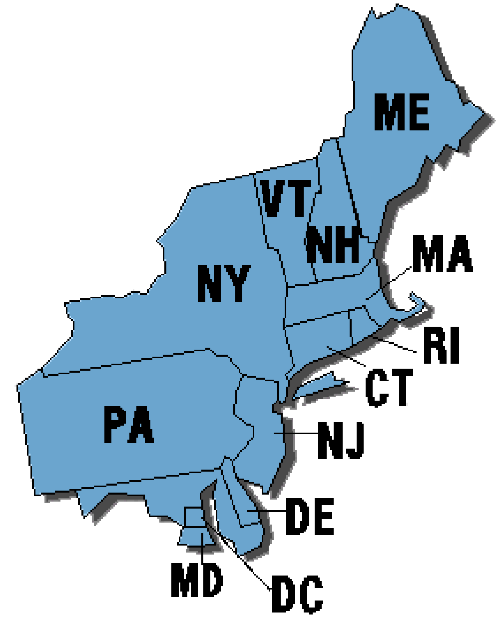
Georgetown Climate Center:
A Resource for State and Federal Climate Policy

- Launched in 2009 as a resource to states
- Works at the nexus of federal-state policies
- Supports states and other stakeholders through research, facilitation and convening

GEORGETOWN CLIMATE CENTER
A Leading Resource for State and Federal Policy

Transportation and Climate Initiative

- 11 northeast and mid-Atlantic states and the District of Columbia
- TCI launched in 2010
- Working together to reduce energy use and GHG emissions from transportation



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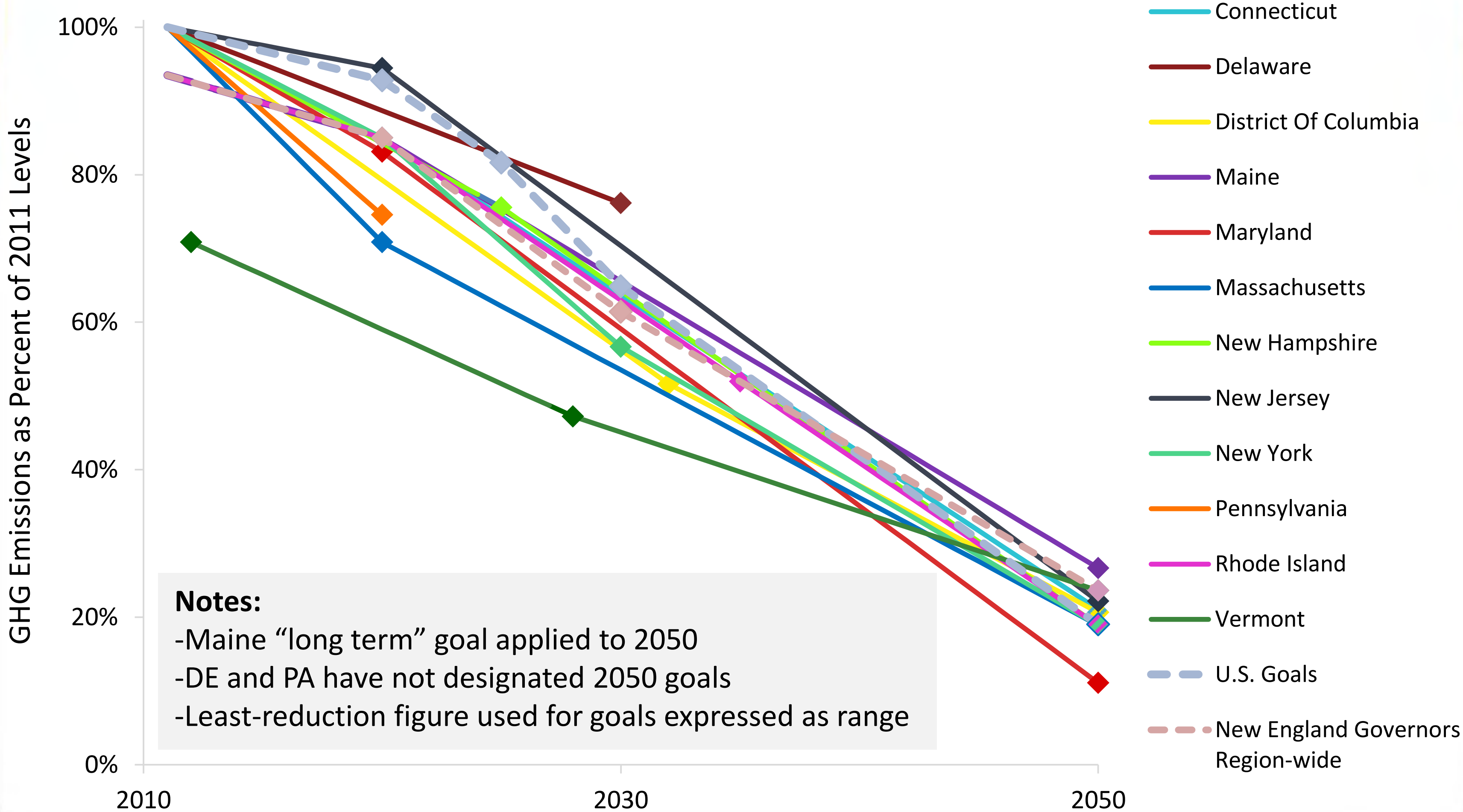
US and TCI States Have Set Economy-Wide GHG Reduction Goals



Notes:
-Maine “long term” goal applied to 2050
-DE and PA have not designated 2050 goals
-Least-reduction figure used for goals expressed as range

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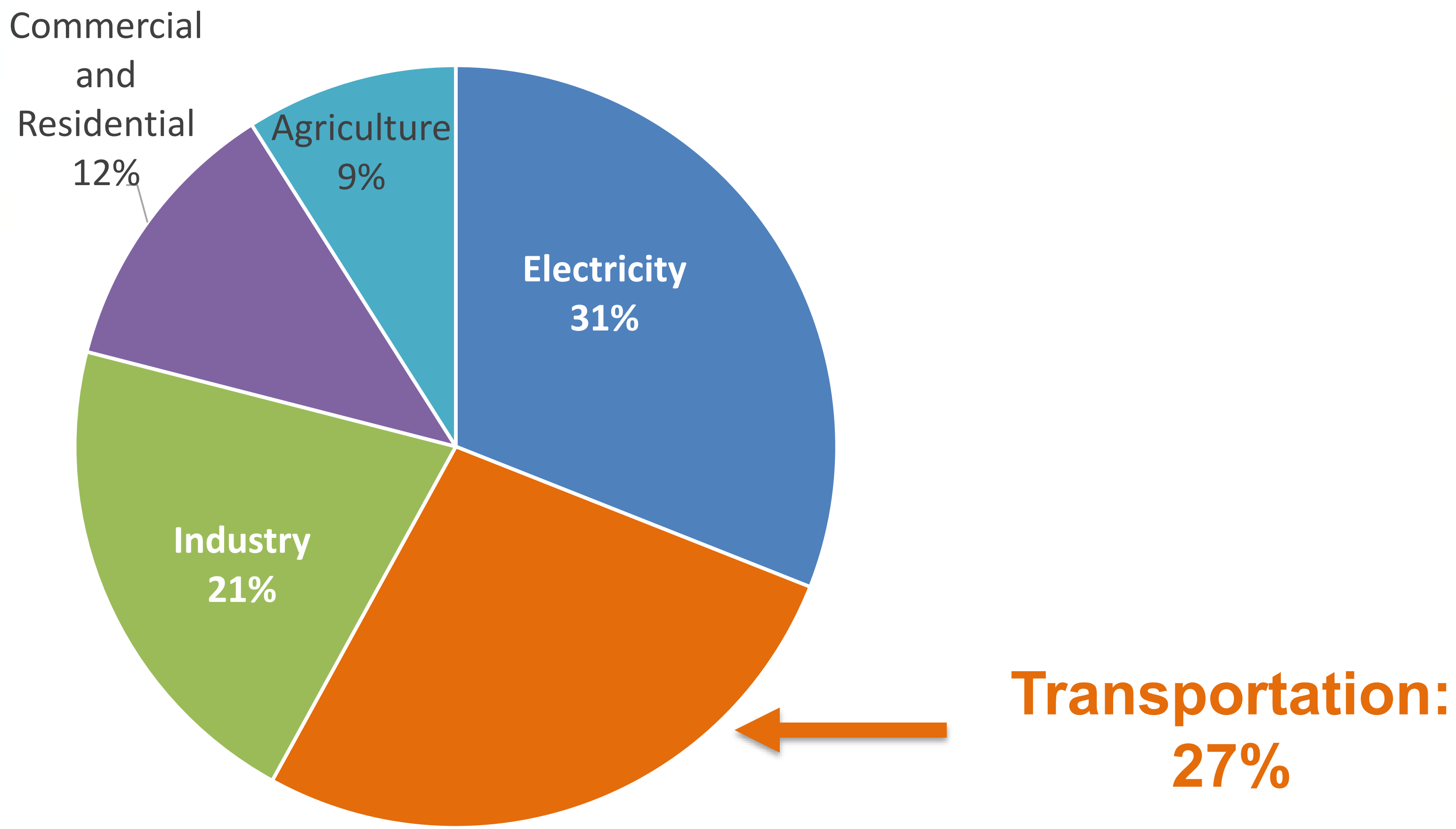
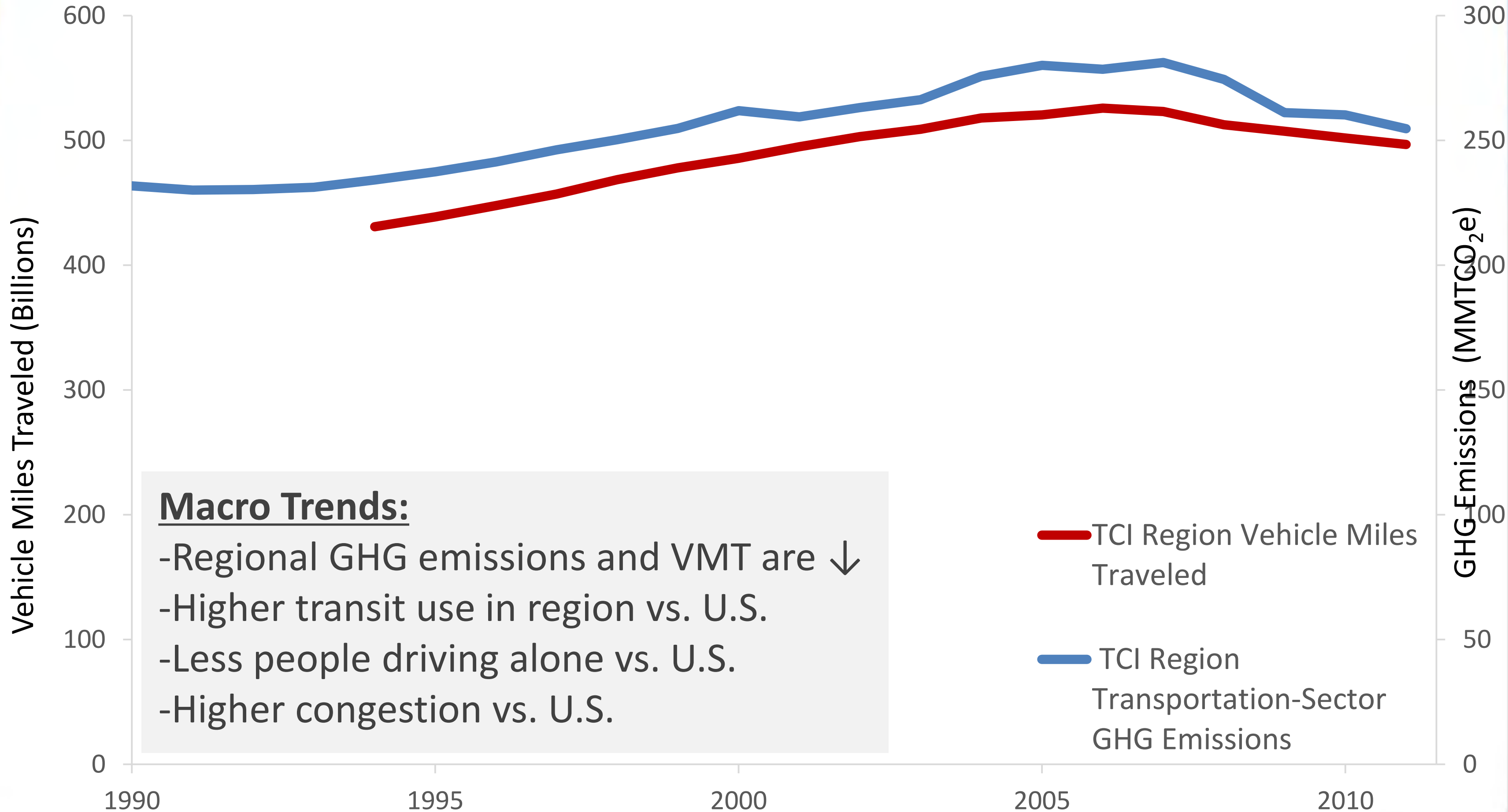
Transportation is the Next Big Challenge



Source: EPA, 2015, Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2013

The TCI Region is Already Reducing Emissions and Leading in Transit Use



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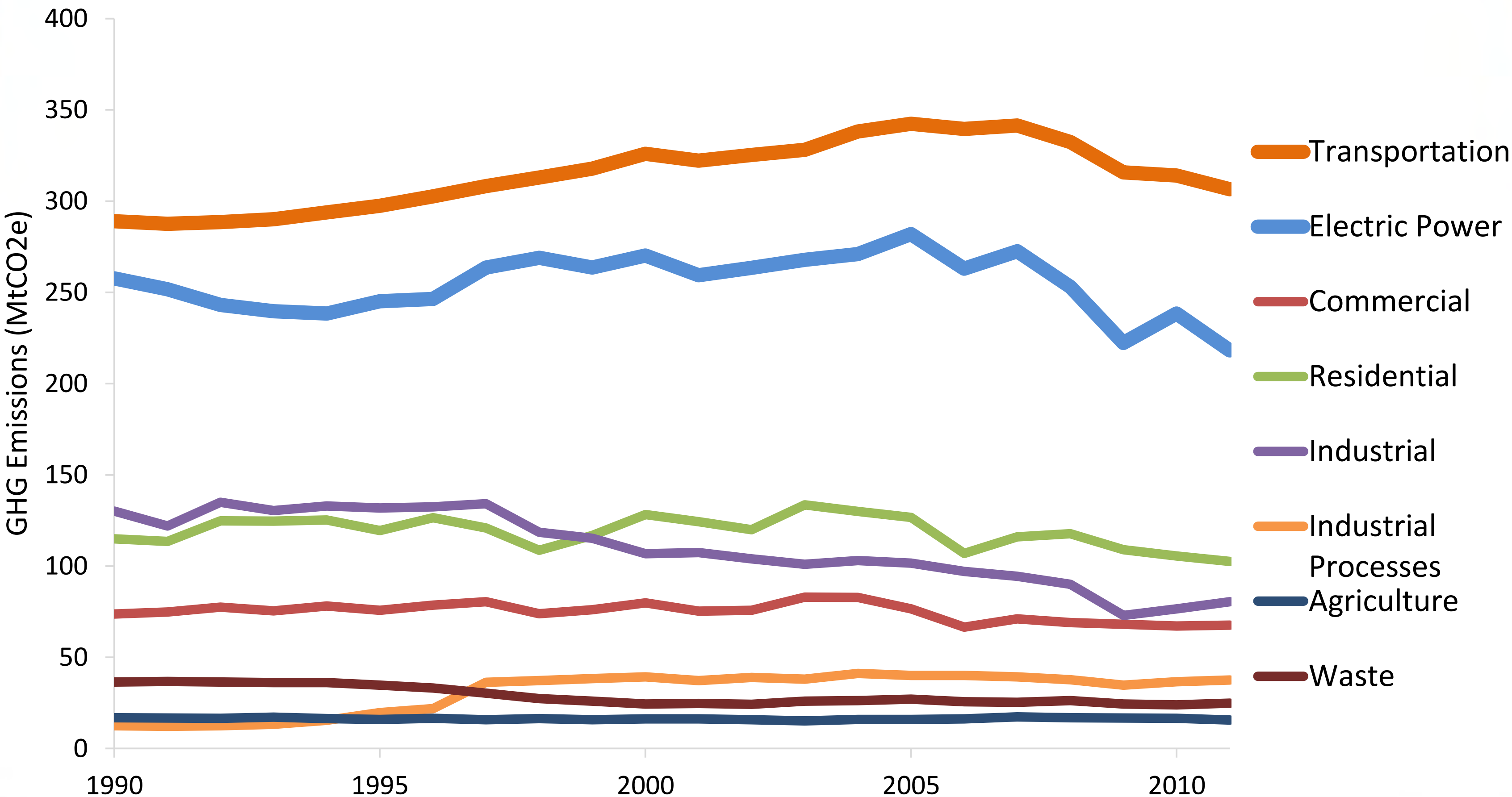
More Progress Will be Needed



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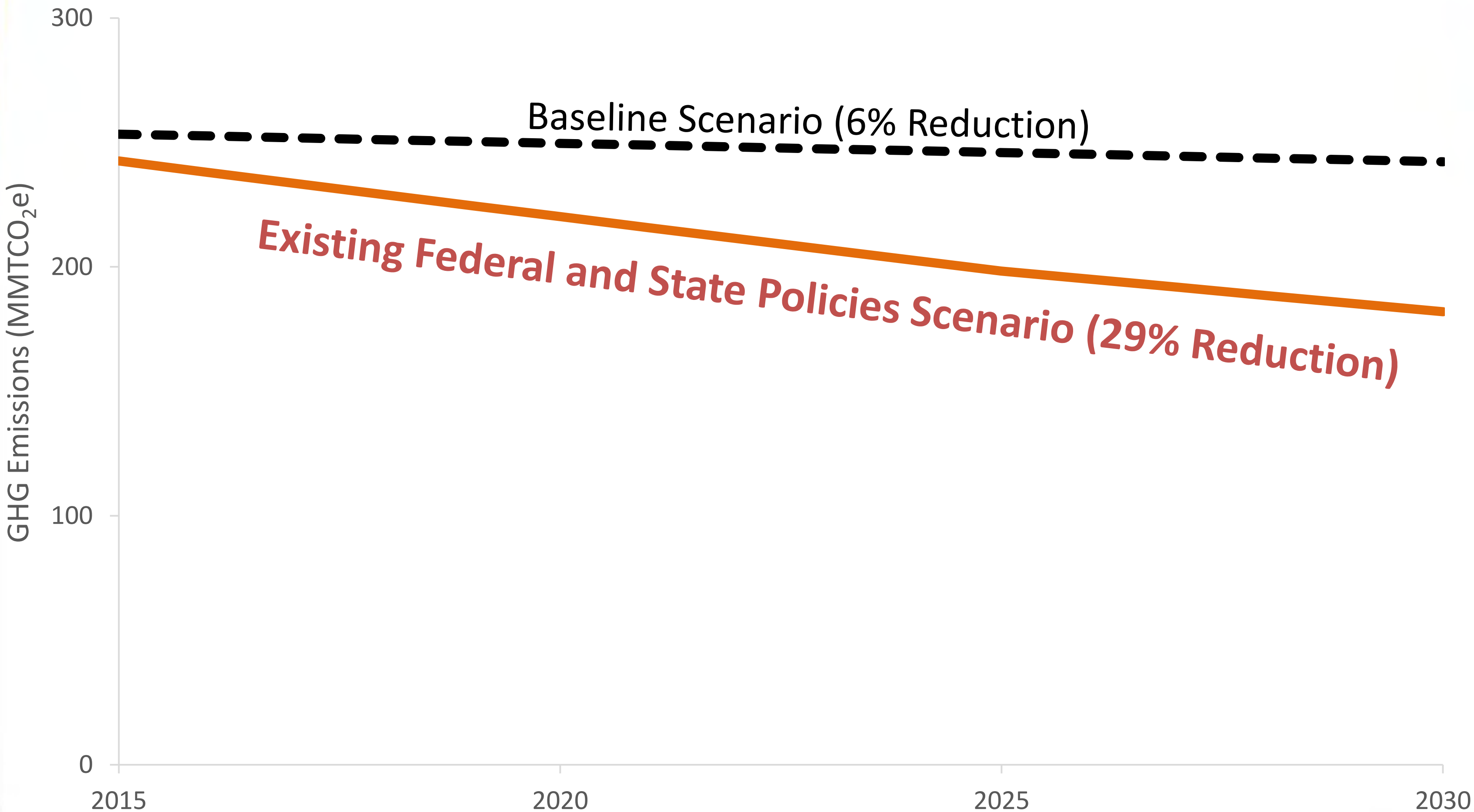
Existing Federal and State Policies will Achieve Significant Reductions…



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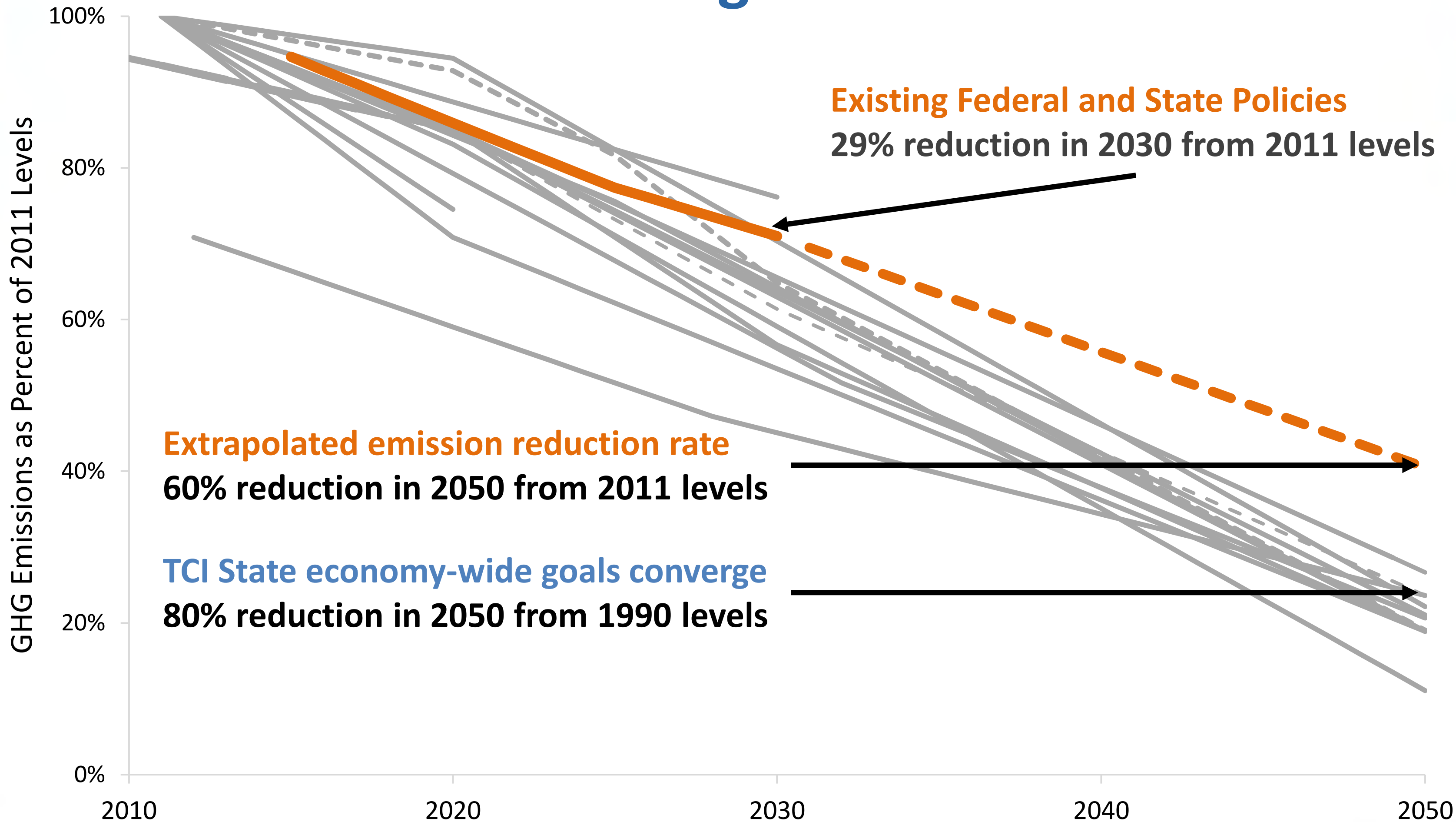
…But Will Not Put States on Track to Meet Long-Term Goals



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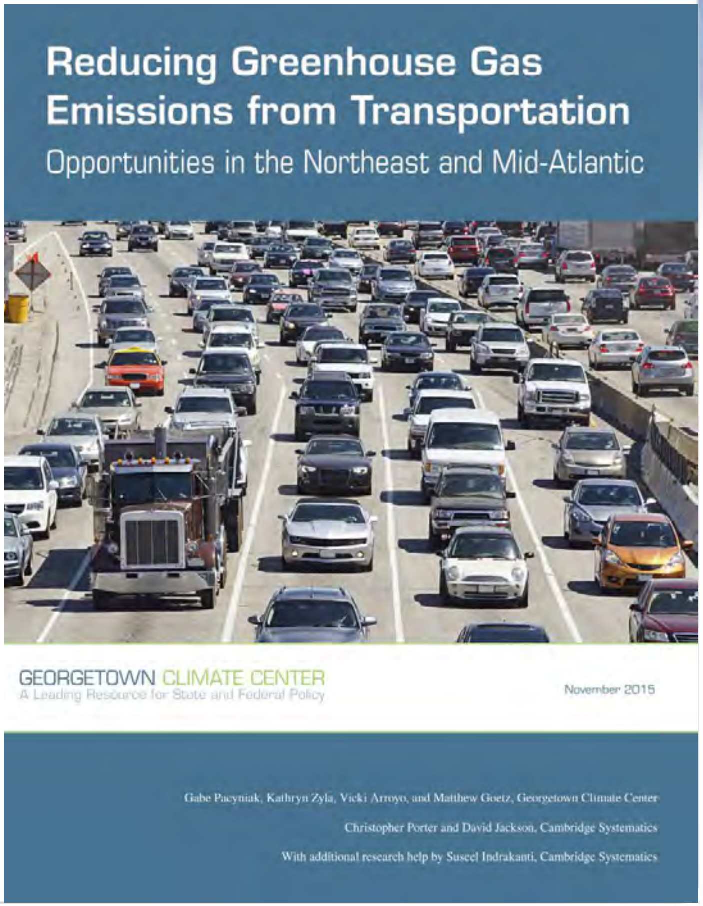
GCC Analyzed Additional Emission Reduction Opportunities to Inform States

- Considered broad portfolio of investments in clean transportation
- Showed the region can cut GHG emissions by 29-40% while providing net economic benefits



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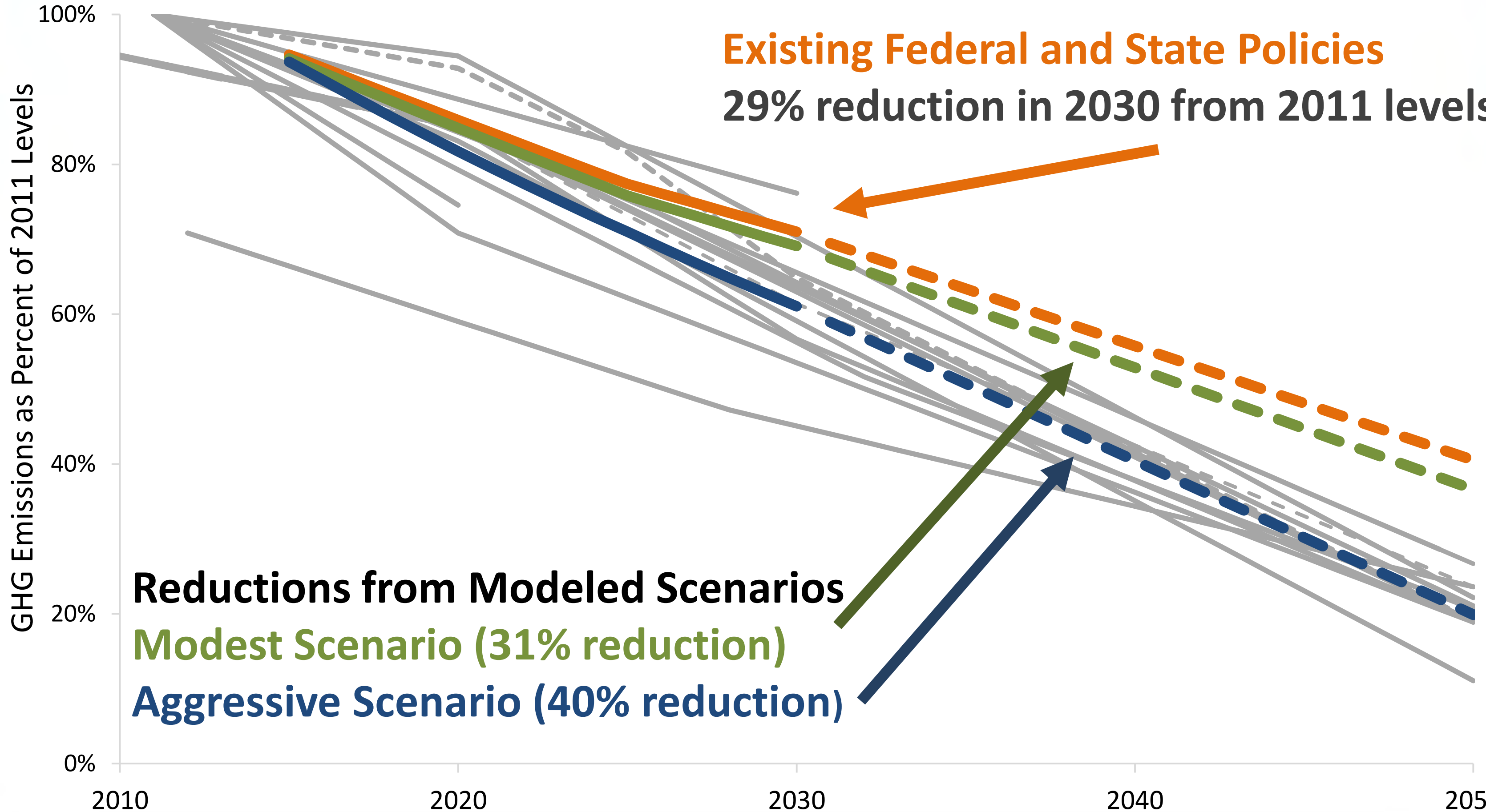
Resulting Reductions Would Help States Achieve 2050 Goals



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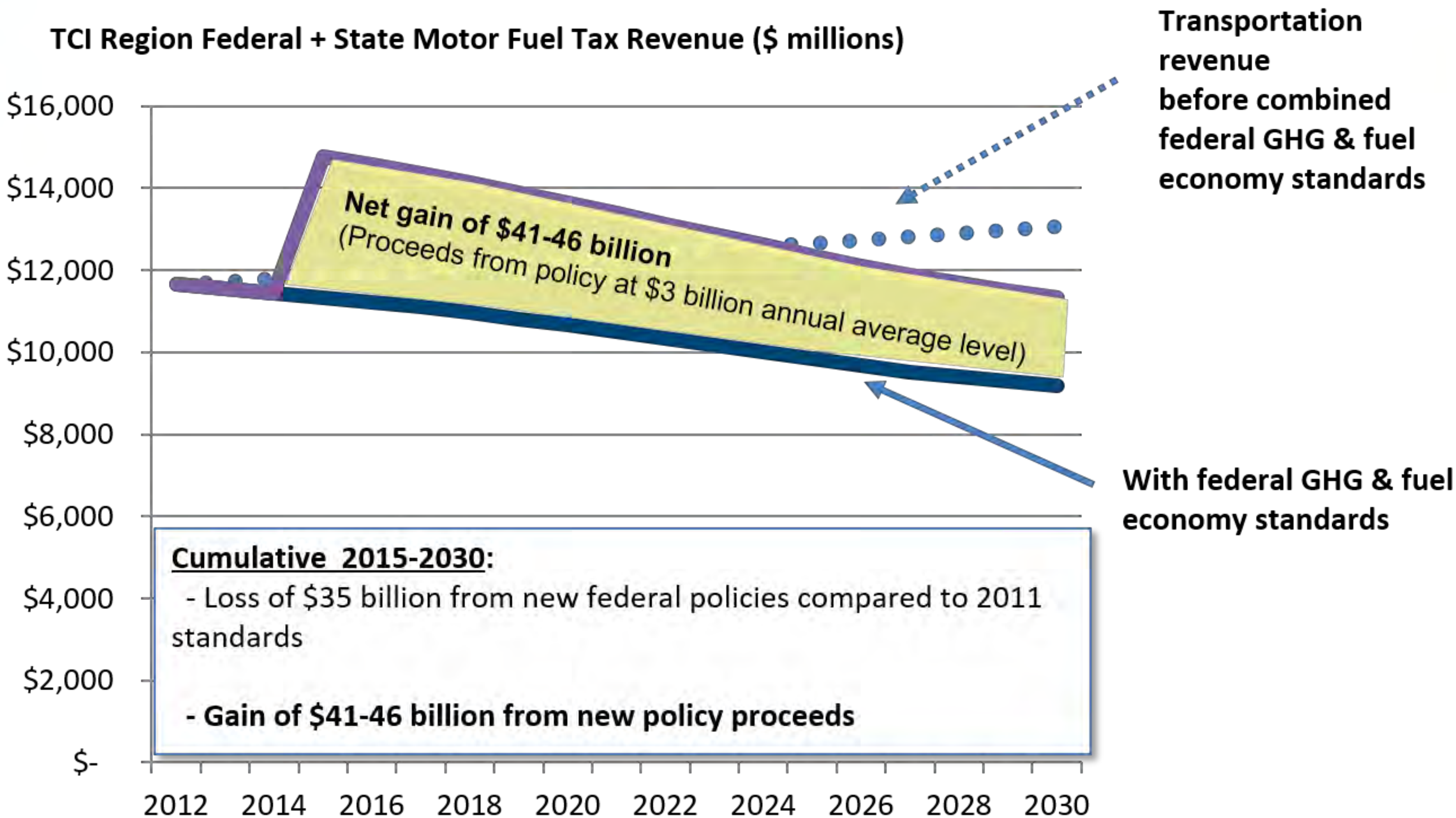
Comprehensive Policy Proceeds Could be Used for Transportation



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$3 Billion Annual Regional Investment Projected to Provide Significant Benefits

Impact	2030	Cumulative 2015-2030
↑ in Regional Employment	91,000-125,000	794,000-1,167,000
↑ in Gross Regional Product	$11.7-17.7 Billion	$92-144 Billion
↑ in Disposable Personal Income	$9.9-14.4 Billion	$71-109 Billion

Range reflects low-end and high-end outcomes of four modeled scenarios

6 Jurisdictions Announce Plans to Develop Potential Market-Based Policies to Reduce GHGs

"Our states will work together through TCI to develop potential market-based policies that, when combined with existing programs, are targeted to achieve substantial reductions in transportation sector"

- November 2015

How do We Harness the Coming Transportation Revolution?

Questions State Leaders Ask …

- Are we sure that this will reduce emissions, and by how much?
- Why should I spend time and energy on this strategy over other strategies?
- Is this ready for prime time?
- What are the benefits to residents?
- What will I need to do to implement this, and how much will it cost me?

Thank You

For inquiries, please contact

Gabe Pacyniak

202-661-6673

pacyniak@law.georgetown.edu

Report is available on Georgetown Climate Center website:
http://www.georgetownclimate.org

- Report materials: http://www.georgetownclimate.org/reducing-greenhouse-gas-emissions-from-transportation-opportunities-in-the-northeast-and-mid-atlanti

TRANSPORTATION TRANSFORMED

ADVANCING ECO-FRIENDLY MOBILITY

8:45am to 5:00pm | Thursday, April 7, 2016

10:30 AM - 11:15 AM / **Session 1** – Technology for Eco-Mobility

MODERATOR

Joseph Tario
Senior Project Manager
NYSERDA

Stanley Young Ph.D., National Renewable Energy Lab/ or
Vassilis Papayannoulis, Ph.D., Metropia: TRANSNET *(Traveler Response Architecture Using Novel Signaling for Network Efficiency in Transportation)*

Jamyn Edis, Adjunct Professor at NYU & CEO /Co-founder @ Dash: "DASH Smart Driving App"

Alain Kornhauser Ph.D., Princeton University: *Shared Autonomous Taxis for Eco-Mobility*

WIFI NYIT_Theater / **Password: CobaltBlue77**

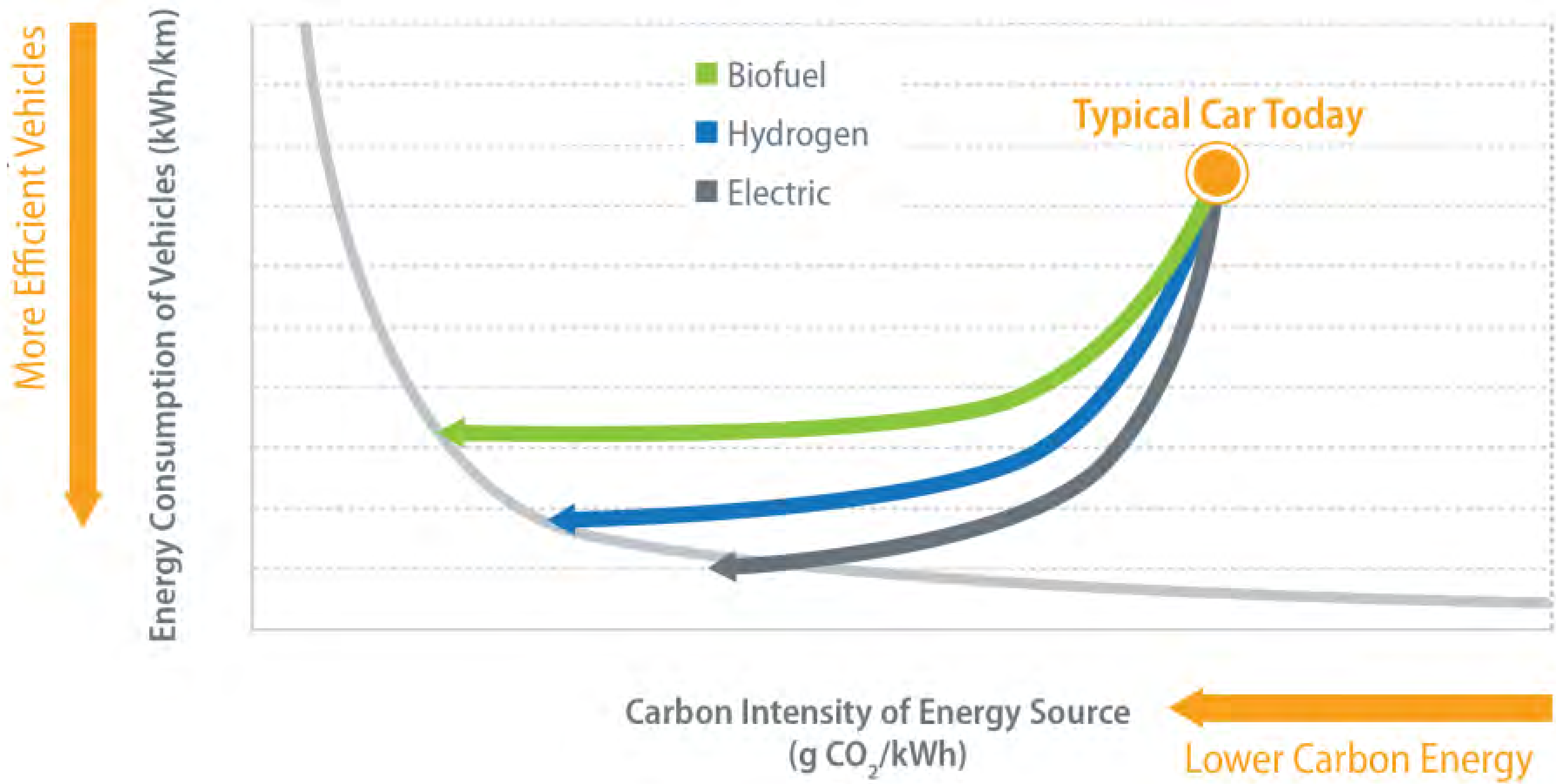
TRANSNET –
The Connected Traveler

Stan Young, Ph.D.
National Renewable Energy Laboratory

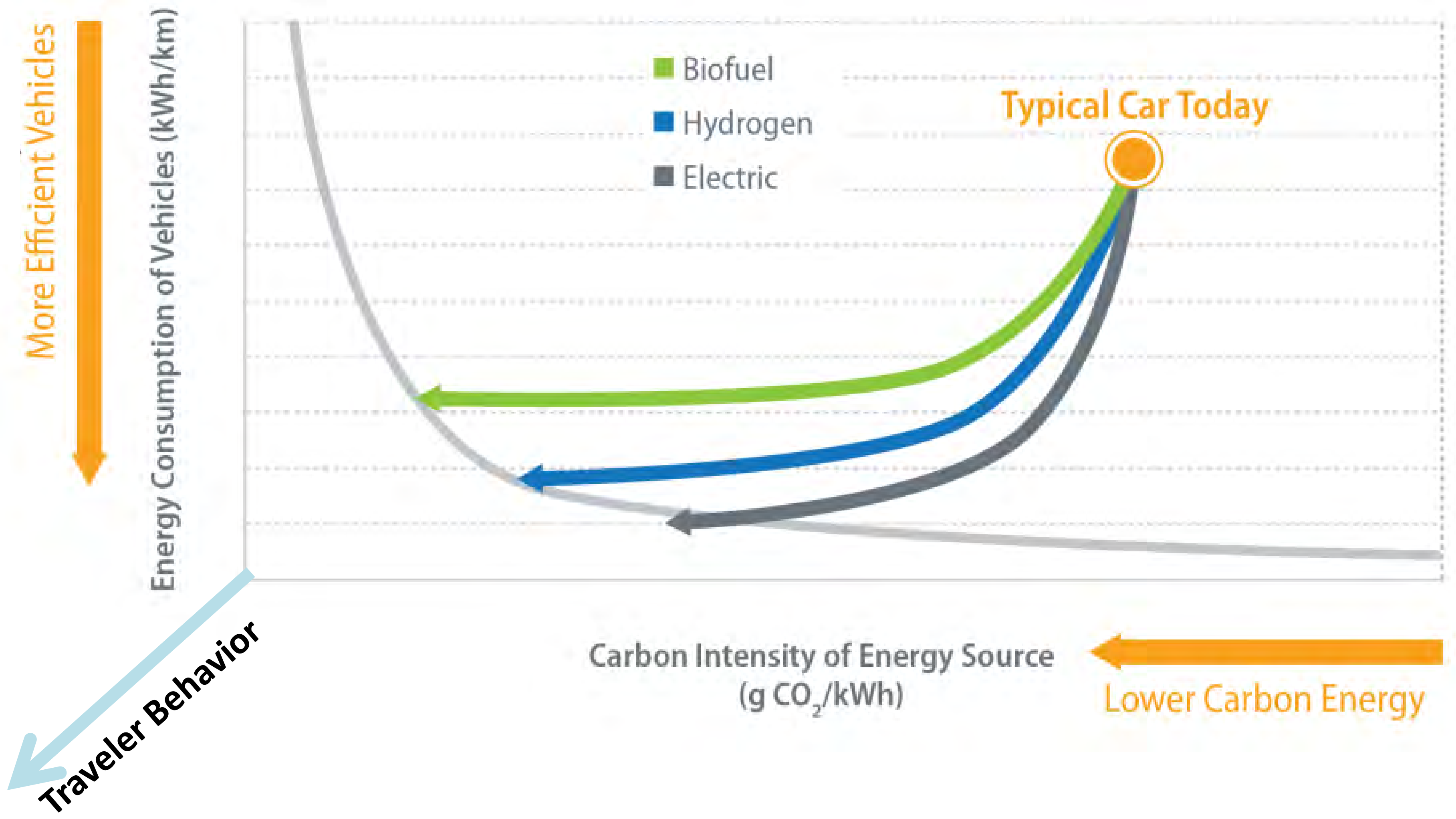
Vassilis Papayannoulis, Ph.D.
Metropia, Inc.

April 07, 2015

Getting the CO_2 Out – Pathways to 2050



Getting the CO_2 Out – Pathways to 2050



The Connected Traveler

The Market Opportunity

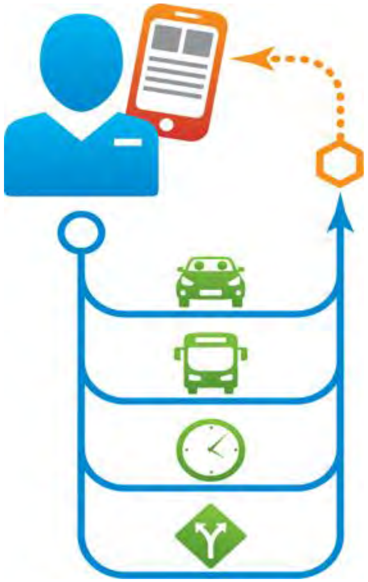
American travel time increased by **6.9 billion hours**

. . . increasing gasoline consumption by **3.1 billion gallons**

. . . resulting in a congestion cost of **160 billion dollars**

Source: Texas A&M Transportation Institute 2015 Urban Mobility Scorecard

The Project



The Team

UC DAVIS — University of California

KU — The University of Kansas

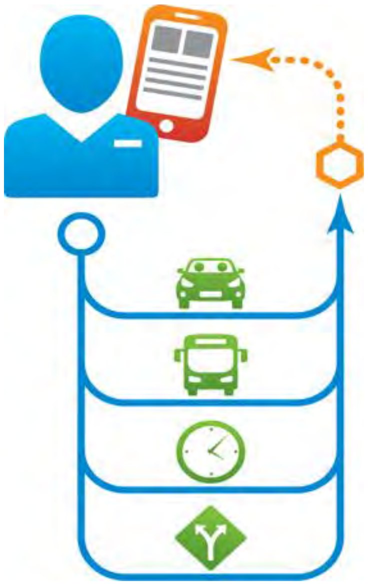
metropia

NREL — National Renewable Energy Laboratory

Texas Transportation Institute

W — University of Washington

Connected Traveler Project Overview



- Multi-disciplinary undertaking that will seek to validate potential for transformative transportation system energy savings by incentivizing efficient traveler behavior
- Control architecture will be developed that incorporates adaptive learning, refined incentives, and control strategies to provide high certainty of adoption
- Metropia platform will allow for real-world validation of traveler behavior and assist in refining incentives and control strategies
- NREL Transportation Secure Data Center and related tools will be used to determine individual energy consumption
- Individual energy impacts will be extrapolated to estimate transportation system energy consumption*

**Additional system model development may be required to refine this to a margin of error that can be used by transportation practitioners*

Framing and Refining Control Strategies

Control Strategies

- Change in Departure Time
- Mode Choice
- Carpooling
- Alternate Routing
- Alternate Destinations
- Elimination of Need for Trips

Framing effects of incentives and benefits will be investigated and refined.

Additional control strategies will be investigated to allow for added savings opportunities and incorporation of new mobility opportunities.

Phase I

- Change in departure time
- Alternate routing
- Alternate destinations

Phase II

- Mode choice
- Carpooling
- Elimination of trips

Framing and Refining Control Strategies

Incentive Spectrum

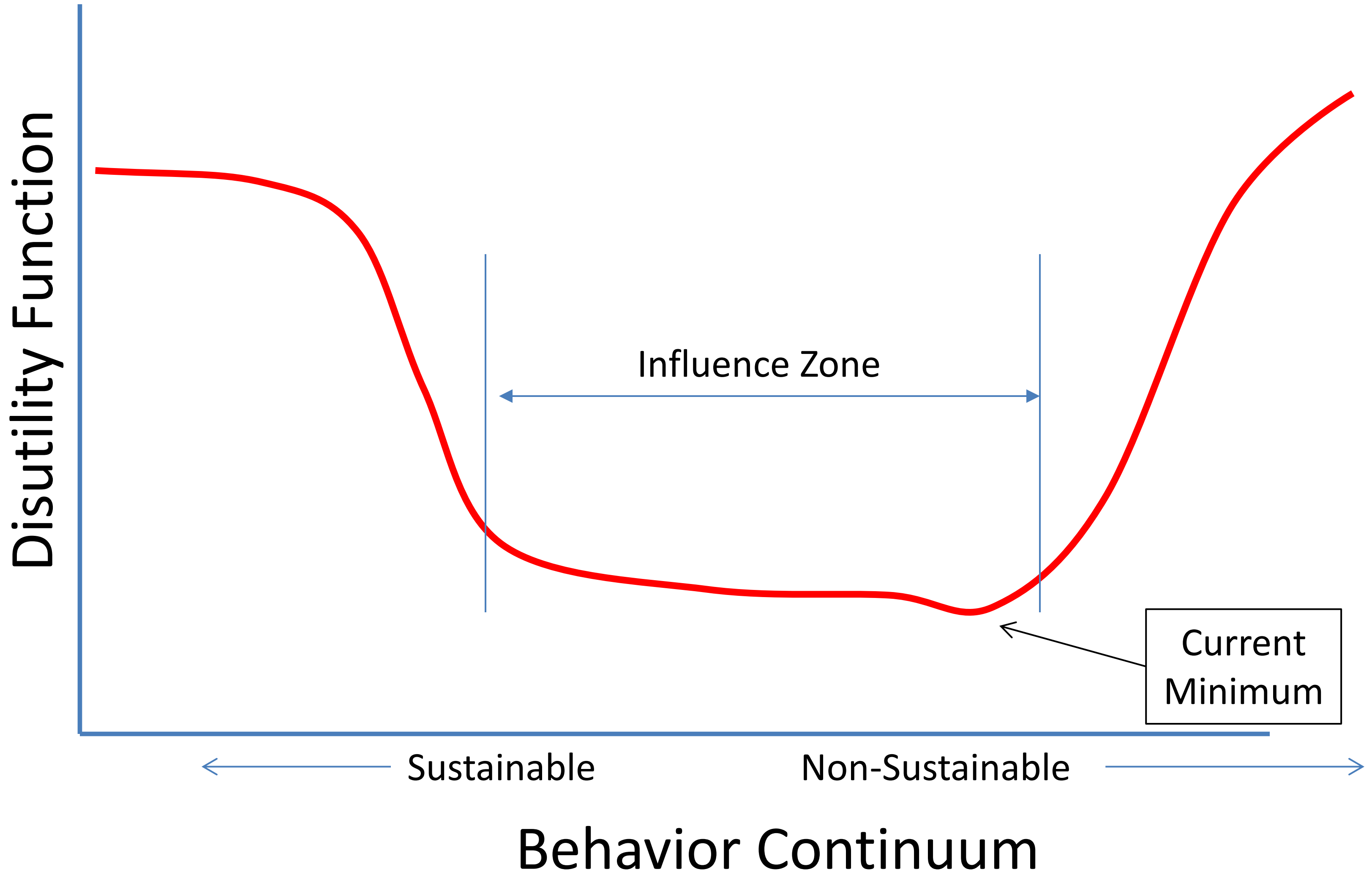
- Navigation Service
- Travel Time Minimization
- Predictive Analytics
- **Points, Points, Points**
- Products – ex., Starbucks coupon
- Services – ex., transit pass or discount
- Charity – ex., plant a tree

The incentives for using the app and accepting its suggestions for routing, mode, time diversions is a set of incentives.

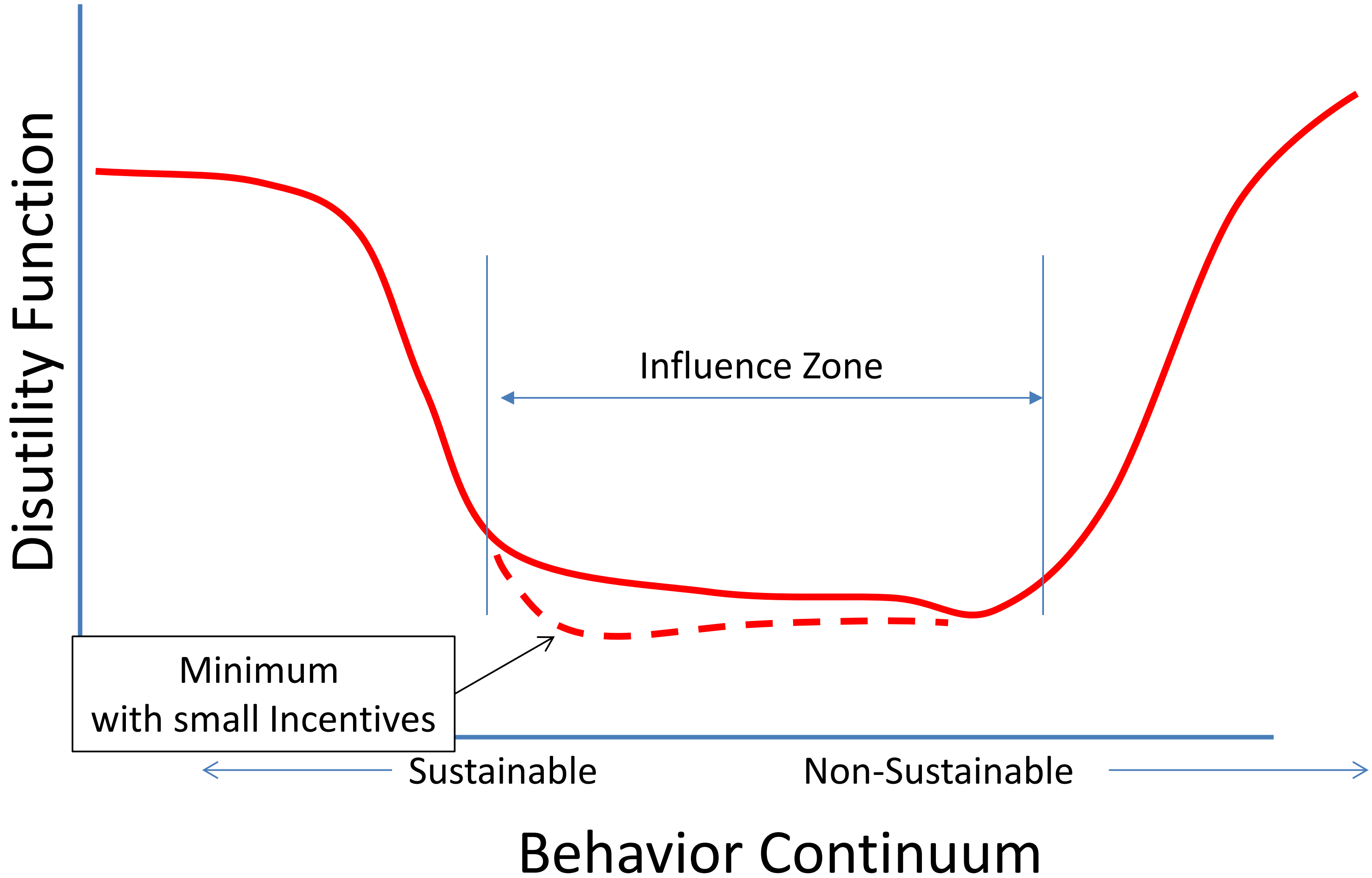
Traditional incentives include rewards as navigation services, route selection to minimize delay, and predictive analytics.

Non-traditional incentives include using the app in a method similar to credit cards or frequent traveler programs. Points are earned toward products, services, and even donations to charities.

Nudging Personal Behavior toward Sustainability



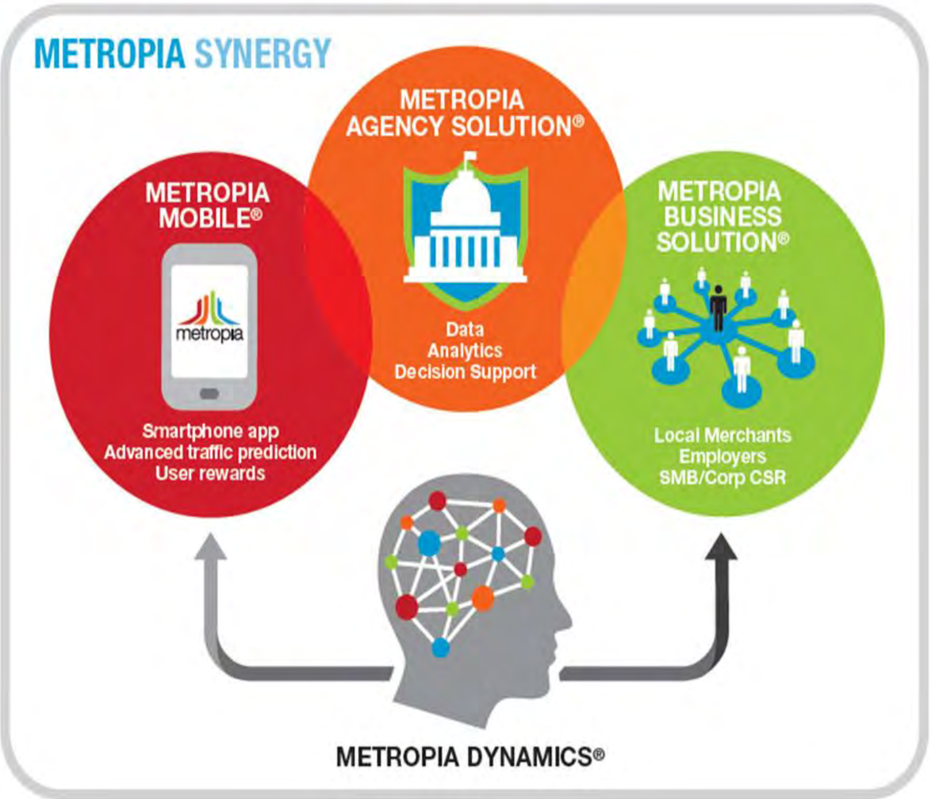
Nudging Personal Behavior toward Sustainability



Metropia's Ecosystem: Community-Based and Incentivizing Change

Metropia Synergy Platform

A sustainable, safe, and efficient transportation system

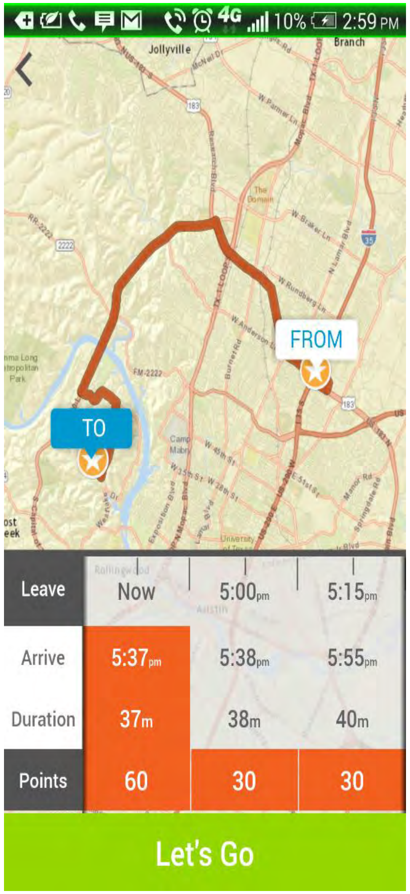


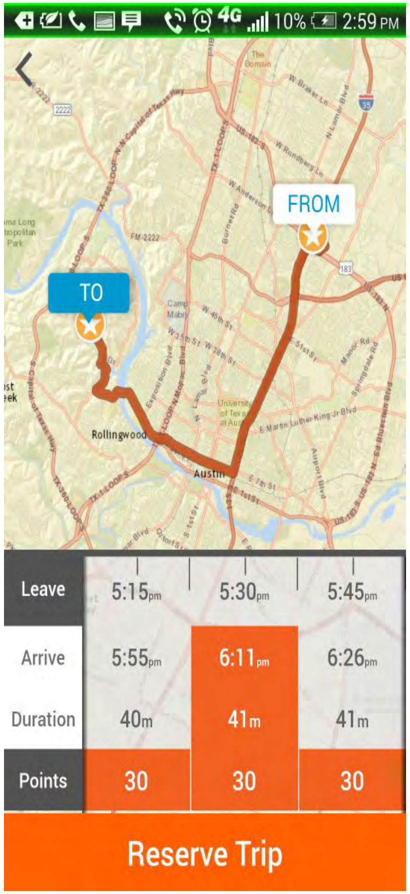
- Metropia Mobile - Smarter Commuting Decisions
  - Patented travel prediction and load balancing algorithms
  - Fuses real time + historical travel time data
- Metropia App Features
  - Departure time and routing information
  - Pre-plan and reserve trips
  - Turn-by-turn voice navigation (validation)
  - Incentivizes travel behavior changes (earn points)
  - Earn more points for shifting departure out of peak period or alternative route
- Deployment Schedule
  - Currently in Tucson, Austin, El Paso, and New York
  - 4-5 more cities expected in 2016

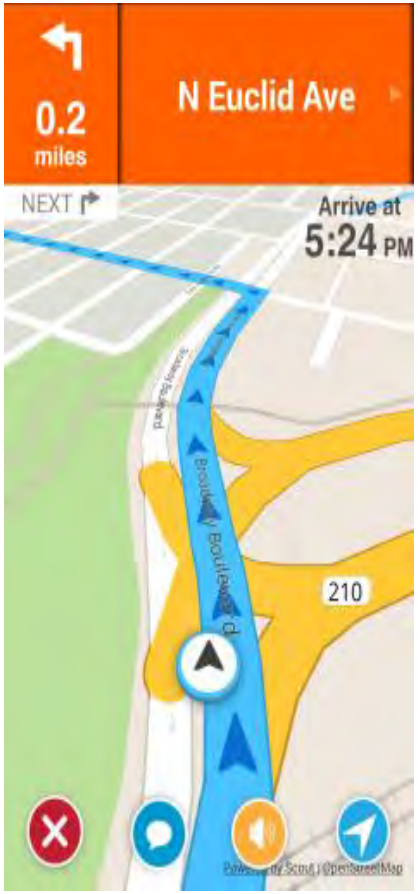
Predictive Routing and Load Balancing

Reserve

Validate

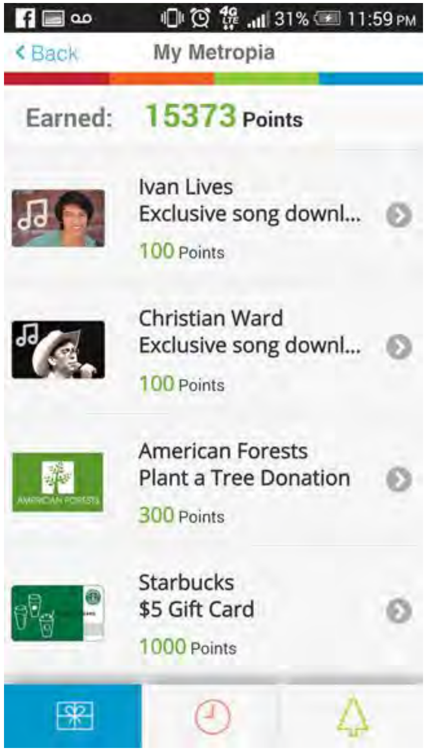


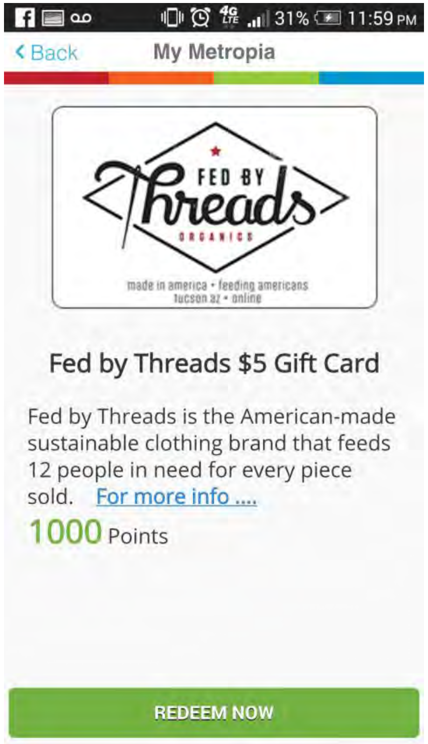




Metropia's Gamification Features

Earning Points can be exchanged for local merchant rewards or to plant trees.

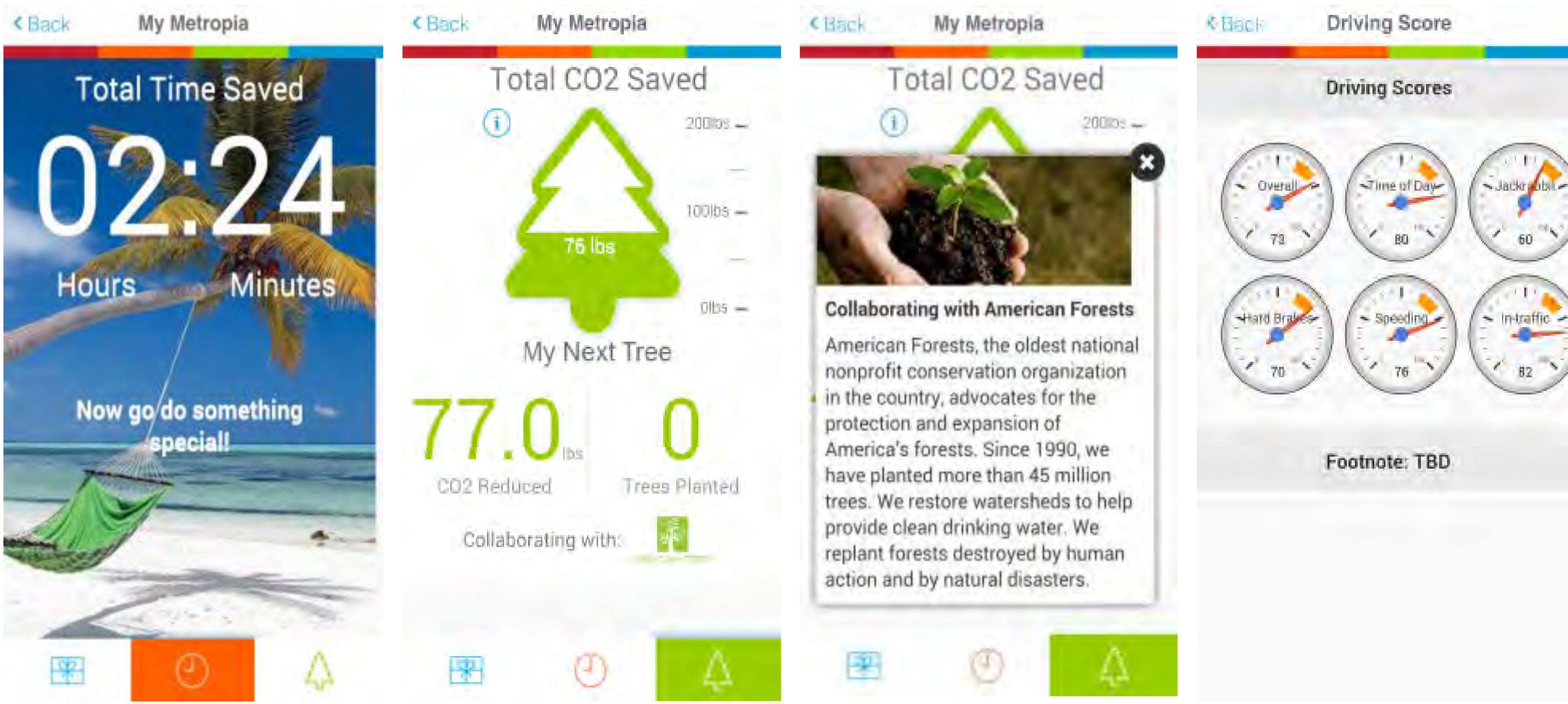




THE UNIVERSITY OF ARIZONA

Metropia's Gamification Features

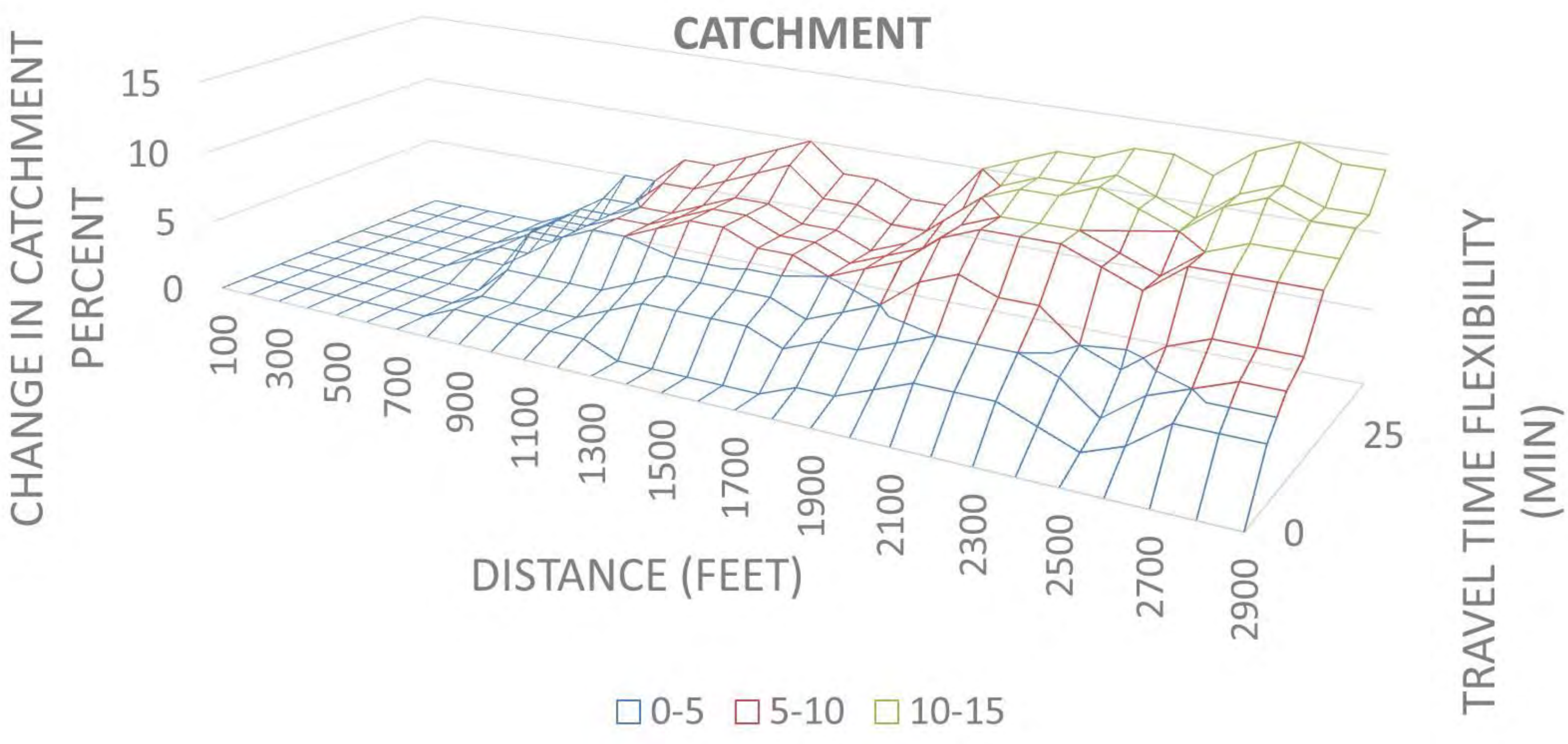
Users also get CO2 and Time Savings and Driving Scores.



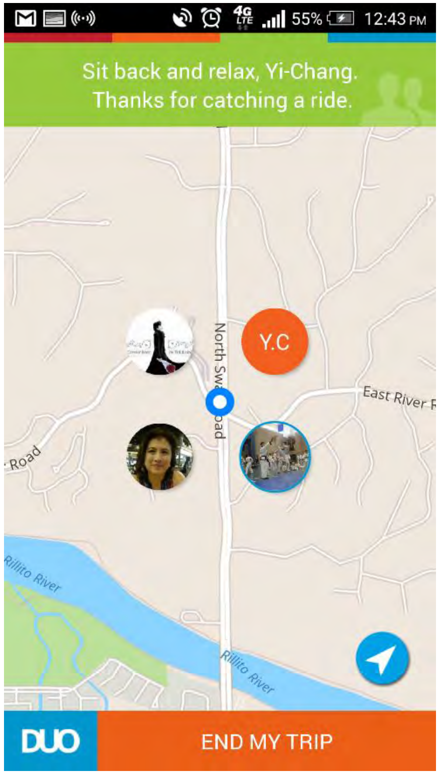
THE UNIVERSITY OF ARIZONA

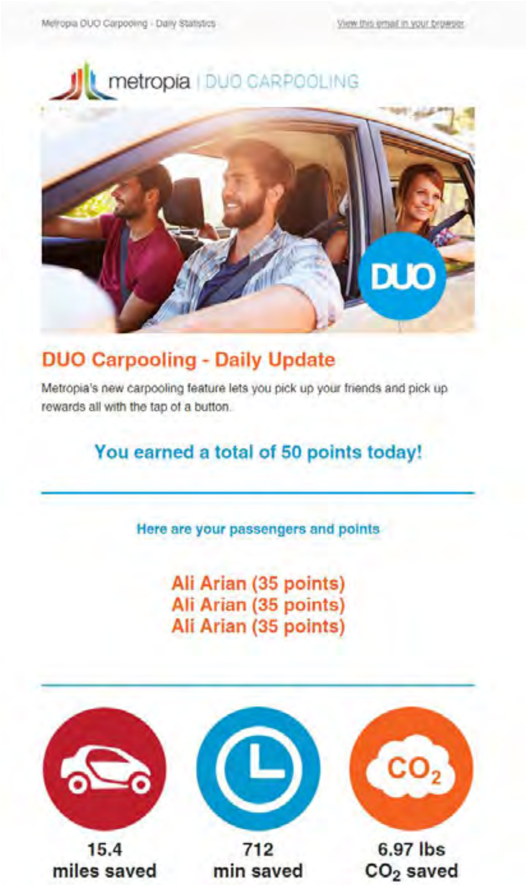
Metropia Tucson User Trips vs Walking Distance

Up to 15% of user trips can be serviced by transit based on a 3,000 ft. walking distance (door-to-door) and 25 min travel time flexibility.



DUO (Drive Up Occupancy)





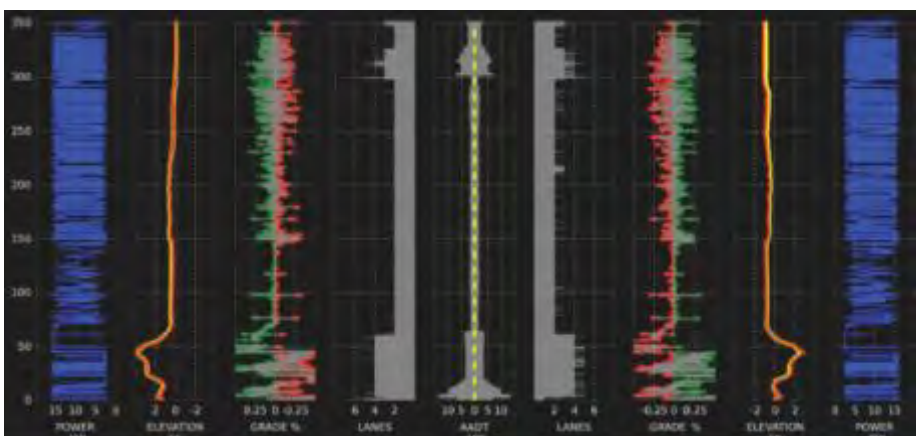
Iterating a Baseline for Energy Consumption

Accessing Diverse Transportation Data Sets

NREL’s Transportation Secure Data Center (TSDC) houses data from travel surveys and studies conducted using GPS devices. It features millions of data points—second-by-second GPS readings, vehicle characteristics (if applicable), and demographics—for all modes of travel.

Leveraging Existing Tools to Estimate Energy Impact

- DRIVE
- FASTSim
- Fleet DNA



Example of TSDC Analysis

Integration of TomTom infrastructure details with road load equation to estimate instantaneous power demand (blue) for a Chevy Volt at a constant speed given instantaneous grade. Average annual daily traffic is visualized in the center indicating vehicle count.

Source: NREL

Project Timeline – Key Milestones

Year 1	
Q1	• Tech to Market Plan completed • Target city identified • Phase I control architecture development begins
Q4	• Energy estimation for Phase I control strategies completed

Year 2	
Q5	• Initial control strategies implemented in Metropia app • Phase II control architecture development begins
Q6	• Sensitivity analysis for control strategies completed
Q7	• Integrate Phase I/II control strategies and incentives into Metropia app • Energy estimation of all control strategies complete • System energy estimation performs within 10% accuracy
Q8	• Development of learning algorithm completed

Year 3	
Q9	• Updated Metropia application deployed to mobile app markets (e.g., iOS app store)
Q10	• Project close-out

Project Team

Lead: H. Michael Zhang, Ph.D.
Professor of Civil and Environmental Engineering

Lead: Derek Reed, Ph.D.
Associate Professor and Director Graduate Studies, Applied Behavioral Sciences

Lead: Vassilis Papayannoulis, Ph.D.
Principal

Lead: Stan Young, Ph.D.
Advanced Transportation and Urban Scientist

Lead: Jeff Shelton
Research and Implementation Lead

Lead: Cynthia Chen, Ph.D.
Associate Professor and Director of Transportation-Human Interaction and Knowledge Network (THINK) Lab

Questions?

dash

X

University Transportation Research Center

Transportation Transformed
Advancing Eco-Friendly Mobility

Dash – Data Driven

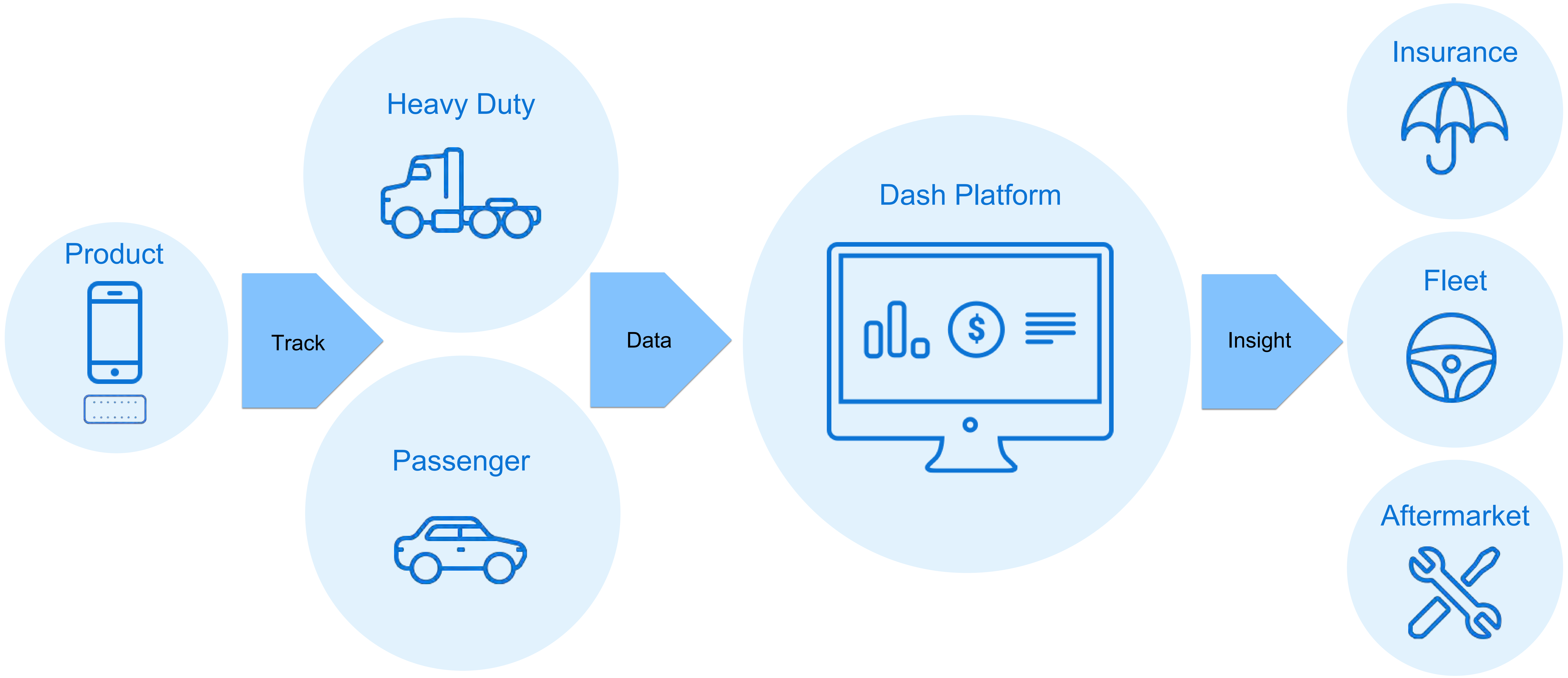
Video: https://vimeo.com/152433942

Dash is DATA DRIVEN

- Dash is one of the world's leading open connected vehicle platforms
- Our telematics products connect vehicles and drivers, harnessing data
- Leverage driving analytics, to make transportation operations more efficient
- Insights enable businesses to grow revenues and decrease costs

dash

Dash Solution



Dash's front end products track vehicle information & driver behavior

Dash's platform & data analytics generates insights to improve operational efficiency

Realize revenue increase & cost decrease for Dash's enterprise partners

Product

Affordable devices
Hardware agnostic

Mobile first
Scalable platform

All brands
Since 1996

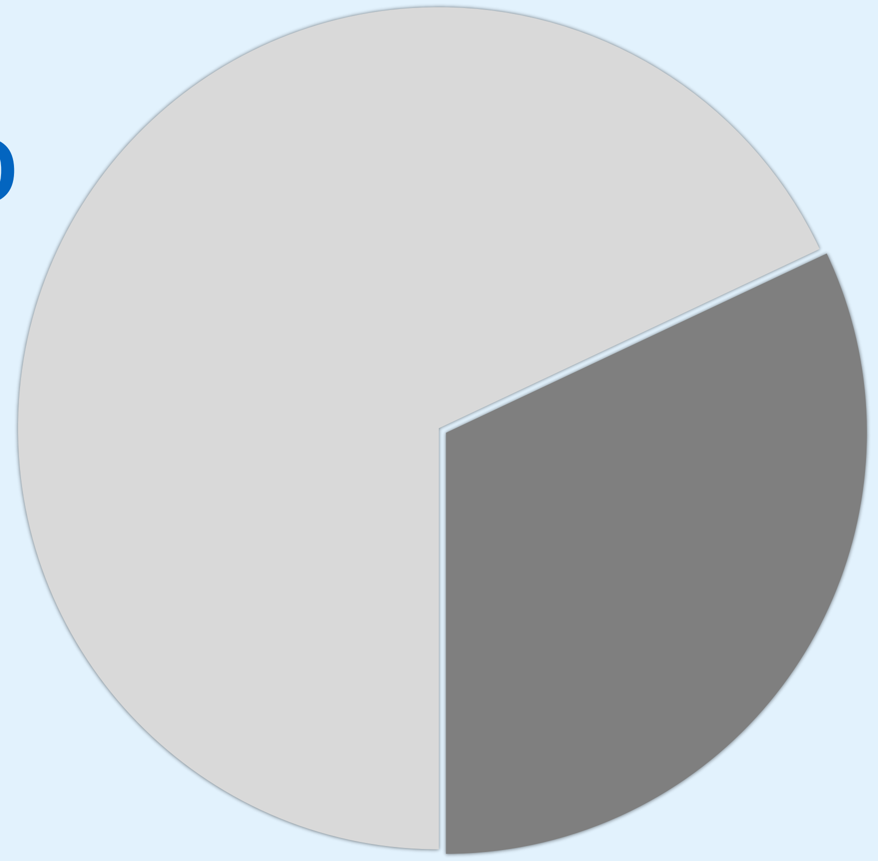
dash

Product

[Play Video]

dash

User Metrics



Top 5 Countries

USA
Canada
UK
Germany
Australia

Top 5 US States

California
Texas
New York
Florida
Illinois

Top 5 US Cities

Los Angeles
New York
Chicago
San Francisco
Atlanta

Press

Business

FORTUNE
THE WALL STREET JOURNAL.
Entrepreneur

Technology

THE VERGE
TechCrunch
Mashable

News

CNN
BBC
CBS

Consumer

Stuff
cnet
T3
FAST COMPANY

Trade

Automotive News
Telematics UPDATE
Advertising Age

Automotive

ROAD & TRACK
HOT ROD
JALOPNIK

Awards

THE WHITE HOUSE
WASHINGTON

DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

EDITORS' CHOICE
INNOVATION 2015
Better Homes and Gardens

13/14
Cloud
INNOVATION
WORLD
CUP
WINNER

Ford

HACKOMOTIVE

For full press coverage, see http://press.dash.by

dash

CONFIDENTIAL

IFTTT jamynedis

Automatic Temp Control - Park at home, turn temp down

Notes: Very Simple, Set your geographic region to your home. With Dash, every time you turn your engine off after a trip, your Nest turns the temp down in your home.

by jdnanne
December 17, 2014
added 1 time

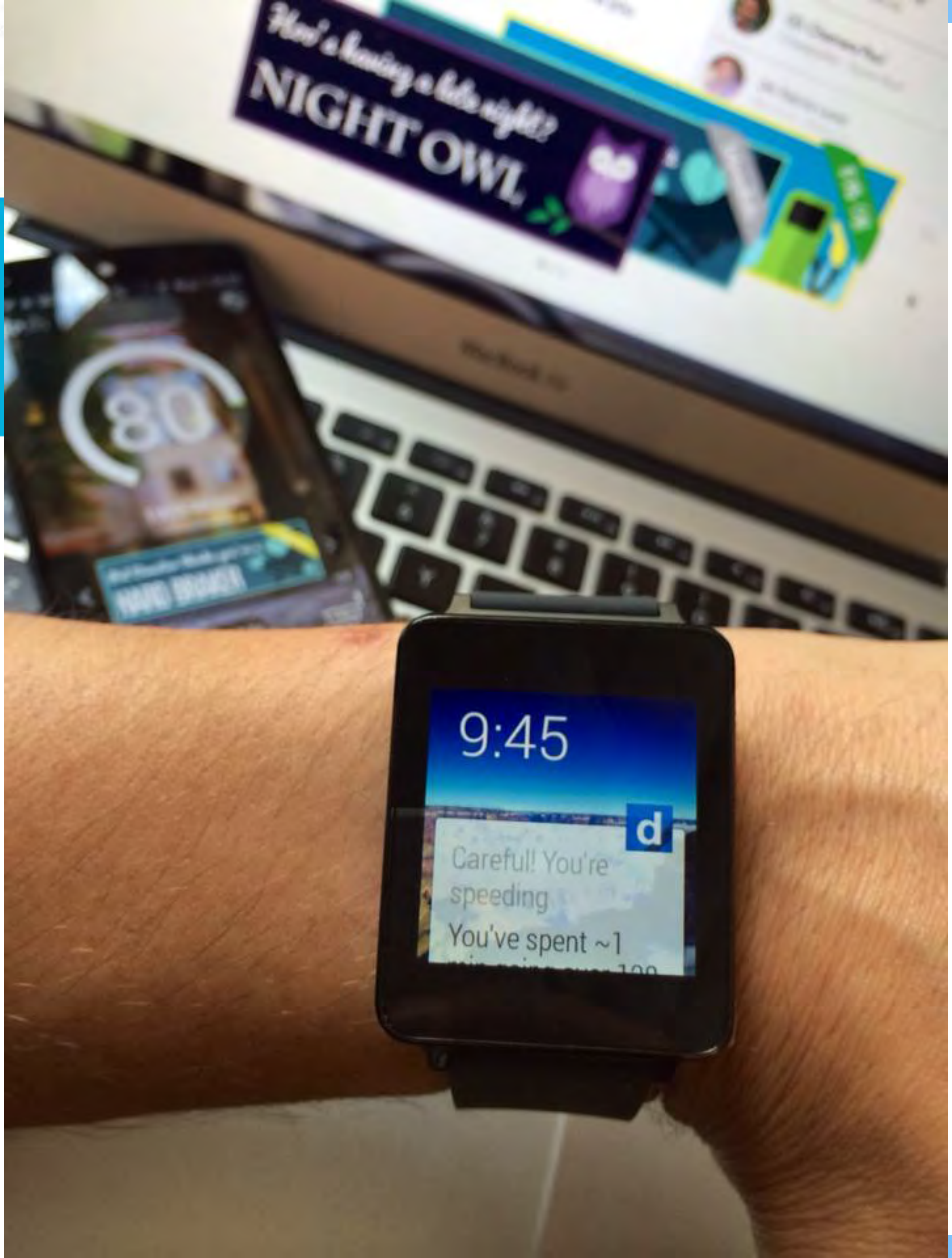
Which device?

Please select

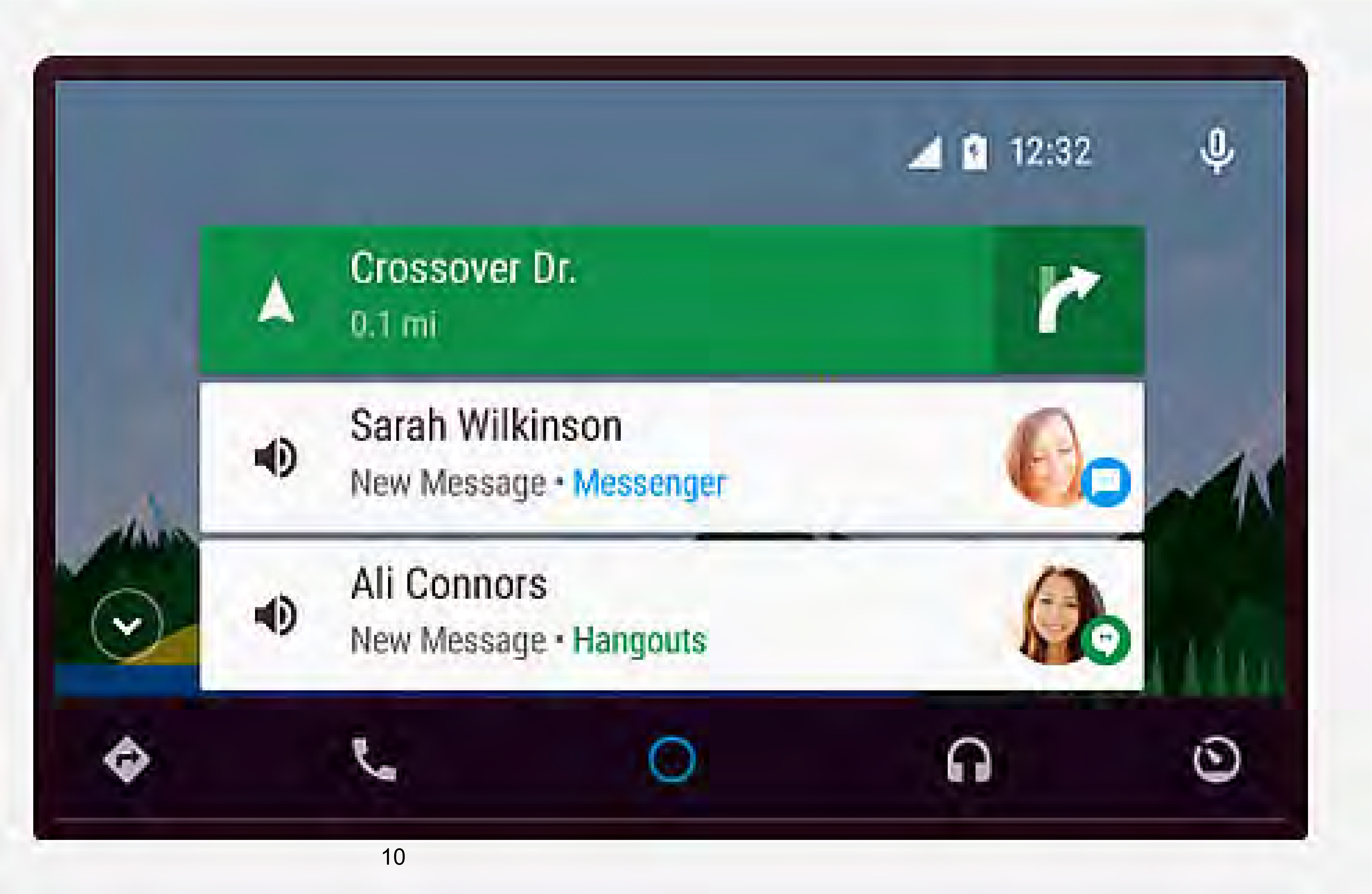
Receive notifications when this Recipe runs

Add Recipe

9

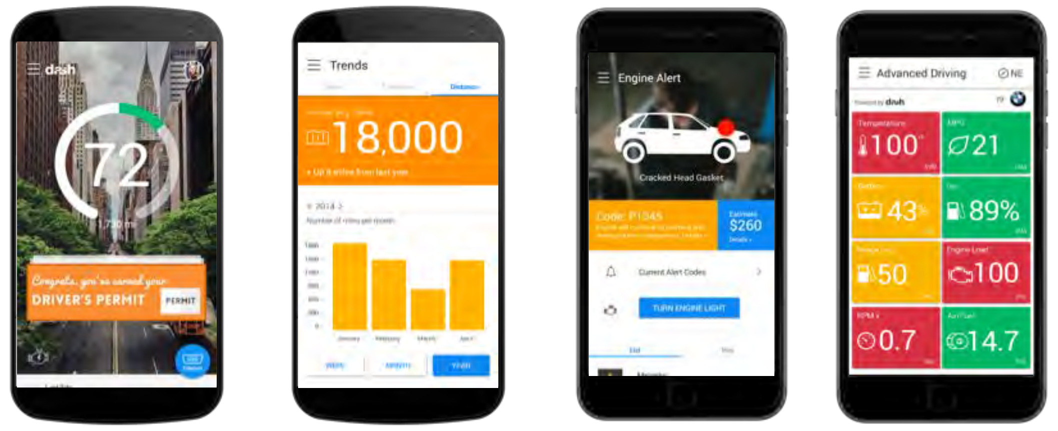


android auto



Coming soon

Roadmap



dash

- Core consumer product for Android & iOS
- OBD supported (hardware agnostic)
- ‘Smarter. Driving. Every Day’

dash XL

- Enterprise grade solutions
- J1939 ‘Heavy Duty’ OBD (Vnomics, Intel)
- Fleet & Usage Based Insurance

dash IQ

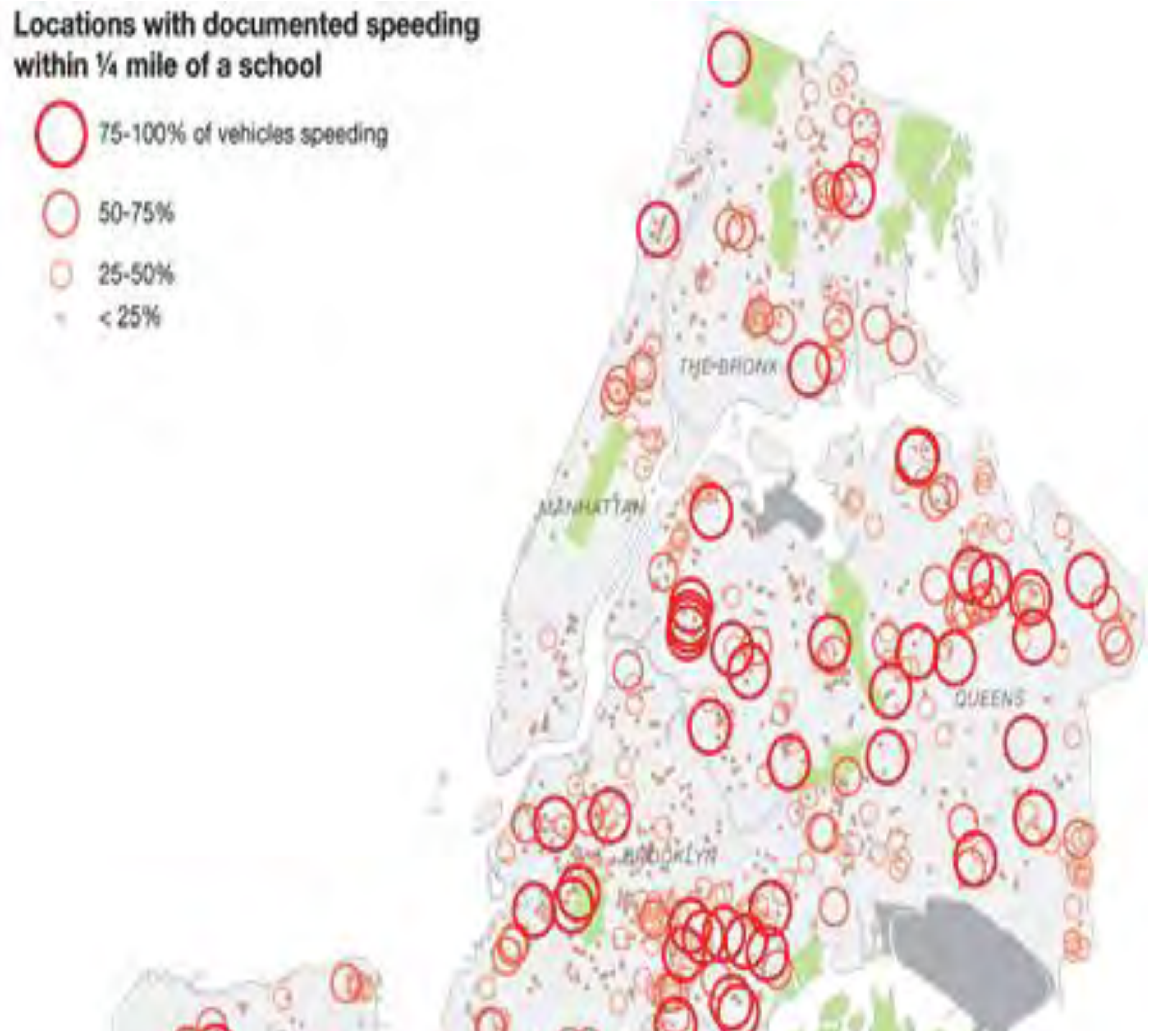
- Data & analytics solution
- Built on Dash’s ‘Chassis API’
- Developer platform & IFTTT extensions

Drive Smart – NYC DOT

NEW YORK CITY DOT

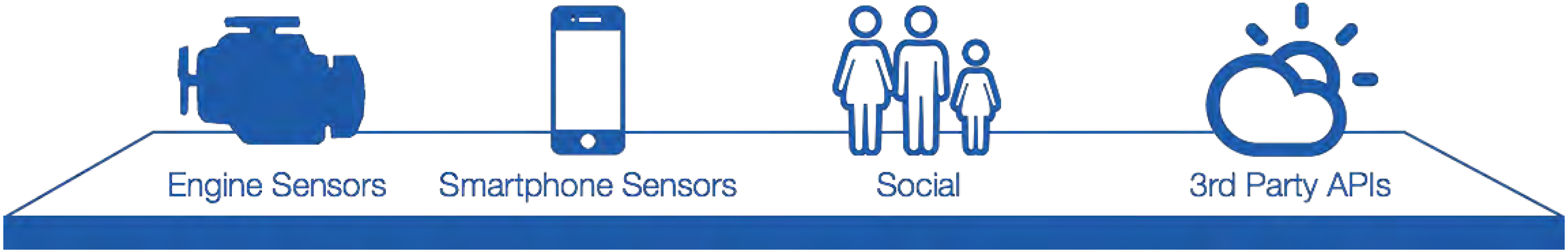
NYC Taxi and Limousine Commission

The City of New York Office of the Mayor



VISION ZERO

‘Automotive Graph’



- e.g. speed, RPM, fuel level, engine alerts, passenger
- e.g. GPS, compass accelerometer, barometer
- e.g. gender, age, income, friends, affinity groups
- e.g. weather forecast, traffic business nearby

dash

Platform Commercialization

Traditional

	Short Term	Long Term
Traditional	OEM / Dealers Parts / Repair Oil / Gas Rental/ Rideshare	Insurance Financing Mapping / Nav Data Aggregator
Emerging	Technology Telecom Hardware Government	CRM Advertising Billboard Analytics Hedge Funds

dash DATA

- Dash's vision is to build the 'Automotive Graph'
- Phase 1 - activating driving 'data gatherers', both consumer and enterprise
- Phase 2 - leveraging the Chassis platform and data with traditional transportation and ancillary sector partners


nest
AIRWAVE
72
dash

Driving Evolved
Dash x Microsoft x WeWork

Video: https://youtu.be/dc8j96x7mwM

Contact

Jamyn Edis, CEO

+1-857-540-9790

jamyn@dash.by

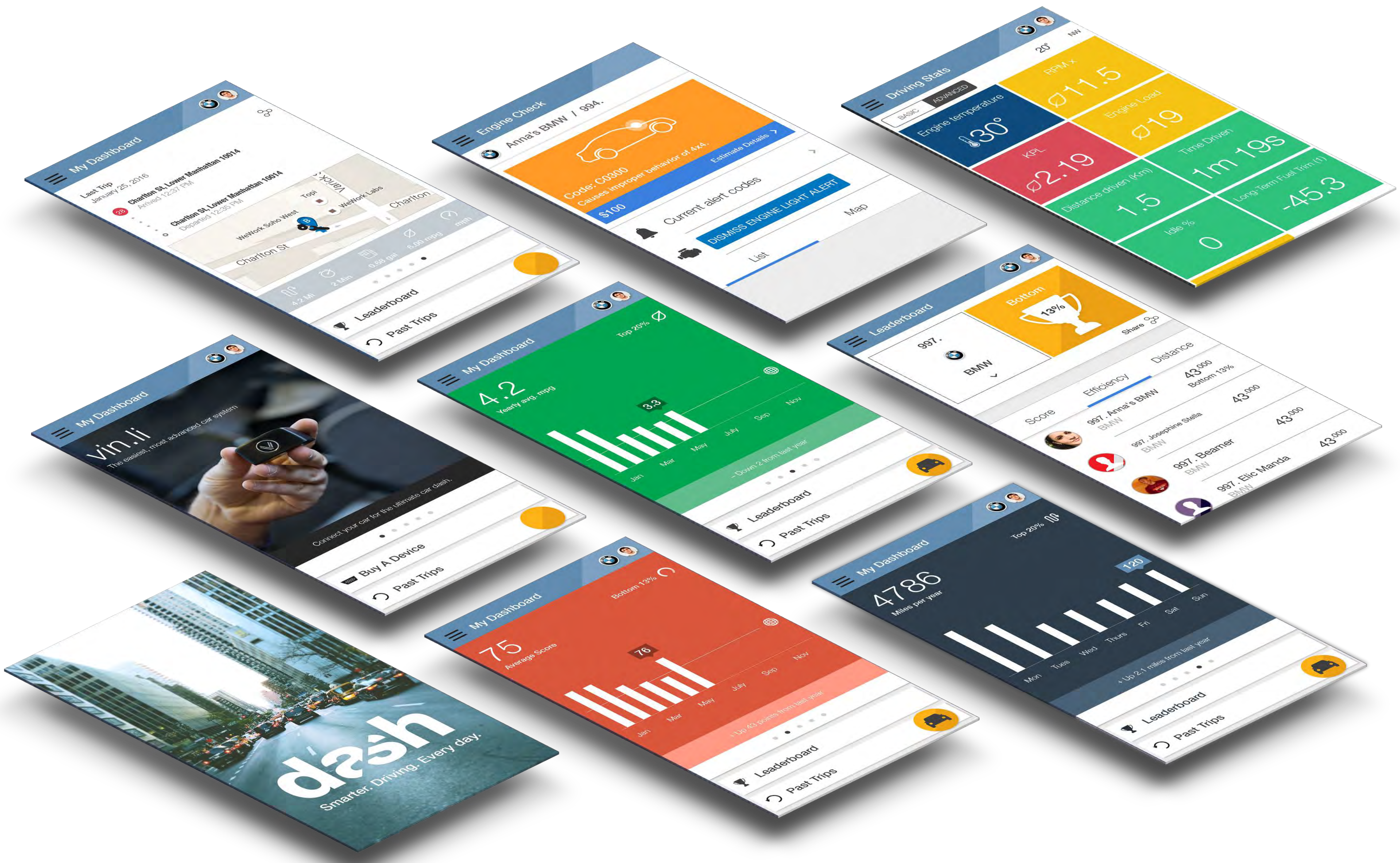
Company

dashmobile.co

/dashmobile

@dashmobile

Product



My Dashboard
Leaderboard
Past Trips
Engine Check
Anna's BMW / 994.
Code: C0300
$100
Estimate Details
Current alert codes
DISMISS ENGINE LIGHT ALERT
List
Map
Driving Stats
BASIC
ADVANCED
Engine temperature
KPL
Engine Load
Time Driven
Distance driven (Km)
Long Term Fuel Trim (1)
Idle %
-45.3
Top 20%
4.2
Yearly avg. mpg
Bottom
13%
Share
BMW
Score
Efficiency
Distance
997. Anna's BMW
997. Josephine Stella
997. Beamer
997. Elic Manda
vin.li
Buy A Device
75
Average Score
Bottom 13%
4786
Miles per year
Jan
Mar
May
July
Sep
Nov
Mon
Tues
Wed
Thurs
Fri
Sat
Sun
dash
Smarter. Driving. Every day.

Milestones

2013

Raised $1.5m from Slow Ventures & Techstars

- Prototype built, including integration into Ford OpenXC & GM's API
- Award from White House & Dept. of Energy
- Techstars NYC'13 Program
- Beta rollout & pilots

2014

Award-winning product launches on Android & iPhone

- Android
- IFTTT Channel
- International
- iOS
- Chassis API
- Multiple awards & press incl. Fortune, CNN, BBC, WSJ, Wired, Fast Company, The Verge

2015

Growth to 300,000 users & $1m in enterprise revenue

- UBI solution built for European insurer
- Dash 2.0
- 'Drive Smart' program with Dept. of Transport & AllState
- Fleet management partner Vnomics
- Product partnerships incl. Edmunds, Vinli, OpenBay, Urgently

Metrics

- Dash launched our first consumer mobile product in Q1 2014
- Users are 60% USA and 40% international
- Los Angeles is our largest market
- Largest territories outside of USA include Canada, UK, Australia, Germany
- Mileage reported only when car is connected to a device; Dash's product can be used as a standalone mobile app

Website

340k
Visitors

900k
Page Views

80k
Email Signups

75k
Social Followers

Mobile Product

300k
User Installs

100+
Countries

30k
Car Models

25 min
Per Session

5m
Trips

50m
Miles

dash

Team


Jamyn Edis
Founder, CEO


Brian Langel
Founder, CTO


Mavi Puri
Architecture


Chen Yuan
Android


Elliot Goldman
iOS


Anna Fine
UX / UI


Kenton Nix
Ops

Investors


Dennis Crowley
Foursquare


Dave Morin
Path


Bre Pettis
Makerbot

techstars

SLOW VENTURES

PHYSTECH VENTURES

CyberAgent Ventures

AlphaPrime Ventures

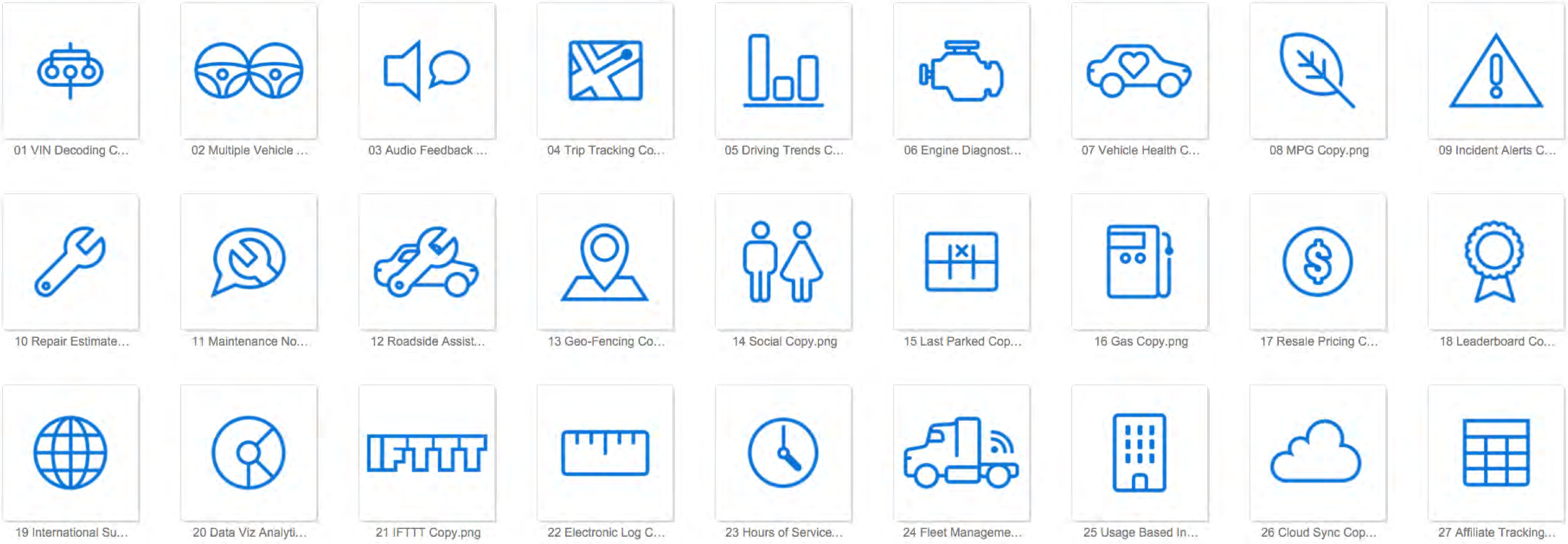
URBAN.US

AngelList

dash

Benefits

- Dash's product deliver value to users across the spectrum - from every day commuting, to heavy commercial use by small fleets – enabling them to 'drive smart'
- The full suite of functionality helps make the roads safer, greener and more affordable



Selected Features

Princeton University

PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Shared autonomousTaxis

For Eco-Mobility

by

Alain L. Kornhauser, PhD

Professor, ORFE
(Operations Research & Financial Engineering)
Director, CARTS
(Center for Automated Road Transportation Safety)
Faculty Chair, PAVE
(Princeton Autonomous Vehicle Engineering)
Princeton University

Presented at

TRANSPORTATION TRANSFORMED:
ADVANCING ECO-FRIENDLY MOBILITY

April 7, 2016
New York Institute of Technology
NYC

TRANSPORTATION TRANSFORMED:
ADVANCING ECO-FRIENDLY MOBILITY

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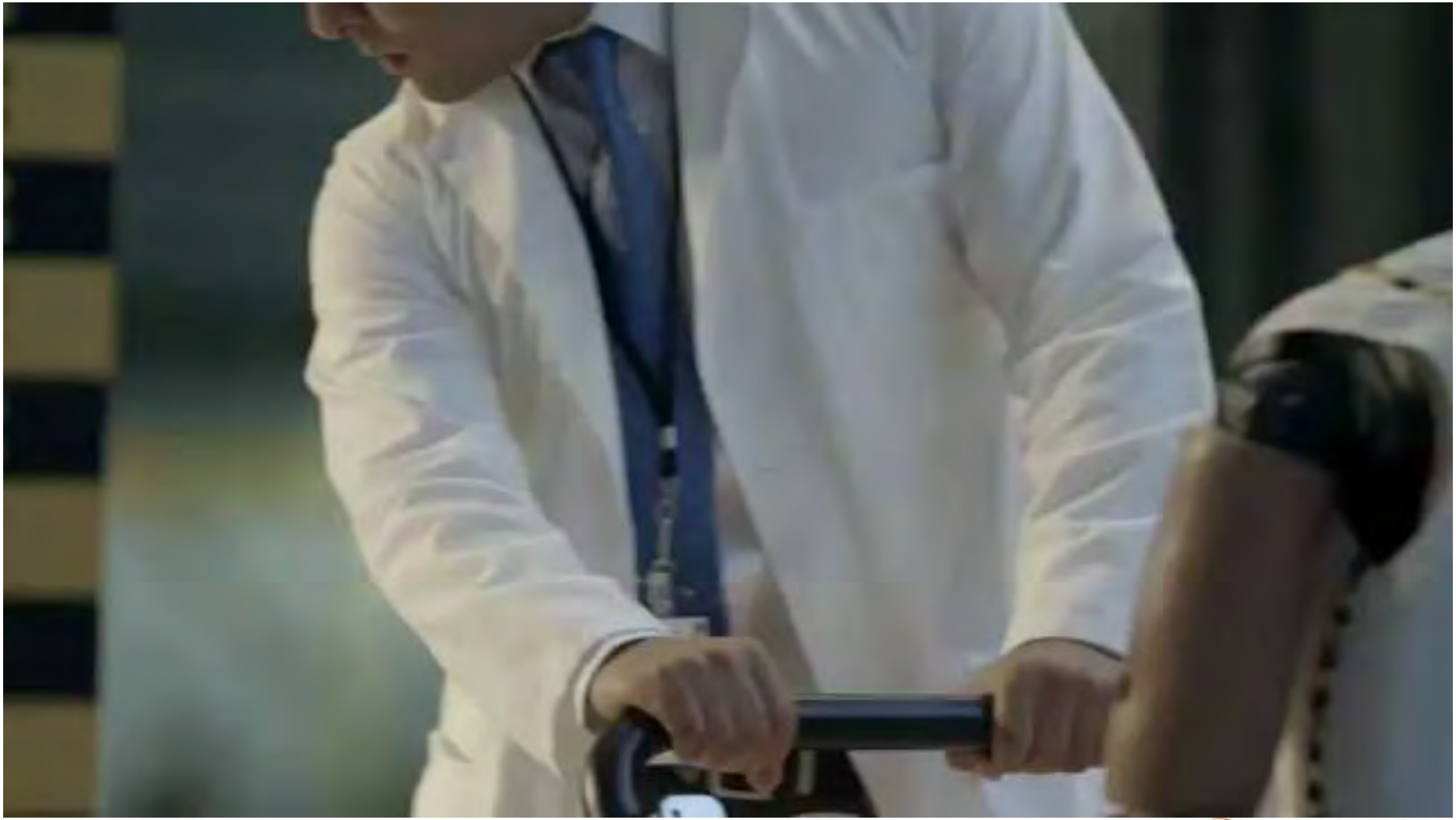
Automated Driving

- Today (Self-Driving) ... It is all about **SAFETY**!
- Ultimately (Driverless) ...It is all about **Enhanced Mobility**
    - "On Demand" for All
    - Substantially Cheaper
    - Substantially Safer
    - Substantially More Energy Efficient
    - Substantially Lower GHG & Other Pollutants
    - Substantially Less/Elimination of Road Congestion

How Do AVs Address the Safety Challenge ?

http://orfe.princeton.edu/~alaink/SmartDrivingCars/Videos/Subaru%20EyeSight_Commercial60secCrashTest.mp4

Fundamental AV Concept



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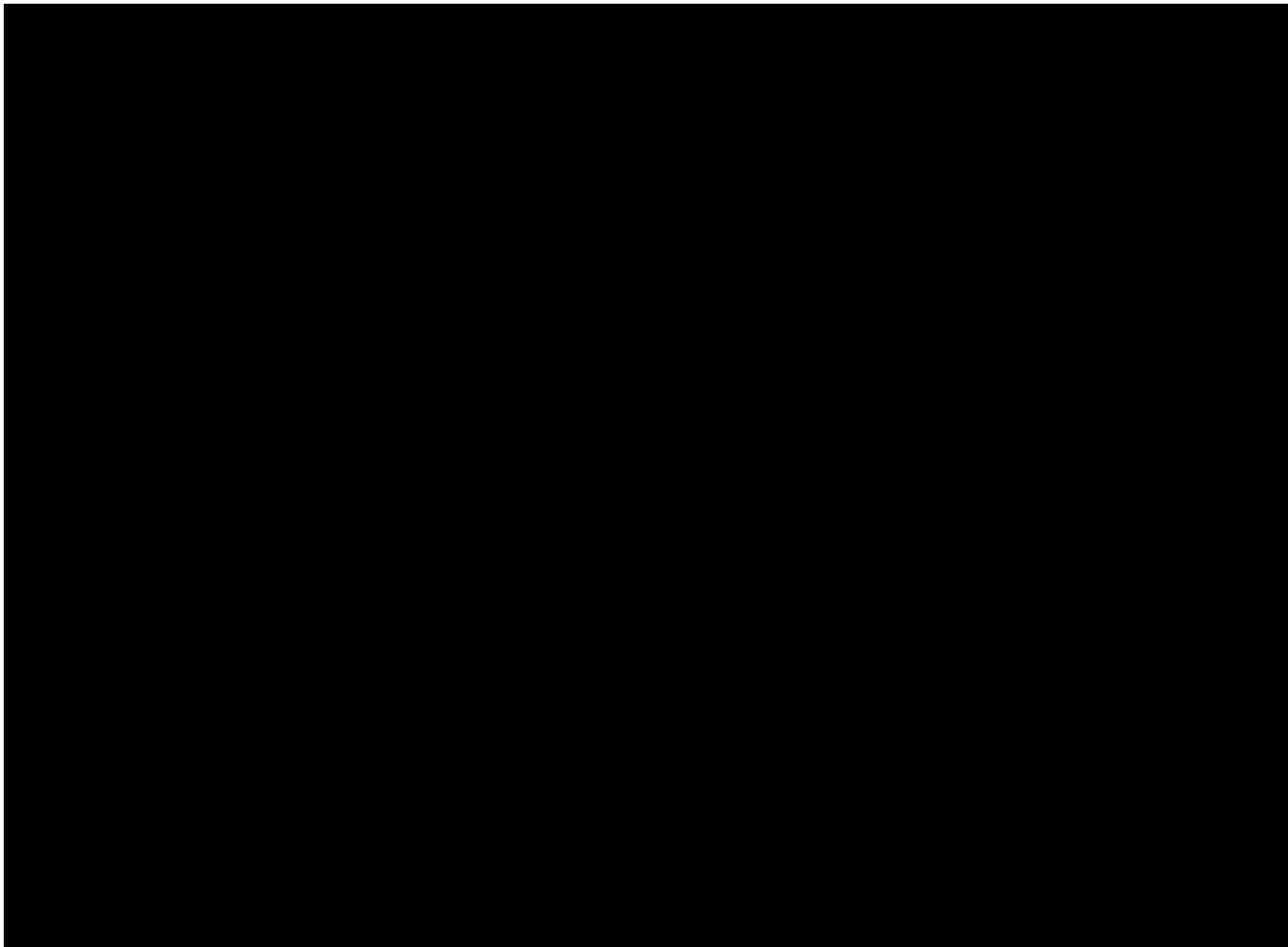
PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

https://www.youtube.com/watch?v=yARbNYcjPQM

Fundamental AV Concept



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CARTS The Center for Automated Road Transportation Safety

http://www.youtube.com/watch?v=dWj44GjrSs0

Fundamental AV Concept

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What are Automated Vehicles?

What the Evolving Levels Deliver:

Levels 1 -> 2: (Driverless Repositioning) **Safety,** Comfort & Convenience

An **Insurance Discount** Play

Levels 3:
Pleasure, Safety, Comfort & Convenience

An **Enormous Consumer** Play

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Why AVs are Inevitable…

- One only needs to get the Automated Vehicles technology to "**work**" on a "single" vehicle to initiate **viral adoption**!
  - Definition of "**work**":

Cost of the Technology

<

Net Present Value { Expected Liability Savings $_{\text{delivered by that technology}}$}

- Since the technology
  - Does **NOT** require any infrastructure costs
  - Involves mostly "Moore's Law Elements
- The inequality will be achieved and
  - **Insurance** will fuel the viral adoption.

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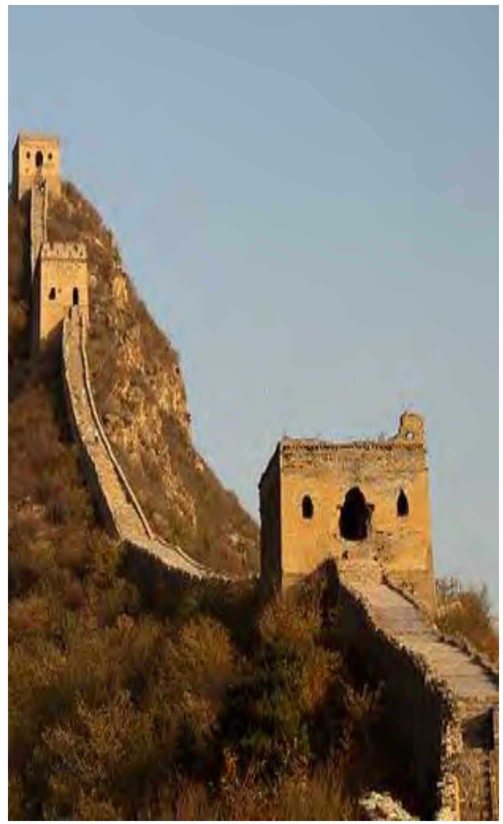
What are Automated Vehicles?

PRINCETON AUTONOMOUS VEHICLE ENGINEERING

What the Evolving Levels Deliver:

Levels 1 -> 2: **(Driverless Repositioning)** **Safety, Comfort & Convenience**

An **Insurance Discount** Play



Level 4 **(Driverless Repositioning) : Pleasure, Mobility, Efficiency, Equity**

Elimination of cost of Labor Revolutionizes "Mass Transit" by Enabling Low-cost to even single riders "zero"

A **Corporate Utility/Fleet** Play

Levels 3:

Pleasure, Safety, Comfort & Convenience

An **Enormous Consumer** Play

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Synthesizing Individual Travel Demand in New Jersey

Trips everyone in NJ wants/needs to make on a typical day

Philip Acciarito '12
Luis Quintero '12
Spencer Stroeble '12
Natalie Webb '12
Heber Delgado-Medrano *12
Talal Mufti *12
Bharath Alamanda '13
Christopher Brownell '13
Blake Clemens '13
Charles Fox '13
Sarah Germain '13
Akshay Kumar '13
Michael Markiewicz '13
Tim Wenzlau '13

Professor Alain L. Kornhauser *71

Department of Operations Research & Financial Engineering
Princeton University

January, 2012

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Synthesize from publically available data:

- “every” NJ Traveler on a typical day **NJ_Resident file**
  - Containing appropriate demographic and spatial characteristics that reflect trip making
- “every” trip that each Traveler is likely to make on a typical day. **NJ_PersonTrip file**
  - Containing appropriate spatial and temporal characteristics for each trip

Creating the **NJ_Resident** file

for "every" NJ Traveler on a typical day

NJ_Resident file

Start with Publically available data:

United States Census 2010

AMERICAN COMMUNITY SURVEY
U.S. CENSUS BUREAU

Princeton University

NJ_PersonTrip file

	All Trips		
Home County	Trips #	TripMiles Miles	AverageTM Miles
ATL	936,585	27,723,931	29.6
BER	3,075,434	40,006,145	13.0
BUC	250,006	9,725,080	38.9
BUR	1,525,713	37,274,682	24.4
CAM	1,746,906	27,523,679	15.8
CAP	333,690	11,026,874	33.0
CUM	532,897	18,766,986	35.2
ESS	2,663,517	29,307,439	11.0
GLO	980,302	23,790,798	24.3
HUD	2,153,677	18,580,585	8.6
HUN	437,598	13,044,440	29.8
MER	1,248,183	22,410,297	18.0
MID	2,753,142	47,579,551	17.3
MON	2,144,477	50,862,651	23.7
MOR	1,677,161	33,746,360	20.1
NOR	12,534	900,434	71.8
NYC	215,915	4,131,764	19.1
OCE	1,964,014	63,174,466	32.2
PAS	1,704,184	22,641,201	13.3
PHL	46,468	1,367,405	29.4
ROC	81,740	2,163,311	26.5
SAL	225,725	8,239,593	36.5
SOM	1,099,927	21,799,647	19.8
SOU	34,493	2,468,016	71.6
SUS	508,674	16,572,792	32.6
UNI	1,824,093	21,860,031	12.0
WAR	371,169	13,012,489	35.1
WES	16,304	477,950	29.3
Total	**32,862,668**	**590,178,597**	**19.3**

- **9,054,849** records
  - One for each person in **NJ_Resident** file
- Specifying **32,862,668** Daily Person Trips
  - Each characterized by a precise
    - **{oLat, oLon, oTime, dLat, dLon, Est_dTime}**

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PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Uncongested Mobility for All

New Jersey's Area-wide aTaxi System

ORF 467

Professor Alain L.Kornhauser

Iris Chang '13
Christina Clark '13
JingKang Gao '13
Damjan Korac '13
Brett Leibowitz '13
Philip Oasis '13
Zixi Xu '13
Jaison Zachariah '13
Natasha Harpalani '14
Eileen Lee '14
Alice Lin '14
Aria Miles '14
Hannah Rajeshwar '14
Lucia Wang '14
Charquia Wright '14
Kristin Bergeson '15
Franklyn Darnis '15
Matthew Shackleford '15
Sonia Skoularikis '15
Roger Sperry '15
Andrew Swoboda '15

Operations Research and Financial Engineering
Princeton University
Fall 2012 - 2013

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New Jersey Summary Data

Item	Value
Area (mi^2)	8,061
# of Pixels Generating at Least One O_Trip	21,643
Area of Pixels (mi^2)	5,411
% of Open Space	32.9%
# of Pixels Generating 95% of O_Trips	9,519
# of Pixels Generating 50% of O_Trips	1,310
# of Intra-Pixel Trips	447,102
# of O_Walk Trips	1,943,803
# of All O_Trips	32,862,668
Avg. All O_TripLength (miles)	19.6
# of O_aTaxi Trips	30,471,763
Avg. O_aTaxiTripLength (miles)	20.7
Median O_aTaxiTripLength (miles)	12.5
95% O_aTaxiTripLength (miles)	38.0

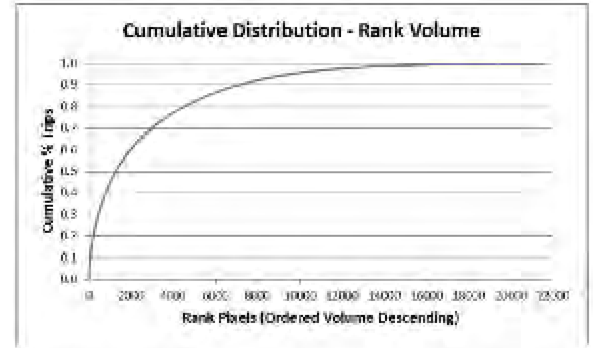

Figure 4.14: NJ State - Cumulative Distribution by Rank of Volume of Pixel

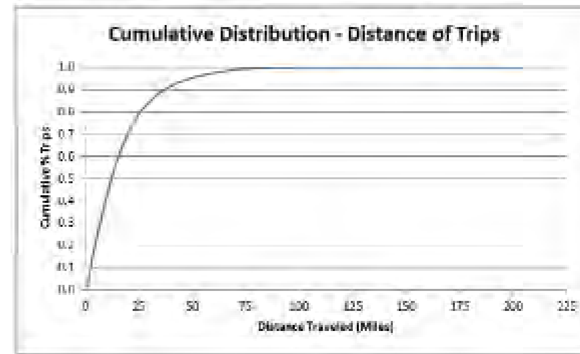

Figure 4.15: NJ State - Cumulative Distribution of Distance Traveled.

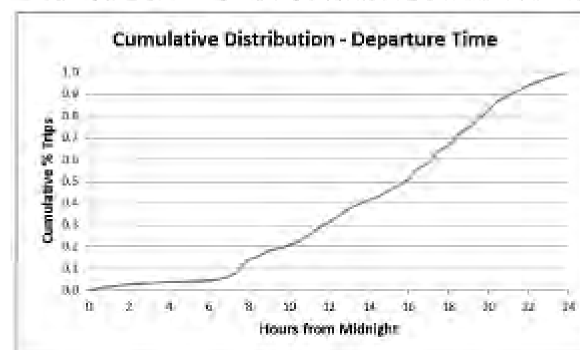

Figure 4.13: NJ State - Cumulative Distribution by Departure Time

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Pixelation of New Jersey

NJ State Grid

Zoomed-In Grid of Mercer

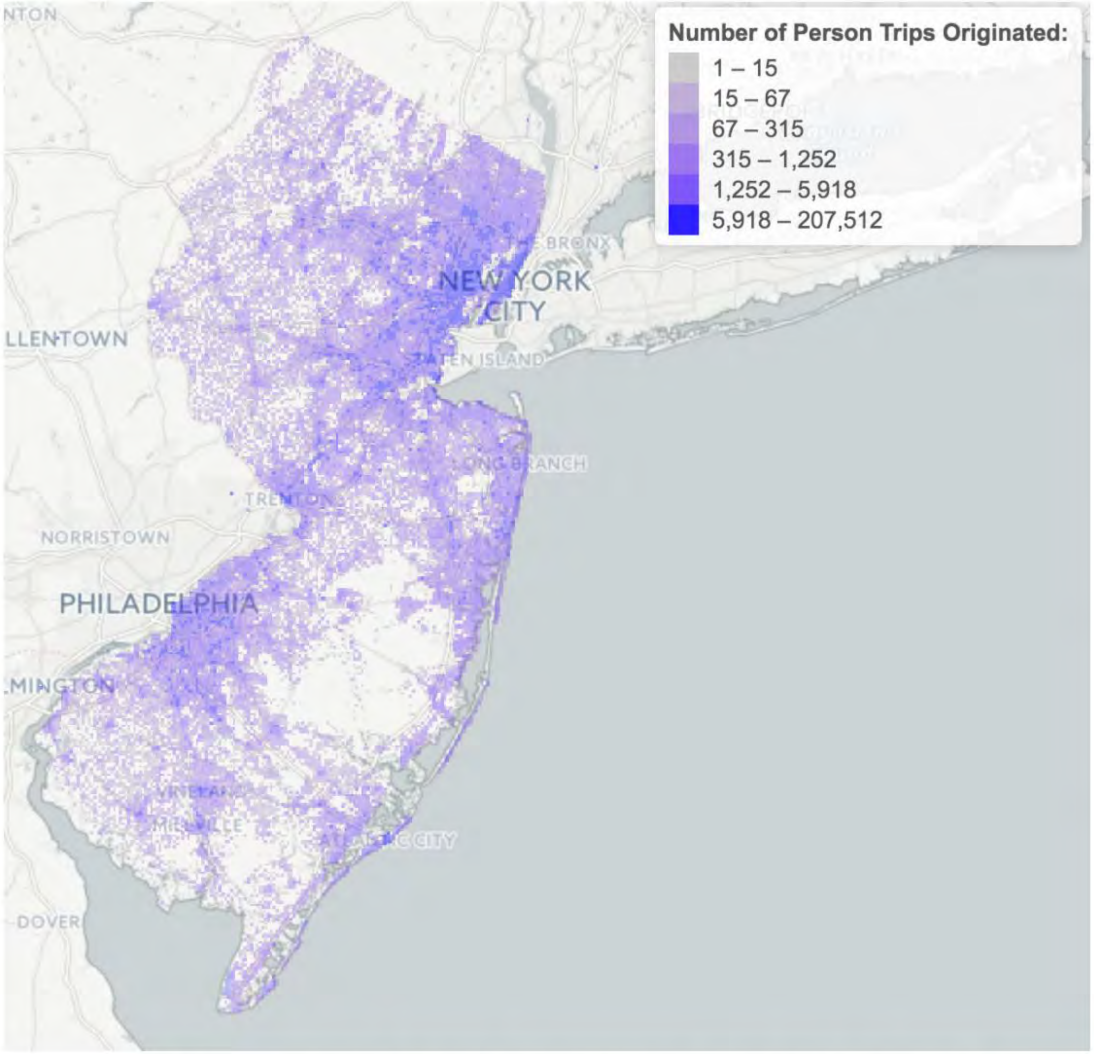

Figure 3.3: Spatial distribution of person trips originated in each pixel. The breaks represent the 10th, 25th, 50th, 75th, and 95th percentiles of the data. 95% of the pixels have fewer than 5,918 Person Trips originated.

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PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Traffic Flow Display System: Typical Weekday autonomousTaxi Trips throughout NJ

Trips generated by Princeton University Trip Synthesizer

County Pixel Direction: Only Origin Origin County: Type: Taxi AVO:1 Timeframe: 00:00 am - 12:00 pm Load

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http://depler.no/route/#/

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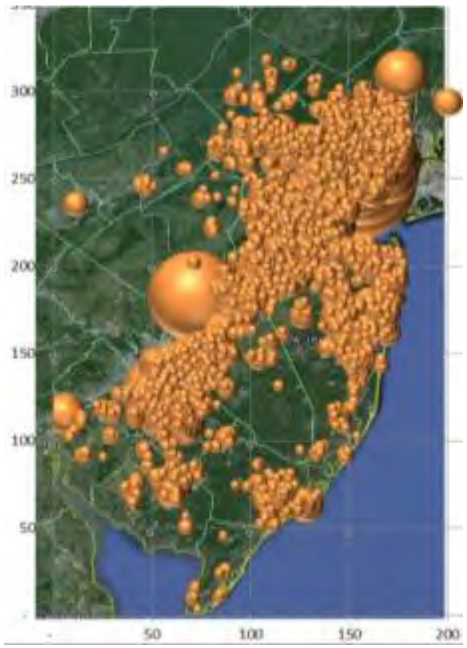
PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Sharing aTaxis

- By walking to a station/aTaxiStand
  - At what point does a walk distance makes the aTaxi trip unattractive relative to one's personal car?
  - ¼ mile (5 minute) max
- Like using an Elevator!



Elevator

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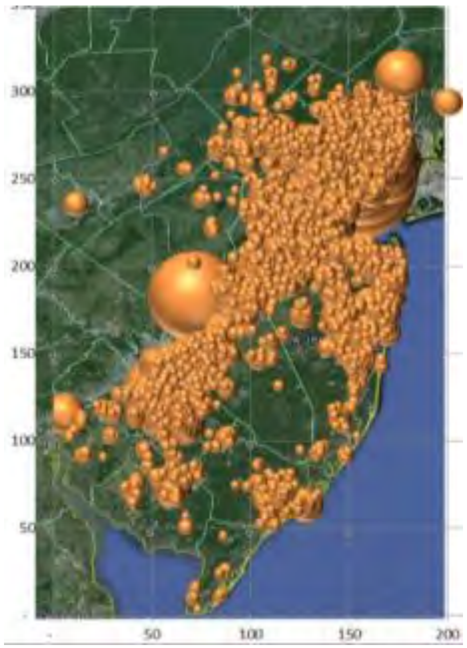
aTaxis and RideSharing

- "AVO < 1" RideSharing
  - Eliminate the "Empty Back-haul"; AVO Plus
- "Organized" RideSharing
  - Diverted to aTaxis
- "Tag-along" RideSharing
  - Only Primary trip maker modeled, "Tag-alongs" are assumed same after as before.
- "Casual" RideSharing
  - This is the opportunity of aTaxis
  - How much spatial and temporal aggregation is required to create significant casual ride-sharing opportunities.



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Elevator Analogy of an aTaxi Stand
Temporal Aggregation
Departure Delay: DD = 300 Seconds

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PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Elevator Analogy of an aTaxi Stand
60 seconds later

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PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Pixelating the State with half-mile Pixels

xPixel = *floor{108.907 * (longitude + 75.6)}*

yPixel = *floor{138.2 * (latitude – 38.9))*

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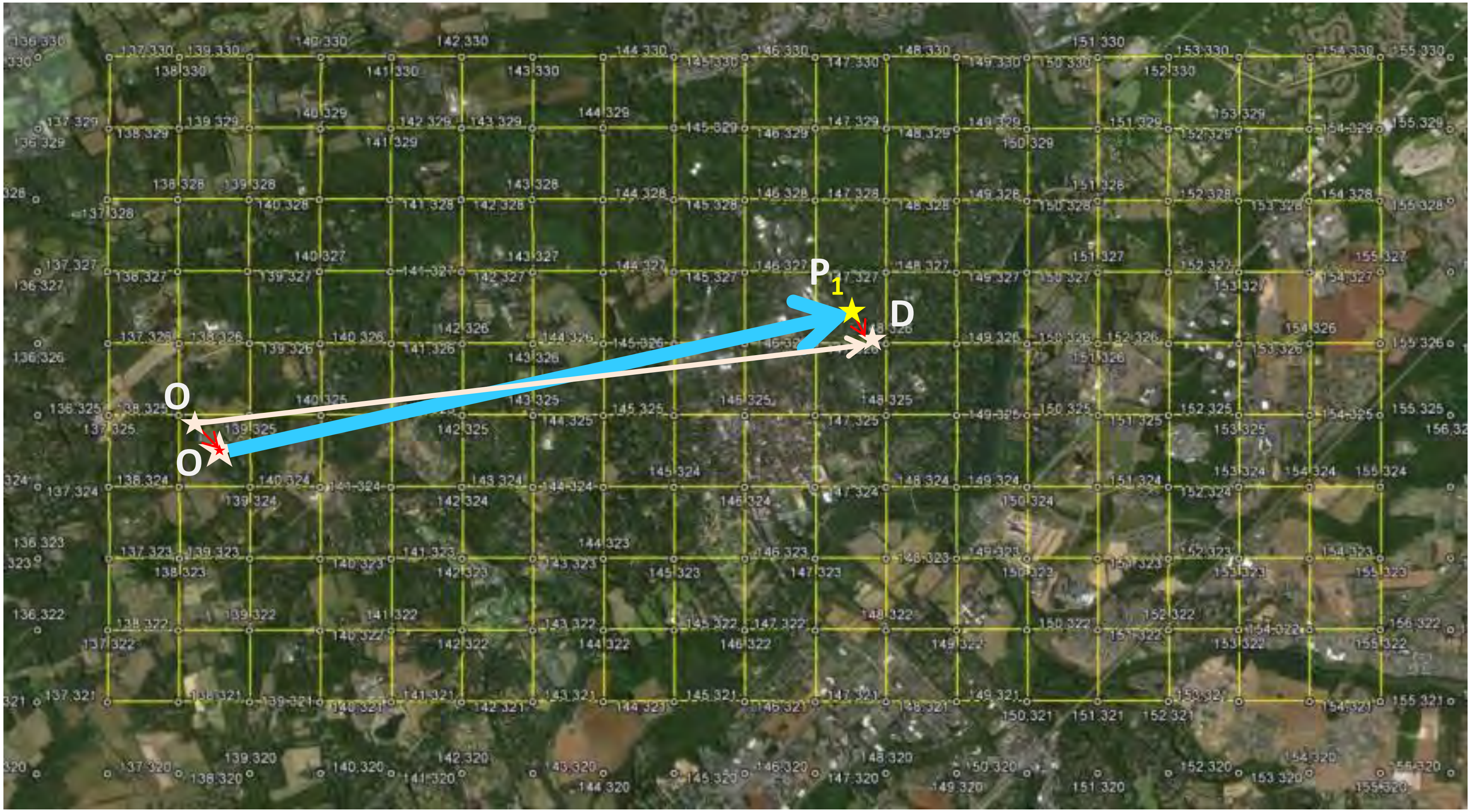
An aTaxiTrip

{oYpixel, oXpixel, oTime (Hr:Min:Sec) ,dYpixel, dXpixel, Exected: dTime}



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Common Destination (CD)
CD=1p: Pixel -> Pixel (p->p) Ride-sharing

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TripMiles = 3*L*

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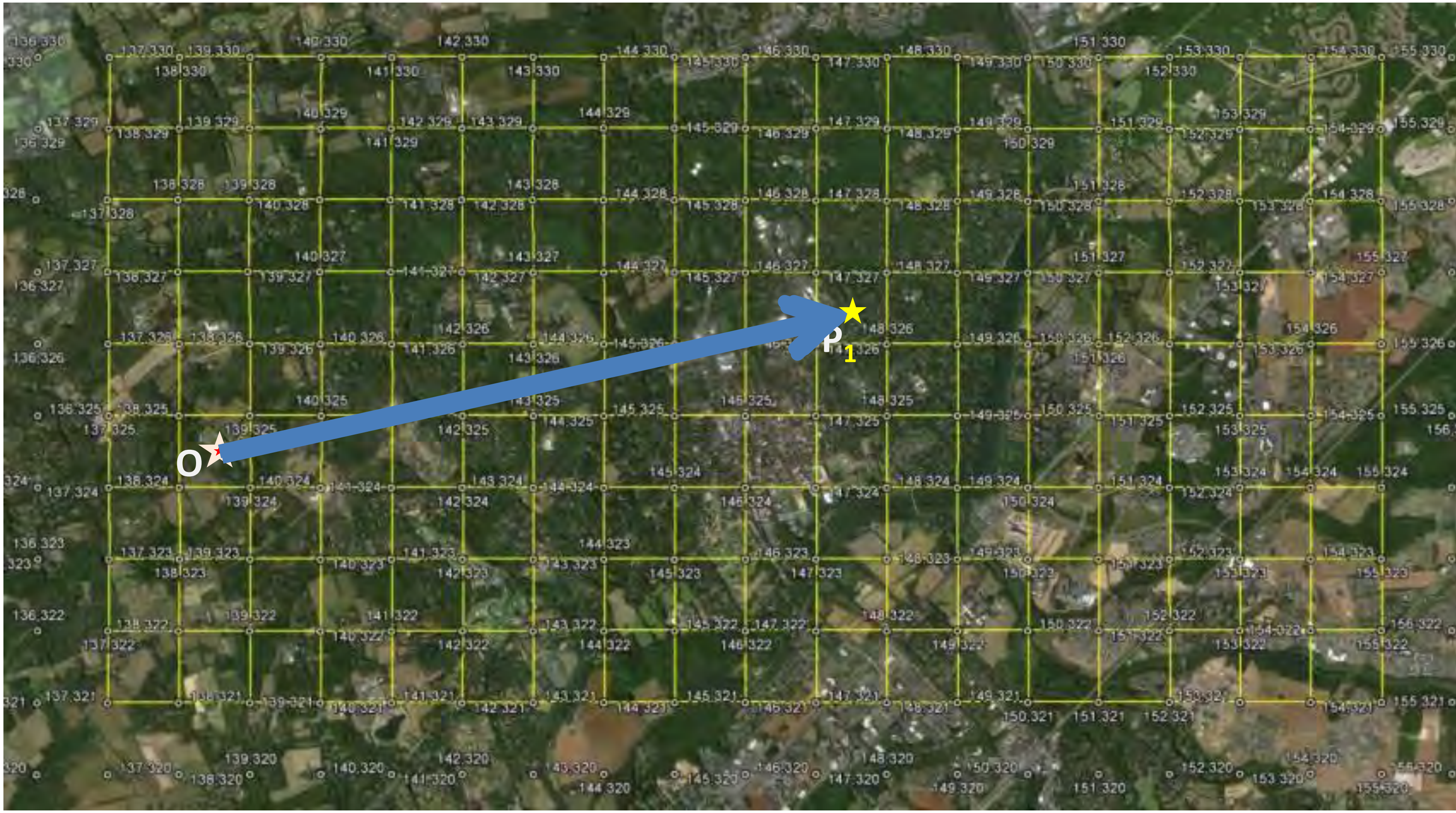
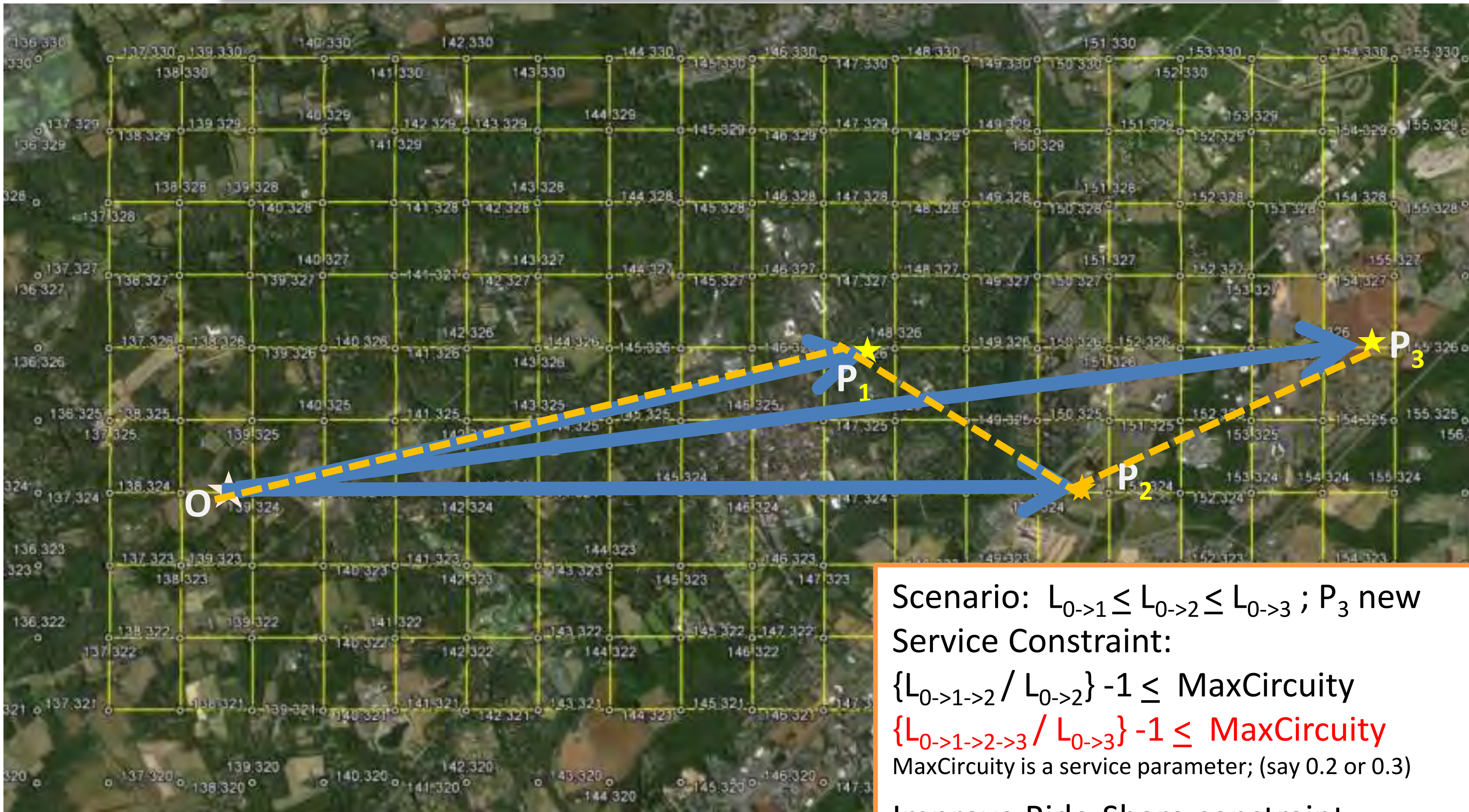


PersonMiles = 3L
aTaxiMiles = L
AVO = PersonMiles/aTaxiMiles = 3

CD= 3p: Pixel ->3Pixels Ride-sharing; P_3 New



Scenario: $L_{0\to1} \leq L_{0\to2} \leq L_{0\to3}$; P_3 new

Service Constraint:

$\{L_{0\to1\to2} / L_{0\to2}\} - 1 \leq$ MaxCircuity

$\{L_{0\to1\to2\to3} / L_{0\to3}\} - 1 \leq$ MaxCircuity

MaxCircuity is a service parameter; (say 0.2 or 0.3)

Improve Ride-Share constraint:

($AVO_{Rideshare\ 1,2} > AVO_{Alone}$)

$\{L_{0\to1} + L_{0\to2}\} > L_{0\to1\to2}$

($AVO_{Rideshare\ 1,2,3} > AVO_{Rideshare\ 1,2} + AVO_{3\ Alone}$);

$\{N_{0\to1} * L_{0\to1} + N_{0\to2} * L_{0\to2} + N_{0\to3} * L_{0\to3}\} / \{L_{0\to1\to2\to3}\}$

> $\{N_{0\to1} * L_{0\to1} + N_{0\to2} * L_{0\to2} + N_{0\to3} * L_{0\to3}\} / \{L_{0\to1\to2} + L_{0\to3}\}$

Numerators are identical; Therefore:

$\{L_{0\to1\to2} + L_{0\to3}\} > L_{0\to1\to2\to3}$

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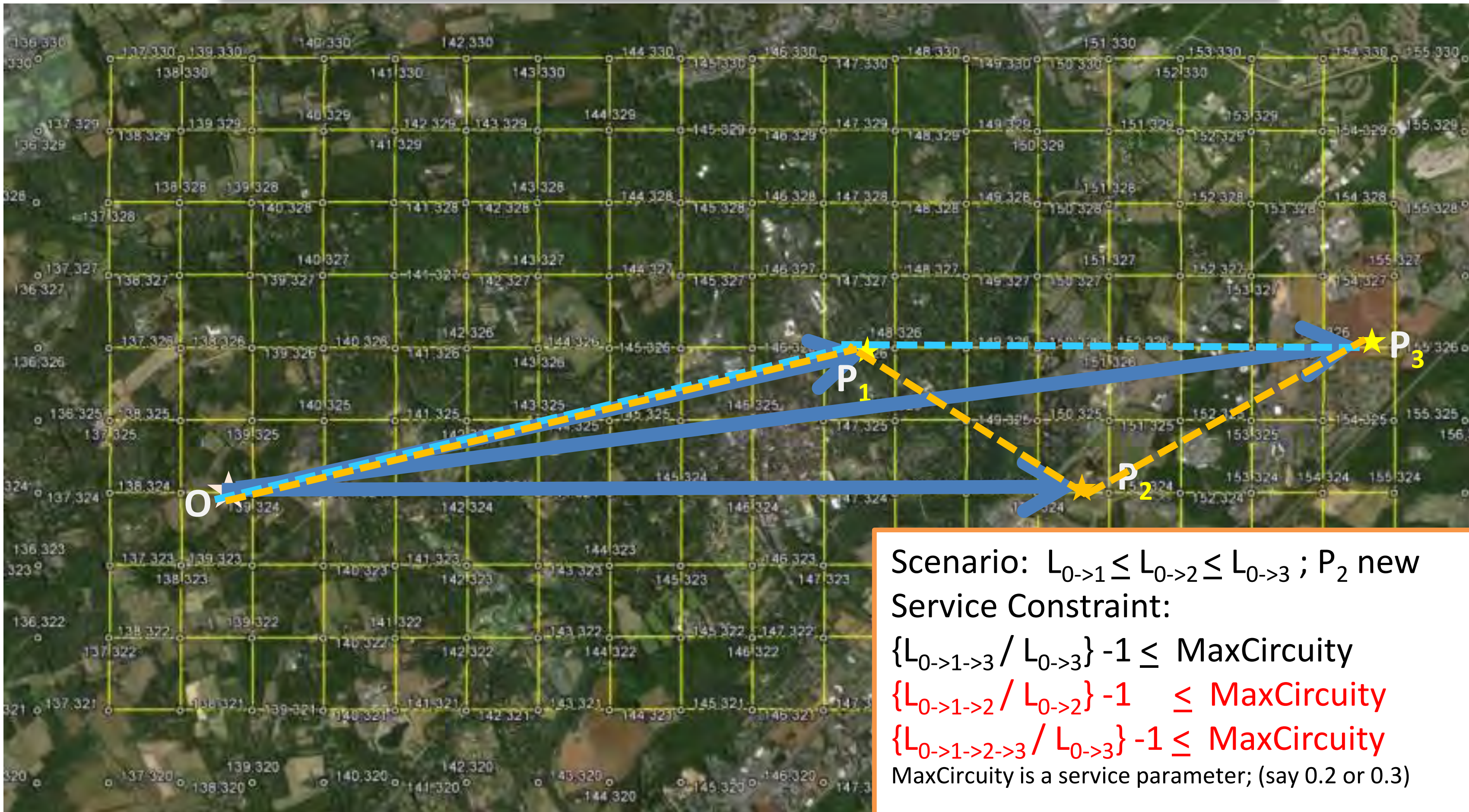
PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

CD= 3p: Pixel ->3Pixels Ride-sharing; P_2 New



Scenario: $L_{0\to1} \le L_{0\to2} \le L_{0\to3}$; P_2 new

Service Constraint:

$\{L_{0\to1\to3} / L_{0\to3}\} -1 \le$ MaxCircuity

$\{L_{0\to1\to2} / L_{0\to2}\} -1 \le$ MaxCircuity

$\{L_{0\to1\to2\to3} / L_{0\to3}\} -1 \le$ MaxCircuity

MaxCircuity is a service parameter; (say 0.2 or 0.3)

Improve Ride-Share constraint:

($AVO_{Rideshare\ 1,3} > AVO_{Alone}$)

$\{L_{0\to1} + L_{0\to3}\} > L_{0\to1\to3}$

($AVO_{Rideshare\ 1,2,3} > AVO_{Rideshare\ 1,3} + AVO_{2\ Alone}$);

$\{N_{0\to1} * L_{0\to1} + N_{0\to2} * L_{0\to2} + N_{0\to3} * L_{0\to3}\} / \{L_{0\to1\to2\to3}\}$

$> \{N_{0\to1} * L_{0\to1} + N_{0\to2} * L_{0\to2} + N_{0\to3} * L_{0\to3}\} / \{L_{0\to1\to3} + L_{0\to2}\}$

Numerators are identical; Therefore:

$\{L_{0\to1\to3} + L_{0\to2}\} > L_{0\to1\to2\to3}$

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NJ Transit Train Station "Consumer-shed"

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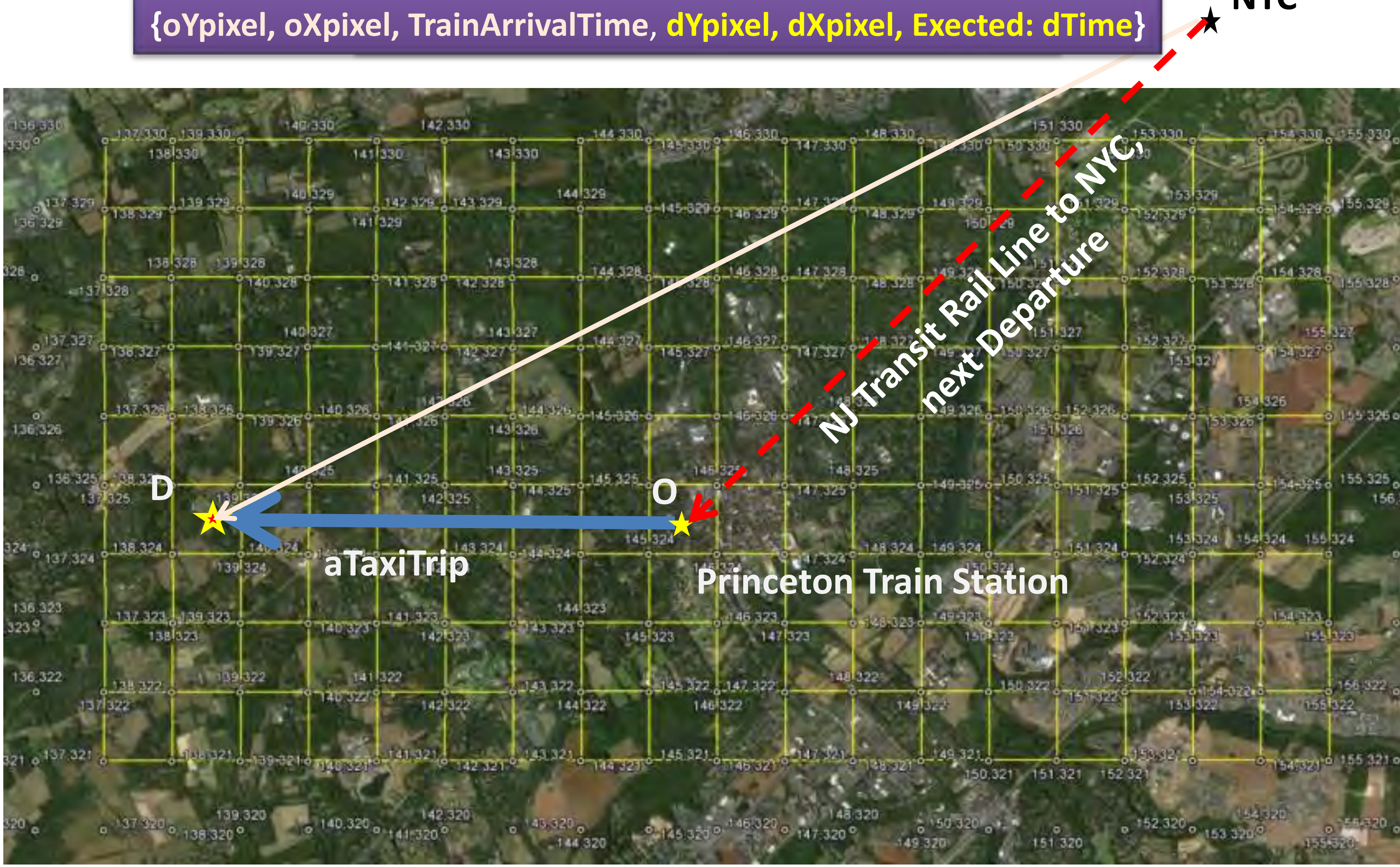
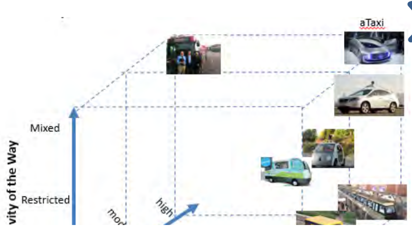
An aTaxiTrip

{oYpixel, oXpixel, TrainArrivalTime, dYpixel, dXpixel, Exected: dTime}





"Last Mile" Impact on NJ Transit Rail

Train Statistics	
Total Train Trips	1,513,339
Train Passenger Miles	24.37 million mi.
Average Train Trip Length	16.12 mi.

Table 1: Train Network

(Today: 281,576, +537% !)

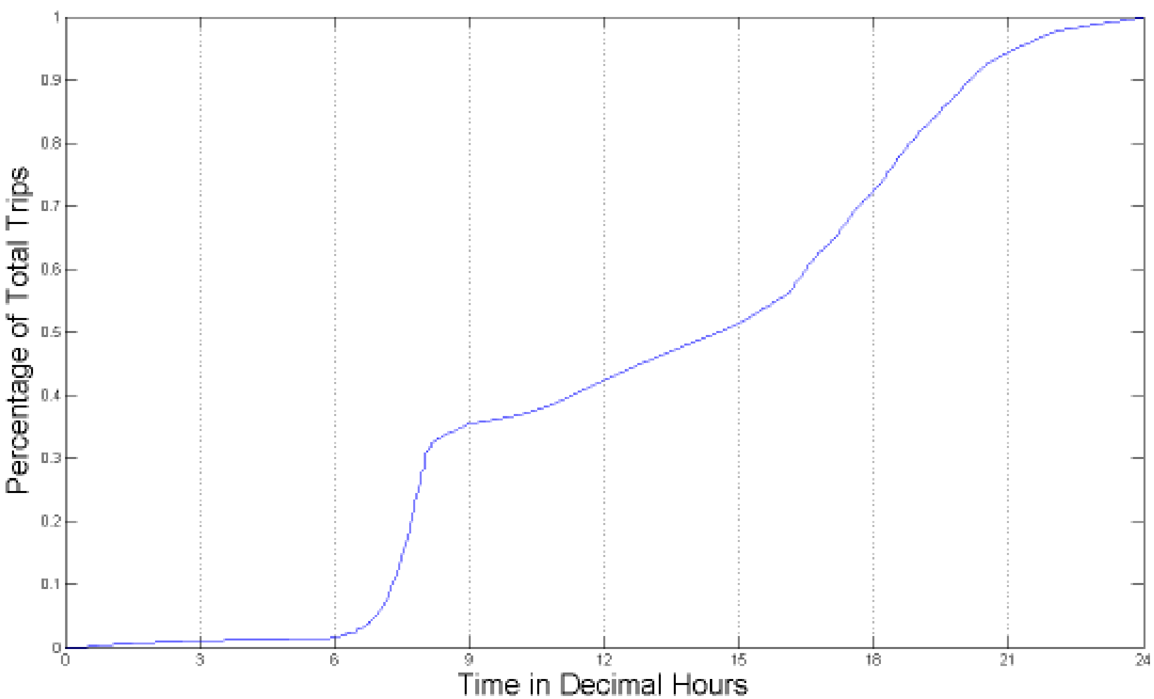
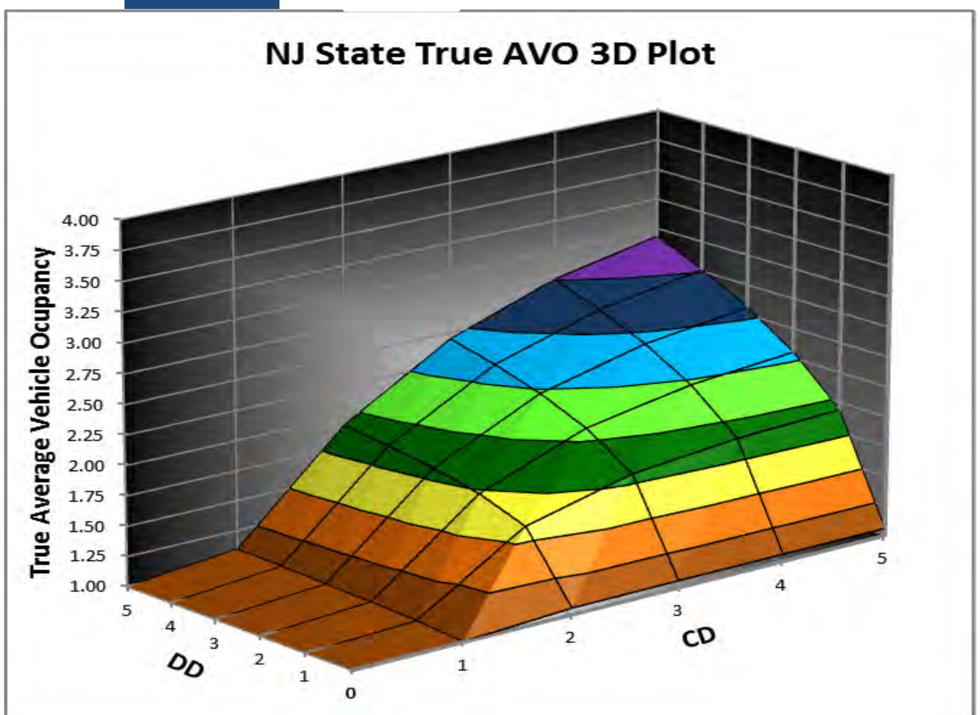


Figure 7: Geographic Spread of Passenger Volume of Train Trips

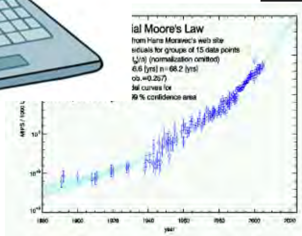
Results

New Jersey - True Average Vehicle Occupancy

	CD = 0	CD = 1	CD = 2	CD = 3	CD = 4	CD = 5
DD = 0		1.00	1.05	1.06	1.06	1.06
DD = 1		1.04	1.59	1.81	1.90	1.94
DD = 2		1.06	1.73	2.07	2.23	2.30
DD = 3		1.07	1.82	2.23	2.45	2.56
DD = 4		1.08	1.88	2.35	2.62	2.76
DD = 5		1.10	1.92	2.45	2.76	2.93



Fundamentals of Level 4 Driverless



$$\Rightarrow \quad \$_{new} = \frac{\$_{now}}{8}$$

$$\Rightarrow \quad \$_{Capital} = \text{ZERO!}$$

$\Rightarrow$

 $_{new} =$  $_{now}$ / AVO

$_{new} =$

$_{now}$ / AVO

$$\$_{new} = \frac{\$_{now}}{8 \times AVO}$$

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Discussion!

Thank You

alaink@princeton.edu

www.SmartDrivingCar.com

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Near-Term Implications

- Implications of "today's" with Level 2/3:
  - **Increase demand for use of bridges and tunnels in line with increased VMT induced by AV technology.**
  - **Fewer accidents on/in the bridges and tunnels.**
- Above achieved proportional to the adoption rate of the technology.

Near-Term Opportunities

What about increasing Trans-Hudson Mobility?

What are the Bottlenecks in Trans-Hudson Mobility

- Automobiles
  - Forget about it
- Rail
  - The Amtrak Tunnels
  - Few stations
- Buses
  - PABT
  - 495 viaduct
  - Lincoln Tunnel

Near-Term Opportunities

- Retrofit The Trans-Hudson Commuter Bus Fleet with Today's Level 2/3 Automation.
  - **Not new... Originally proposed it over 20 years ago..**

Received: by soil.Princeton.EDU (5.57/1.115) id AA11336; Tue, 10 Oct 95 12:50:27 -
Operational Test of AHS
Applied to a High-Capacity Transit Corridor,
The Lincoln Tunnel XBL.

Professor Alain Kornhauser
Princeton University
Professor Lou Pignataro
NJIT
Executive Summary
Background
It is proposed that AHS technology be applied to further increase the safety, service reliability and capacity of the exclusive bus lane (XBL) leading from the New Jersey Turnpike to the 42nd Street Bus Terminal in Manhattan. The XBL has enjoyed an almost

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Near-term opportunity:

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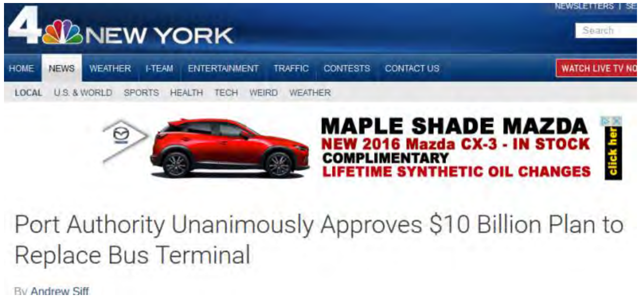

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- **Application of Existing Automated Collision Avoidance Systems (Which include: Lane Keeping & Intelligent Cruise Control)**
  - **(What exists today in Mercedes, Volvo & Tesla)**
- **To the 3,000 buses that currently use the XBL today**
  - **3,000 x $10,000 = $30M (0.3% of $10B)**
- **Could increase the capacity of the XBL by more than 50%**
  - **From 700 to +1,050 buses/hr**
  - **adding +20,000 commuters/hr**
    - **High-quality (fast/comfortable) Trans-Hudson Mobility**
    - **Increases TransHudson PeakHour capacity by 15-20%;**
    - **about = capacity of new rail tunnel**
- **But ONLY if the $10B spent on the new terminal is designed to accommodate this +50% increase in throughput.**

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Potential Increased Capacity of Exclusive Bus Lane (XBL) Using Cooperative Adaptive Cruise Control (CACC)

(Assumes 45 foot (13.7 m) buses @ with 57 seats)

Average Interval Between Buses (seconds)	Average Spacing Between Buses (ft)	Average Spacing Between Buses (m)	Buses Per Hour	Additional Buses per Hour	Seated Passengers Per Hour	Increase in Seated Passengers per Hour
1	6	2	3,600	2,880	205,200	164,160
2	47	14	1,800	1,080	102,600	61,560
3	109	33	1,200	480	68,400	27,360
4	150	46	900	180	51,300	10,260
5 (Base)	212	64	720	-	41,040	-

Longer-Term Implications

Implications of Level 4/Driverless

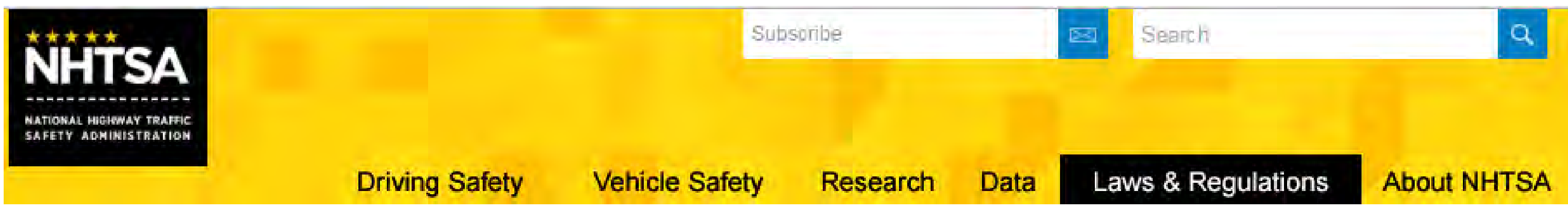
Longer-Term Implications

Implications of Level 4/Driverless

- Level 4 is a Fleet-Play
  - autonomousTaxis (aTaxis) provide shared-ride on-demand mobility to all. ((Horizontal) Elevator Analogy)
  - Higher PMT but Shared-ride -> Lower Peak-hour VMT
    - Lower Tunnel & Bridge volumes
    - Disappearance of airport car rental business
    - Disappearance of airport parking
      - Must be beginning to see this with Uber/Lyft

But you say…

- Alain… Safety doesn't Sell!   Look…
  - Few drive Volvos,
  - Public-sector **Mandates and Threatens** :



Up until now we have focused on **crash mitigation**
(This saves **lives** ☺ , but
hasn't reduced **costs** ☹)

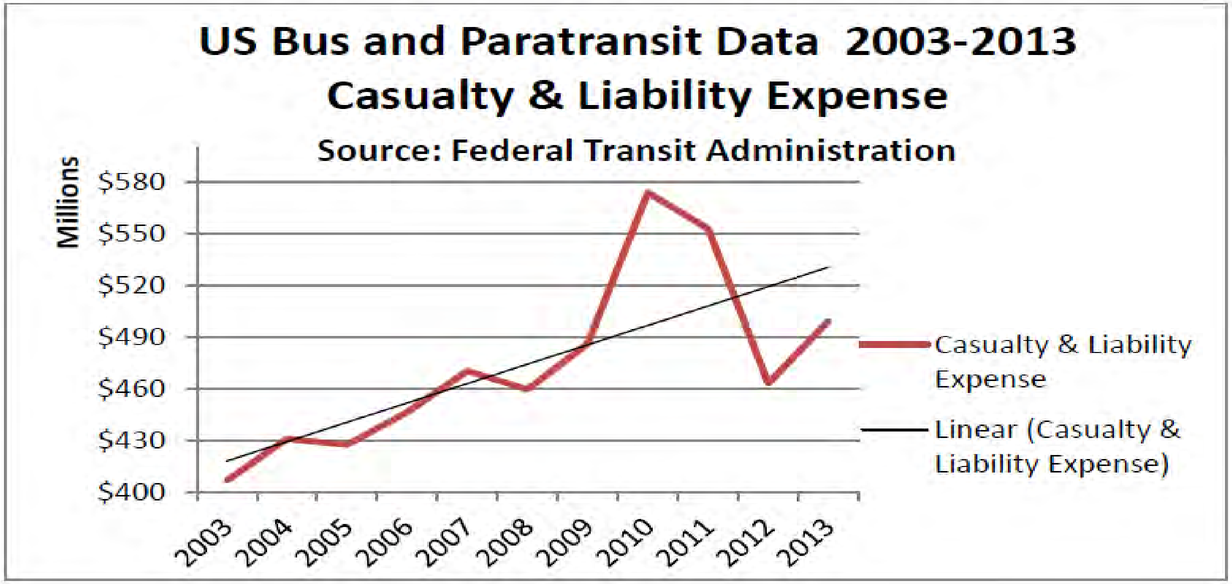
Past

- There seems to be a new realization…

a) What started out in "1939" as Automated Highways

Present: Safety is an Issue!

- NHTSA: Car Crashes cost US $871B/yr (~ $2,800/person 5/29/14)
- Buses:

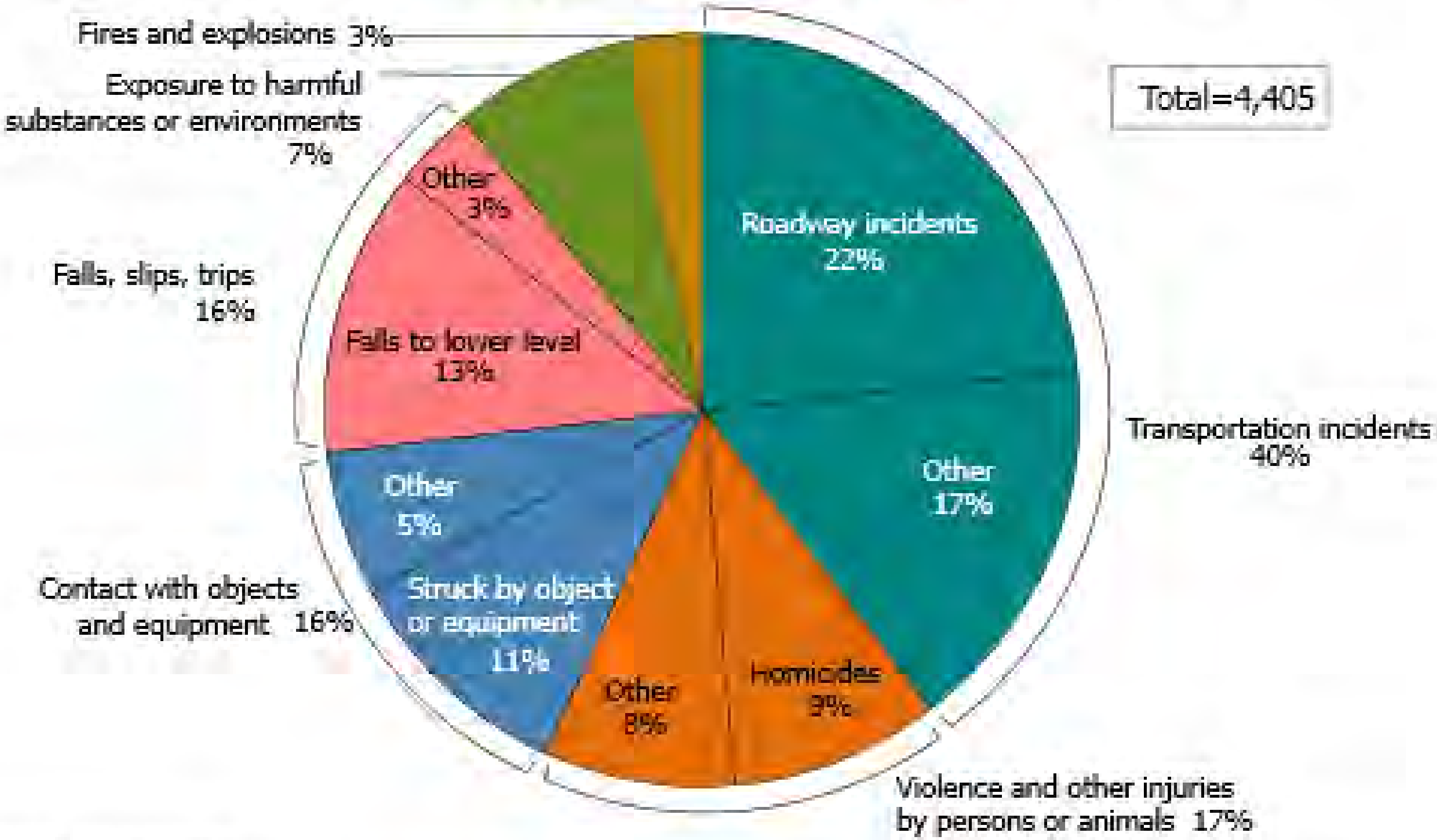


More Viable Future: For Example

Driving a Bus is NOT Simple and Very Stressful

- Requires Continuous Diligence
  - 2 bus drivers in NYC arrested for striking a pedestrian while simply trying to do their job
- Driving is one of the most dangerous occupation

Chart 1. Fatal occupational injuries, by major event, 2013*



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Source: U.S. Bureau of Labor Statistics, U.S. Department of Labor, 2014.

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Chart 2. Number and rate of fatal occupational injuries, by industry sector, 2013*

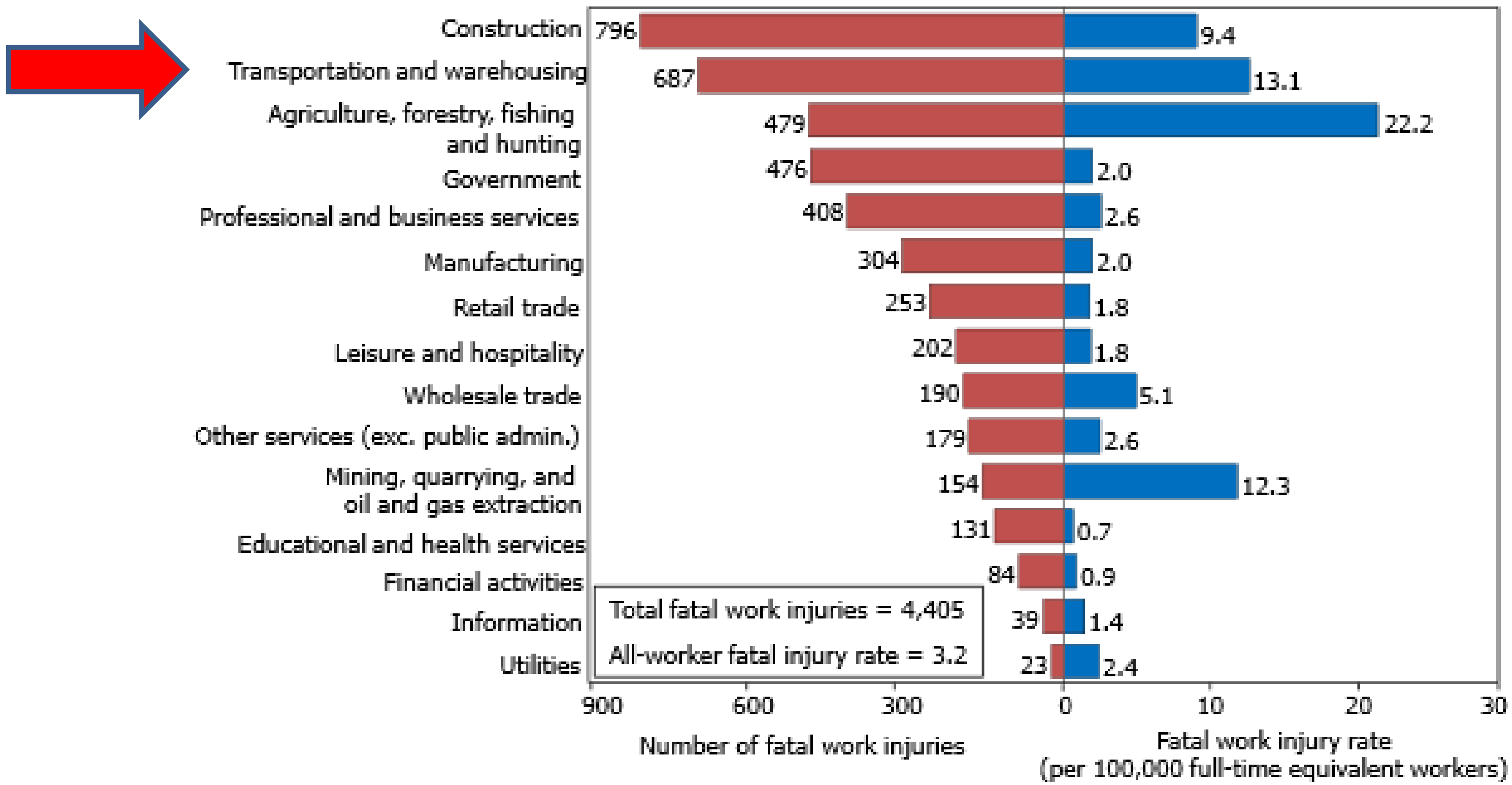

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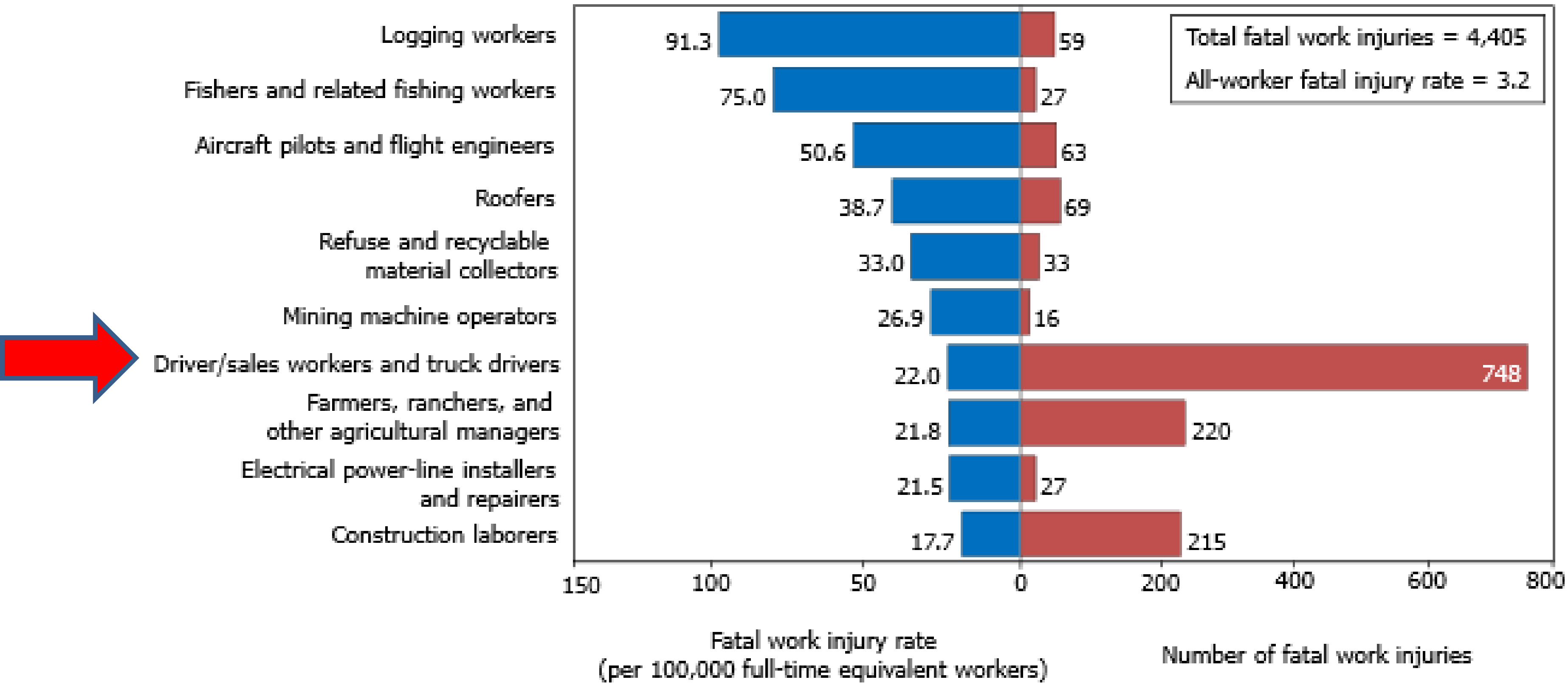
Chart 3. Occupations with high fatal work injury rates, 2013*



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Near-Term Transit Opportunity:
Automated Collision Avoidance

The Political Case

Driving a Bus is NOT Simple and Very Stressful

- Requires Continuous Diligence
  - 2 bus drivers in NYC arrested for striking a pedestrian while simply trying to do their job
- Driving is one of the most dangerous occupation
- **Drivers need help and ACA systems are available to help!**
- **Transit Unions & OSHA need to be demanding deployment of ACAS on all buses!**

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Near-Term Transit Opportunity:

Automated Collision Avoidance

The Business Case

Bus Collisions are Expensive!

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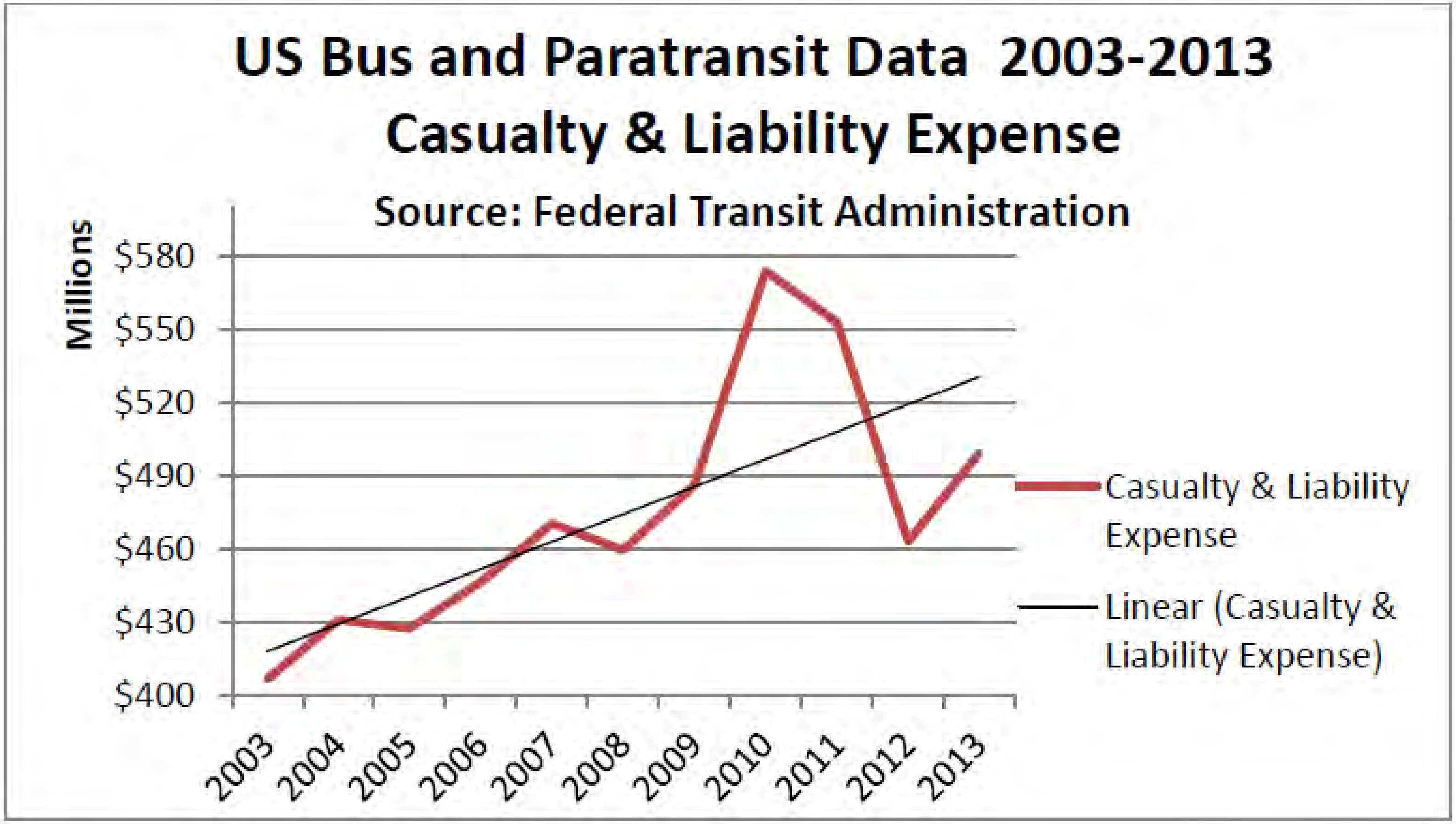
Near-Term Transit Opportunity: Automated Collision Avoidance

The Business Case



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The Trend is NOT Good!

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Near-Term Transit Opportunity:

Automated Collision Avoidance

The Business Case

2013 Nationwide Bus Casualty and Liability Expense Source FTA NTD		
Casualty and Liability Amount	Vehicle-related	119 Fatalities 15,351 Injuries

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Near-Term Transit Opportunity:
Automated Collision Avoidance

The Business Case

Bus Collisions are Expensive!

In the next five days the bus transit industry will spend $6.8 million in casualty and liability expenses

Munich RE

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Near-Term Transit Opportunity: Automated Collision Avoidance

The Business Case

Bus Collisions are Expensive!

Fundamental Business Model

We are near a point where:

Cost of Automated Collision Avoidance Technology

<

Present Value {Expected Liability Savings over life of bus}

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Near-Term Transit Opportunity: Automated Collision Avoidance

The Business Case

Bus Collisions are Expensive!

Business Case for Collision Avoidance Technology Based on 2013 average of $6,187 in casualty & liability expenses per bus					
Example Equipment Price Point	Percent Claims Reduction Achieved				
	10%	20%	30%	40%	50%
$3,000					
$5,000					
$10,000					

Near-Term Transit Opportunity: Automated Collision Avoidance

The Business Case

Bus Collisions are Expensive!

Business Case for Collision Avoidance Technology Based on 2013 average of $6,187 in casualty & liability expenses per bus					
Example Equipment Price Point	Percent Claims Reduction Achieved				
	10%	20%	30%	40%	50%
	Years to Recover Installation Expense Through Claims Reduction				
$3,000	4.8	2.4	1.6	1.2	1.0
$5,000	8.0	4.0	2.7	2.0	1.6
$10,000	16.2	8.1	5.4	4.0	3.2

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Near-Term Transit Opportunity: Automated Collision Avoidance

The Business Case

Bus Collisions are Expensive!

Plus:

Lives Saved,

Injuries Avoided,

Disruptions Averted, and

Arrests not Made

All for Free!!!

Munich RE

PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Past

- There seems to be a new realization…

a) What started out in "1939" as Automated Highways

Present

- The Sensors, Actuators and Algorithms are on the verge of being able to
  - Drive as well as the best of us
    - without needing any infrastructure improvements
      - in enough places
      - at enough times
  - to make a substantial difference in Safety.

Future

- **Evolve** the ***Sensors, Actuators and Algorithms*** to
  - be **Cheaper** & Drive **Better** than the best of us
    - without needing any infrastructure improvements
      - in **More** places
      - at **More** times
  - While continuing to improve Safety, AND
    - Revolutionize **Mobility for All**
    - Substantially Reduce
      - **Energy Consumption**
      - **Pollution, and**
      - **Green House Gases (GHG)**

Fundamentally Strong Business Case!

Discussion!

Thank You

alaink@princeton.edu

www.SmartDrivingCar.com

Does Anyone Doubt that AVs areComing?

Press Release on Feb 16, 2016:

NATIONAL SAFETY COUNCIL ®

NSC Motor Vehicle Fatality Estimates

Prepared by the Statistics Department
National Safety Council

Motor-vehicle deaths up 8% in 2015.

With continued lower gasoline prices and an improving economy resulting in an estimated 3.5% increase in motor-vehicle mileage, the number of motor-vehicle deaths in 2015 totaled 38,300, up 8% from 2014. The 2015 estimate is provisional and may be revised when more data are

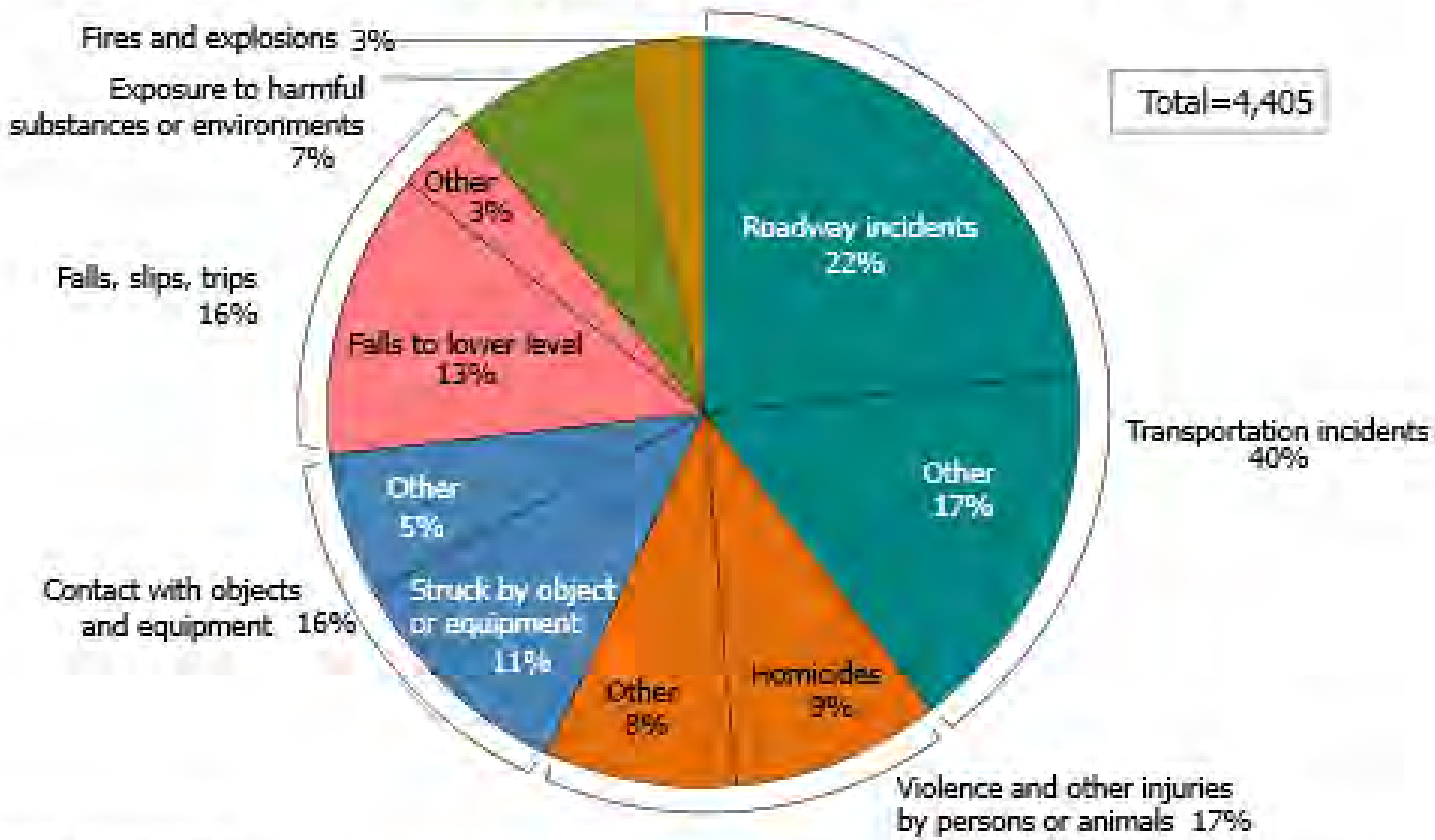
http://www.nsc.org/NewsDocuments/2016/mv-fatality-report-1215.pdf

A Few Realizations about... **Safety**

- Deaths/yr.: ~ **35K** US; ~**1.25M** World
- Leading cause of death for ages of **5 -> 35**
- One of the most dangerous occupations
  - Worse than coal mining
- NHTSA: Car Crashes cost US **$871B/yr** (~ **$2,800/person** 5/29/14)
  - (**$2.8K/person**); 1/3 Cash
- Liability expenses 2013 (Transit Buses, US) $500M/yr.
  - $6,300/bus/yr (120 fatalities/yr)
- > **90%** involve Human error
- The Bad news (Safety Council's Press release): **Things are getting worse!**

Driving is NOT Simple and VERY Stressful

Chart 1. Fatal occupational injuries, by major event, 2013*



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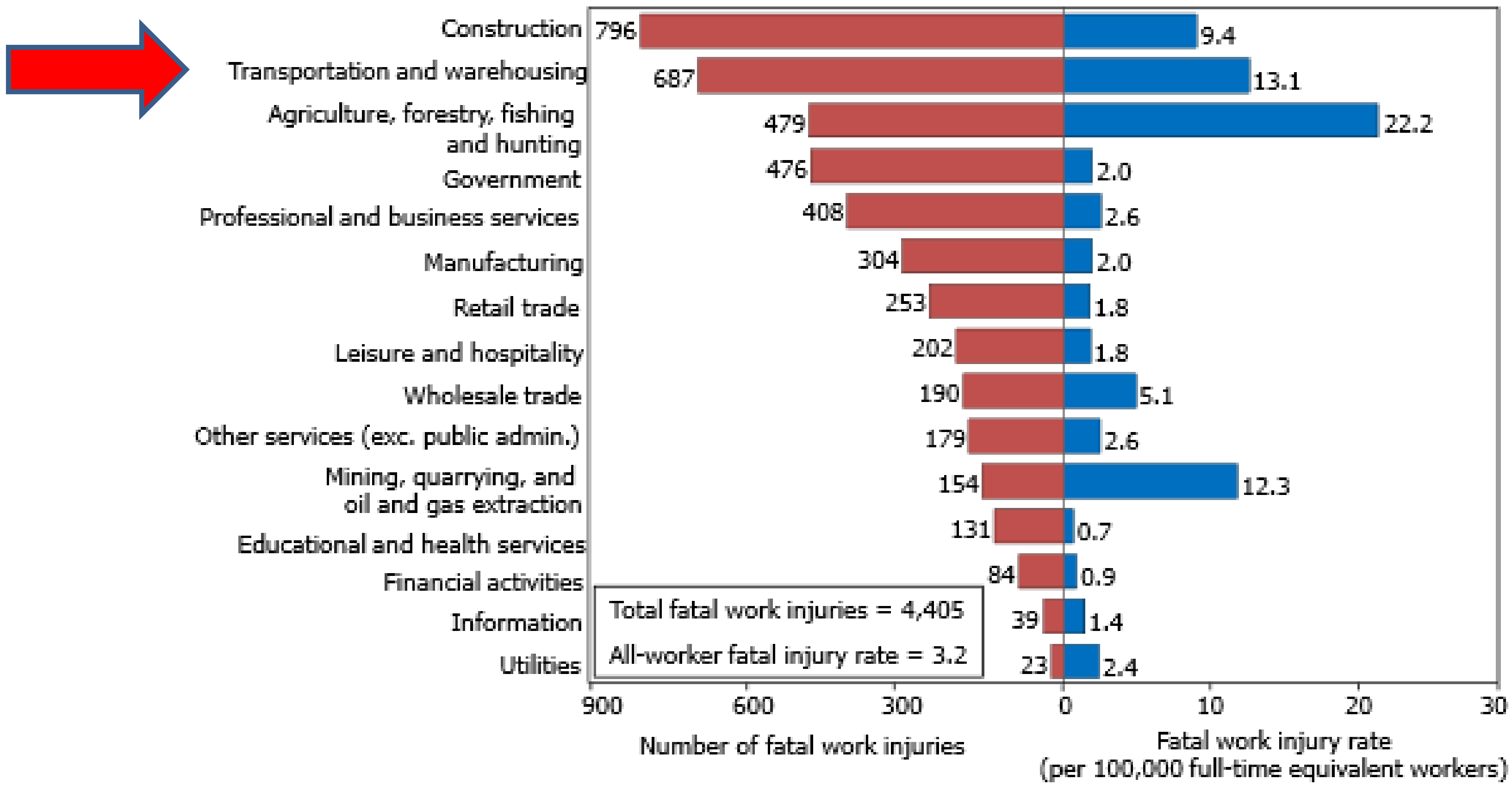

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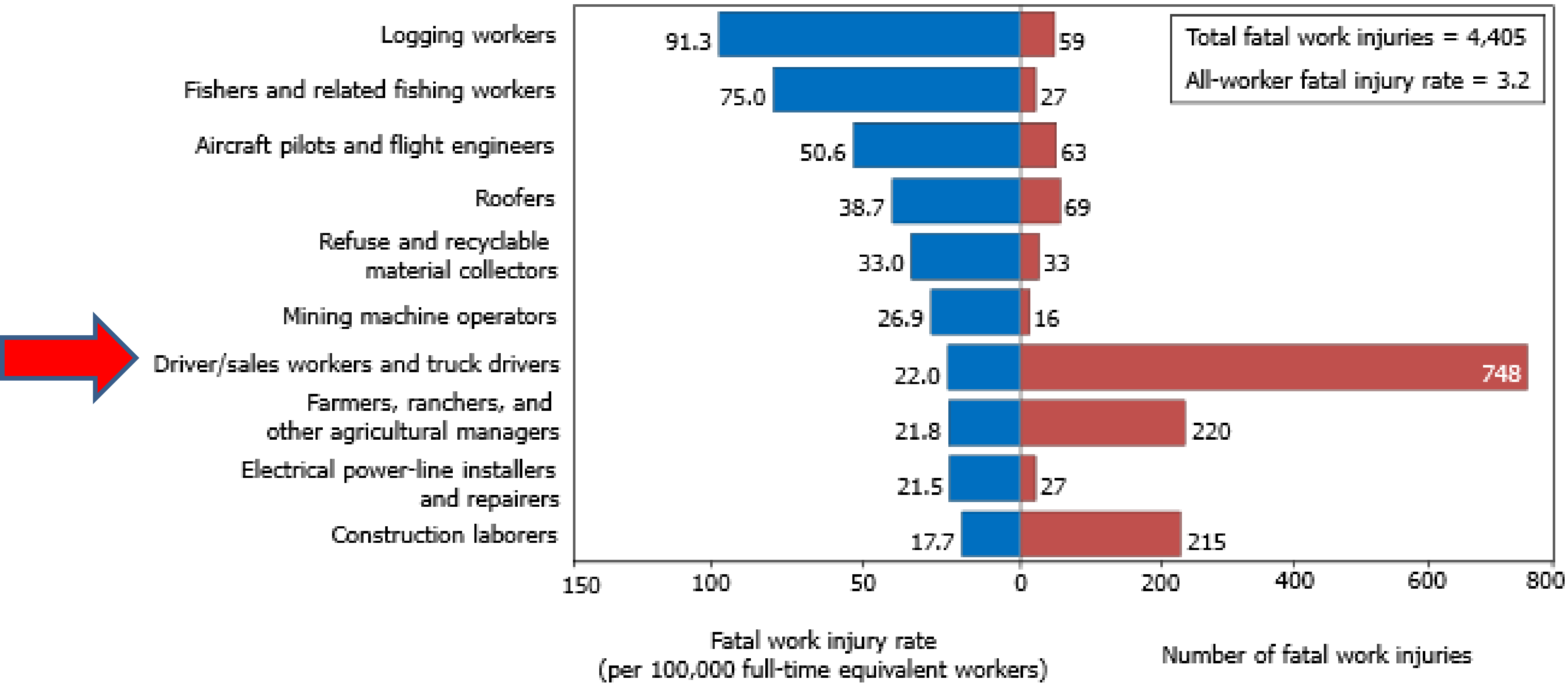

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Source: U.S. Bureau of Labor Statistics, U.S. Department of Labor, 2014.

Driving a School Bus is NOT Simple and VERY Stressful

U.S. Department of Transportation
National Highway Traffic Safety Administration

NHTSA
www.nhtsa.gov

TRAFFIC SAFETY FACTS
2003–2012 Data

DOT HS 811 890 Revised June 2014

School-Transportation-Related Crashes

http://orfe.princeton.edu/~alaink/SmartDrivingCars/PDFs/2013NHTSASchoolCrashes.pdf

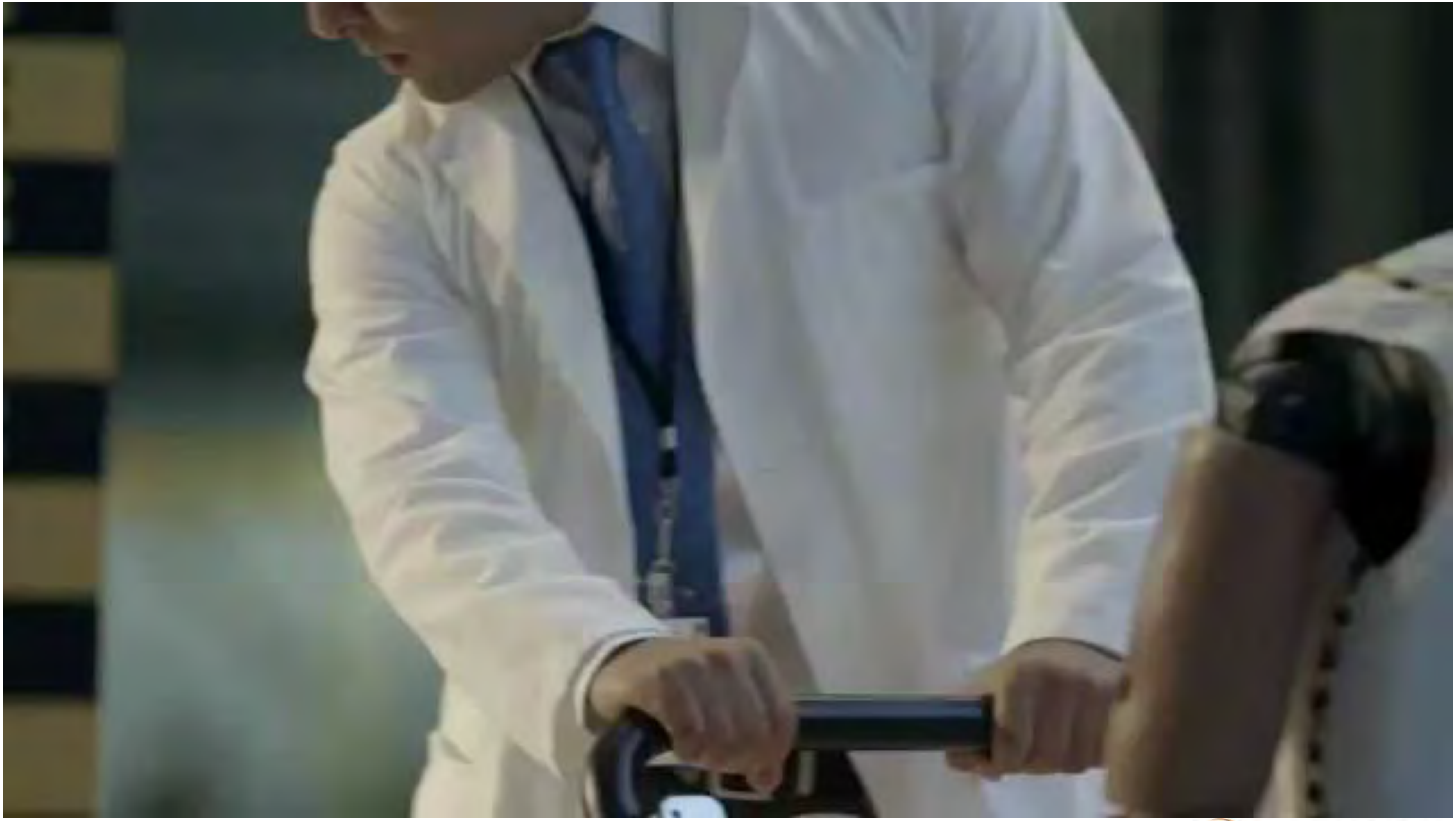
Since 2003, there have been 1,353 people killed in school-transportation-related crashes—an average of 135 fatalities per year. Occupants of school transportation vehicles accounted for 8 percent of the fatalities, and nonoccupants (pedestrians, bicyclists, etc.) accounted for 21 percent of the fatalities.

From 2003 to 2012, seventy percent of the school-age pedestrians fatally injured in crashes were struck by school buses or vehicles functioning as school buses, while

How Do AVs Address the Safety Challenge ?

http://orfe.princeton.edu/~alaink/SmartDrivingCars/Videos/Subaru%20EyeSight_Commercial60secCrashTest.mp4

Fundamental AV Concept



https://www.youtube.com/watch?v=yARbNYcjPQM

Fundamental AV Concept

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http://www.youtube.com/watch?v=dWj44GjrSs0

Fundamental AV Concept

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Why AVs are Inevitable…

- One only needs to get the Automated Vehicles technology to "**work**" on a "single" vehicle to initiate **viral adoption**!
  - Definition of "**work**":

Cost of the Technology

<

Net Present Value { Expected Liability Savings $_{\text{delivered by that technology}}$**}**

- Since the technology
  - Does **NOT** require any infrastructure costs
  - Involves mostly "Moore's Law Elements
- The inequality will be achieved and
  - **Insurance** will fuel the viral adoption.

What is a SmartDrivingCar?

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What are Automated Vehicles?

NHTSA NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Preliminary Statement of Policy Concerning Automated Vehicles

SmartDrivingCars & Trucks

Level 0 (No automation)

The human is in complete and sole control of safety-critical functions (brake, throttle, steering) at all times.

Level 1 (Function-specific automation)

The human has complete authority, but cedes limited control of certain functions to the vehicle in certain normal driving or crash imminent situations. Example: electronic stability control

Level 2 (Combined function automation)

Automation of at least two control functions designed to work in harmony (e.g., adaptive cruise control and lane centering) in certain driving situations.

Enables hands-off-wheel and foot-off-pedal operation.

Driver still responsible for monitoring and safe operation and expected to be available at all times to resume control of the vehicle. Example: adaptive cruise control in conjunction with lane centering

Level 3 (Limited self-driving)

Vehicle controls all safety functions under certain traffic and environmental conditions.

Human can cede monitoring authority to vehicle, which must alert driver if conditions require transition to driver control.

Driver expected to be available for occasional control. Example: Google car

Level 4 (Full self-driving automation)

Vehicle controls all safety functions and monitors conditions for the entire trip.

The human provides destination or navigation input but is not expected to be available for control during the trip. ***Vehicle may operate while unoccupied***. Responsibility for safe operation rests solely on the automated system

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What are Automated Vehicles?

Preliminary Statement of Policy Concerning Automated Vehicles

Level	Insurance Implications	Value Proposition (driver/buyer)	Market Force (who/what)	Societal Implications

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What are Automated Vehicles?

PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Preliminary Statement of Policy Concerning Automated Vehicles

Level	Insurance Implications	Value Proposition (driver/buyer)	Market Force (who/what)	Societal Implications
0 "55 Chevy"		Freedom Life Style	Market Dominance (Madison Avenue)	Death trap

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What are Automated Vehicles?

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Preliminary Statement of Policy Concerning Automated Vehicles

Level	Insurance Implications	Value Proposition (driver/buyer)	Market Force (who/what)	Societal Implications
0 "55 Chevy"	Many Accidents, High Claims	Freedom Life Style	Market Dominance (Madison Avenue)	Death trap
0+ "Crash Mitigation" (air bags, seat belts, energy absorbing)		**Disdain**	**Public sector; Law enforcement**	**Fewer deaths**

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1 "1st generation automated systems" : (Cruise Control & Anti-lock Brakes)		**Some Comfort**	**Public sector**	**Slightly fewer accidents**

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What are Automated Vehicles?

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1 "1st generation automated systems" : (Cruise Control & Anti-lock Brakes)	Slightly reduced claims	Some Comfort	Public sector	Slightly fewer accidents
2 Attentive Automated Driving: (Collision Avoidance & Lane Centering)		**More Comfort**	**Will need help from "Flo & the Gecko"** (Insurance incentivizes adoption)	**"50%" fewer accidents; less severity->**

TRANSPORTATION TRANSFORMED: ADVANCING ECO-FRIENDLY MOBILITY

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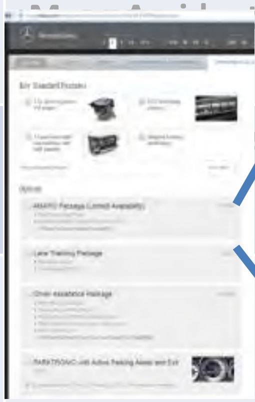
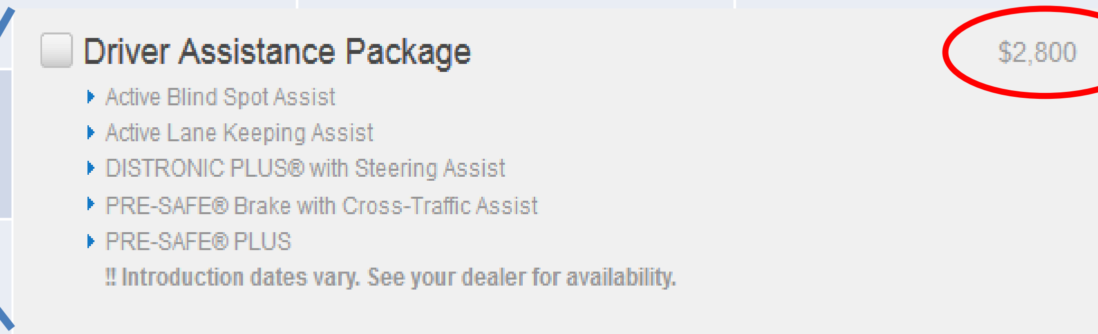
PAVE PRINCETON AUTONOMOUS VEHICLE ENGINEERING

Preliminary Statement of Policy Concerning Automated Vehicles

Level	Insurance Implications	Value Proposition (driver/buyer)	Market Force (who/what)	Societal Implications
0 "55 Chevy"	Many Accidents, High Claims	Freedom Life Style	Market Dominance (Madison Avenue)	Death trap
0+ "Crash Mitigation" (air bags, seat belts, energy absorbing)	Many Accidents,	Disdain	Public sector;	Fewer deaths
1 "1st generation automated systems" : (Cruise Control & Anti-lock Brakes)		...ed		...ts
2 Attentive **Automated Driving:** (Collision Avoidance & Lane Centering)			... incentivizes adoption)	...s;





TRANSPORTATION TRANSFORMED: ADVANCING ECO-FRIENDLY MOBILITY

CARTS The Center for Automated Road Transportation Safety

Princeton University

What is a SmartDrivingCar?

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0+ "Crash Mitigation" (air bags, seat belts, energy absorbing)	Many Accidents, High Claims	Disdain	Public sector; Law enforcement	Fewer deaths
1 "1st generation automated systems" : (Cruise Control & Anti-lock Brakes)	Slightly reduced claims	Some Comfort	Public sector	Slightly fewer accidents
2 Attentive Automated Driving: (Collision Avoidance & Lane Centering)	50% less $ liability; ++ profits	More Comfort	Will need help from "Flo & the Gecko" (Insurance incentivizes adoption)	"50%" fewer accidents; less severity->
3 Un-Attentive Automated Driving : "Texting Machine" (Collision Avoidance, Lane Changing & Centering, Intersection Control)		**Liberation (some of the time/places) ; more Safety**	**Consumers Pull, TravelTainment Industry Push**	**++ Car sales, -- insurance claims, + VMT**

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2 Attentive Auto… Driving: (Collision Avoi… Centering)			W… &	;
3 Un-Attentive A… Driving : “Texting Machine” (Collision Avoidance, Lane Changing & Centering, Intersection Control)	(~Product liability) ++ profits	; more Safety	Tr… Push	+ VMT
4 Driverless: “aTaxi “ Able to		Chauffeured, Mobility Bought “by the Drink” rather than “by the Bottle”	Profitable Business Opportunity for Utilities/Transit Companies	Personal Car = “Bling” not instrument of personal mobility, Comm. Design ++; PMT ?; VMT - -, Energy - -, Congestion - -, Environment ++

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Can Anything be Done?

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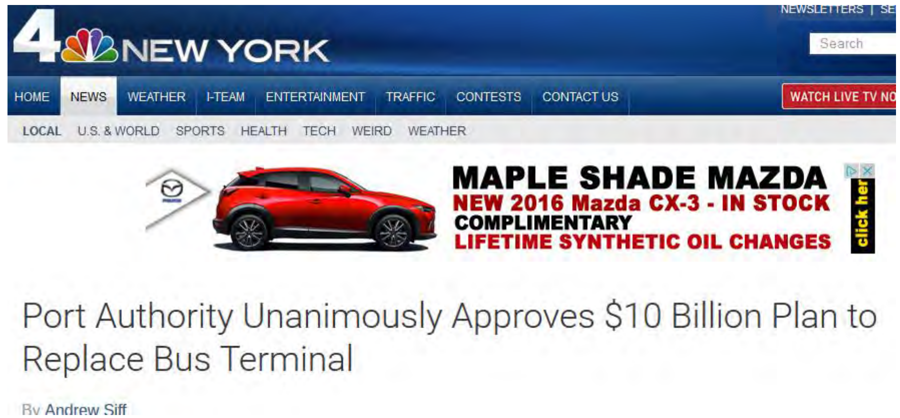

Received: by soil.Princeton.EDU (5.57/1.115) id AA11336; Tue, 10 Oct 95 12:50:27 -
Operational Test of AHS
Applied to a High-Capacity Transit Corridor,
The Lincoln Tunnel XBL.

Professor Alain Kornhauser
Princeton University
Professor Lou Pignataro
NJIT
Executive Summary
Background
It is proposed that AHS technology be applied to further increase the safety, service reliability and capacity of the exclusive bus lane (XBL) leading from the New Jersey Turnpike to the 42nd Street Bus Terminal in Manhattan. The XBL has enjoyed an almost

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Increasing Bus Capacity To Mid-town Manhattan Would Involve Three Elements:

- **Increasing the capacity of the PABT, particularly to accommodate outbound passengers in the PM peak***
- **Increasing the capacity to feed buses into the terminal for PM outbound service, either by making bus storage space available in Manhattan or by expediting the PM eastbound flow of buses through the Lincoln Tunnel.**
- **Increasing the AM peak hour flow of buses through the XBL**

***currently under study**

What are the Bottlenecks in Trans-Hudson Mobility

- **Implications:**
  - **Action:**
    1. **PANYNJ Must Seriously Consider** the role of ACAS-equipped buses in the design and operation of the new bus terminal. (This is the dog, not the tail)

Potential Increased Capacity of Exclusive Bus Lane (XBL) Using Cooperative Adaptive Cruise Control (CACC)

(Assumes 45 foot (13.7 m) buses @ with 57 seats)

Average Interval Between Buses (seconds)	Average Spacing Between Buses (ft)	Average Spacing Between Buses (m)	Buses Per Hour	Additional Buses per Hour	Seated Passengers Per Hour	Increase in Seated Passengers per Hour
1	6	2	3,600	2,880	205,200	164,160
2	47	14	1,800	1,080	102,600	61,560
3	109	33	1,200	480	68,400	27,360
4	150	46	900	180	51,300	10,260
5 (Base)	212	64	720	-	41,040	-

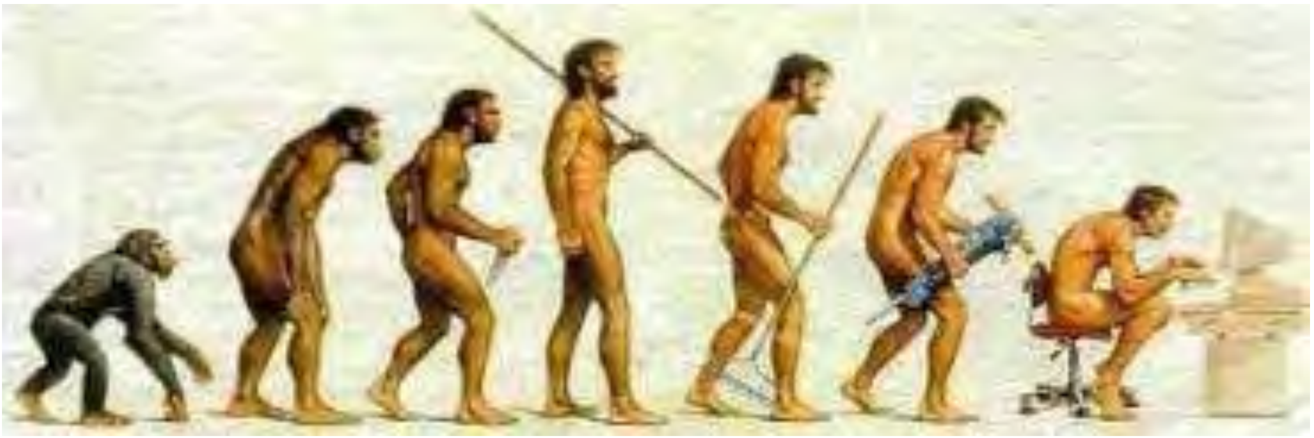
Implications on Terminals

PABT

Implications on PABT

- Near-term opportunities for the New PABT


YOU ARE HERE



Past

- There seems to be a new realization…

a) What started out in "1939" as Automated Highways

Present

- The Sensors, Actuators and Algorithms are on the verge of being able to
  - Drive as well as the best of us
    - without needing any infrastructure improvements
      - in enough places
      - at enough times
  - to make a substantial difference in Safety.

Future

- **Evolve** the ***Sensors, Actuators and Algorithms*** to
  - be **Cheaper** & Drive **Better** than the best of us
    - without needing any infrastructure improvements
      - in **More** places
      - at **More** times
  - While continuing to improve Safety, AND
    - Revolutionize **Mobility for All**
    - Substantially Reduce
      - **Energy Consumption**
      - **Pollution, and**
      - **Green House Gases (GHG)**

Fundamentally Strong Business Case!

But,

an Enormous Amount of Work

Needs to be Done

Over the Past 3 Years


Kick-off Meeting
of the
New Jersey Center for Automated Vehicles
@ Fort Monmouth

Friday, January 30, 2015
8:30am through Lunch

Agenda

8:30	Coffee	10:00	Business Plan/Membership structure
9:00	Welcome, Bruce Steadman FMERA	10:30	Initial Project Focus/Discussion
9:10	Self-introductions	11:00	Value to your organization
9:15	NJ & US Legislative & Regulatory Status	11:30	Public Sector Involvement
9:45	Purpose/Goals/Objectives/Facilities/Assets	noon	Working lunch

A Number of US have been Meeting:

- To Leverage the Region's Assets:
  - Home of major NA HQ: Insurance, Auto OEM, Technology, Communications and University Research
  - Re-purposing of PU's Forrestal Campus, Fort Monmouth & Bell Labs
- To Create the Research, Certification & Commercialization Environment:

That Develops Automated Vehicle (AV) Technology such that:

$$\text{Price}_{SDT} < \textit{NetPresentValue}\,\{\ \text{Expected}\,\{\text{AccidentLiability}_{\text{w/o AV}}\} - \text{Expected}\,\{\text{AccidentLiability}_{\text{w AV}}\}\}$$

- To Create Jobs while Improving Safety, Mobility and the Environment

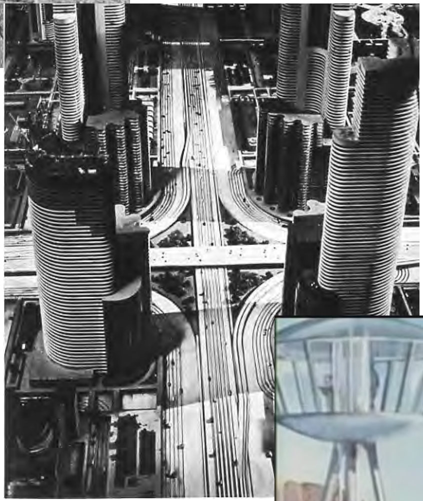
Past

- There seems to be a new Transportation Technology realization…

What started out in "1939" as Automated Highways

AHS: Automated Highway Systems: 1939 - 1997

"Waterloo": No feasible way to get started



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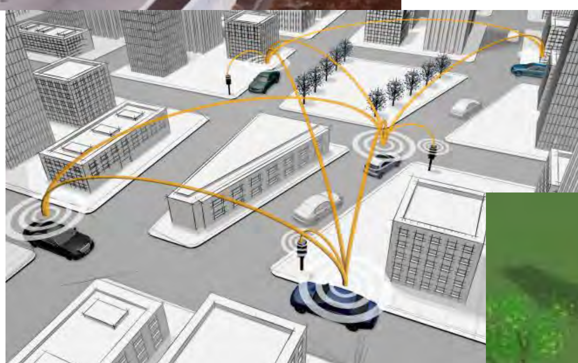
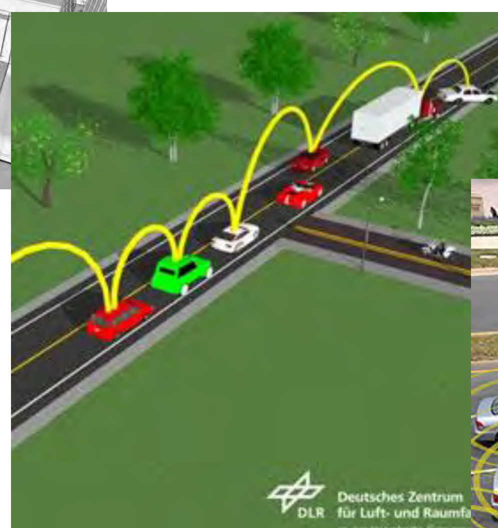
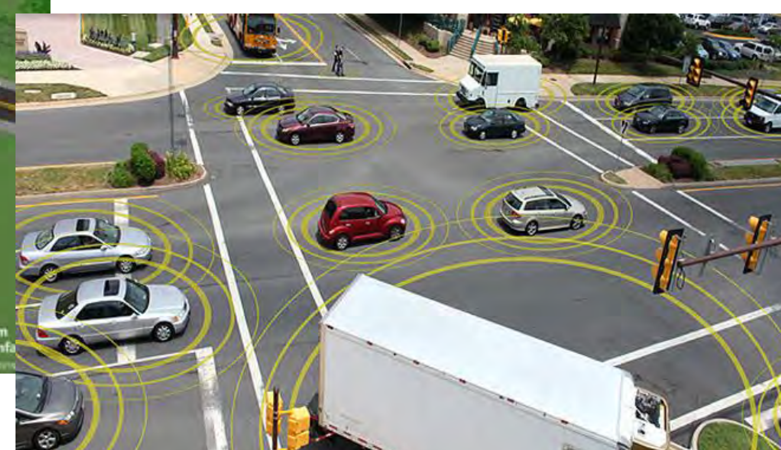
V2V: Connected Vehicles: 1997 -

“Waterloo”: Little value until a substantial market penetration is achieved. Again a non-starter







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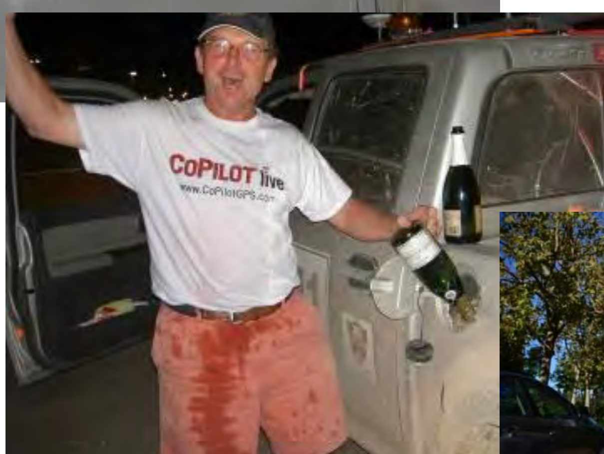
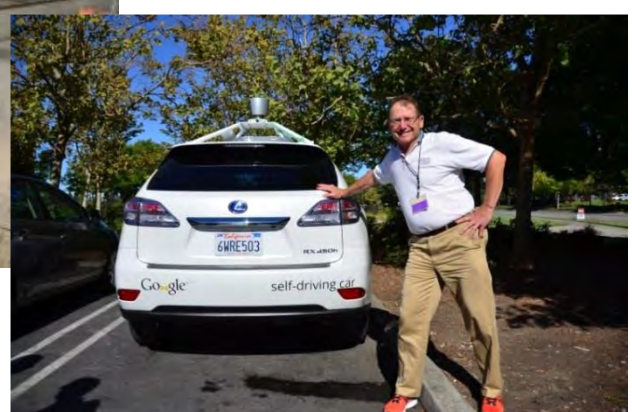
Automated Vehicles (rather than Automated Highways) : 2004 -

Focus on making one Automated Vehicle co-exist with today's infrastructure and human drivers; then simply **replicate**

Real beauty is in its **"autonomy"** **(forgo the "Systems" concept) :** Each replicated vehicle benefits **(Cost of Replication is Small)** !



CityMobil2



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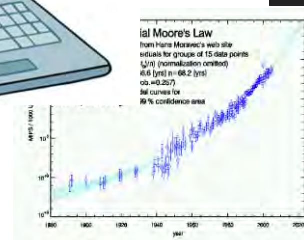
We've created :

- Center for Automated Road Transportation Safety (CARTS)
- Initial Board of Governance:
- Initial Focus on Automated Collision Avoidance
- A Scope that includes
  - Research
  - Certification &
  - Commercialization
- That Spans all Road modes:
  - Cars
  - Buses
  - Trucks
- And Recognizes the Importance of After-market as well as OEM

Fundamentals of Level 4 Driverless



$\Rightarrow$ $\$_{new}$

$\Rightarrow$ $\$_{Capital}$ = ZERO!

$\Rightarrow$

new

new =

now / AVO

$$\$_{new} = \frac{\$_{now}}{8 \text{ x AVO}}$$

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What are Automated Vehicles?

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What the Evolving Levels Deliver:

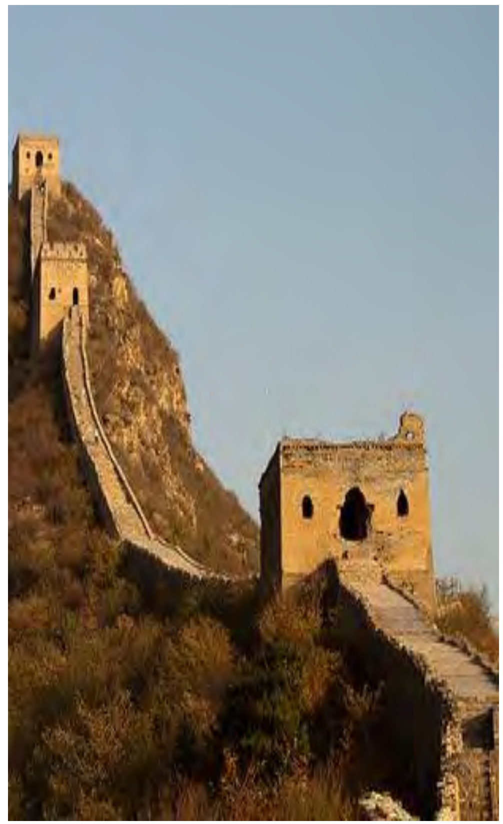
Levels 1 -> 2: **(Driverless Repositioning)** **Safety, Comfort & Convenience**

An **Insurance Discount** Play

Levels 3:

Pleasure, Safety, Comfort & Convenience

An **Enormous Consumer** Play



Level 4 **(Driverless Repositioning) : Pleasure, Mobility, Efficiency, Equity**

Elimination of cost of Labor Revolutionizes "Mass Transit" by Enabling Low-cost to even single riders "zero"

A **Corporate Utility/Fleet** Play

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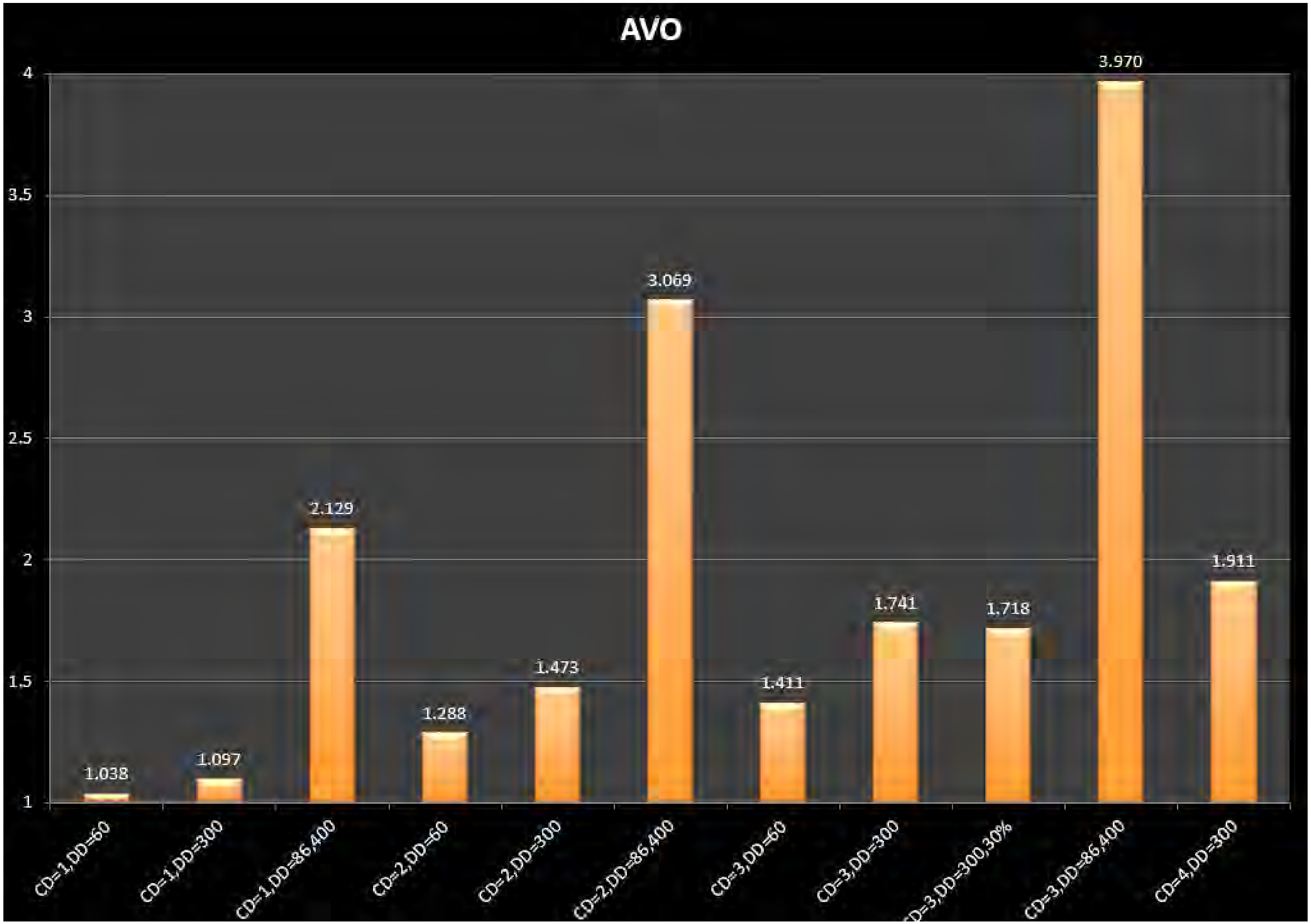
The Center for Automated Road Transportation Safety

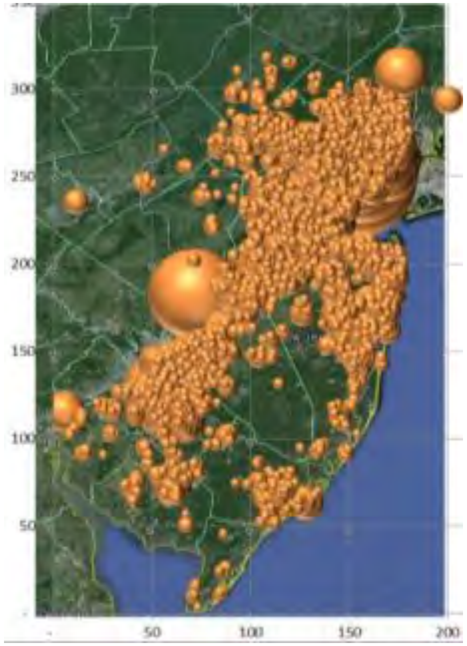
Typical Daily NJ-wide AVO

CD: Common Destinations; DD: Departure Delay (in Seconds)



Spatial Aggregation

- By walking to a station/aTaxiStand
  - At what point does a walk distance makes the aTaxi trip unattractive relative to one's personal car?
  - ¼ mile (5 minute) max
- Like using an Elevator!



Elevator

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Discussion!

Thank You

alaink@princeton.edu

www.SmartDrivingCar.com

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CARTS The Center for Automated Road Transportation Safety

TRANSPORTATION TRANSFORMED

ADVANCING ECO-FRIENDLY MOBILITY

8:45am to 5:00pm | Thursday, April 7, 2016

11:30 AM - 12:30 PM

Session 2 – Academic Research

MODERATOR

Elisabeth Lennon
Sustainability Coordinator, NYSDOT

Angela Sanguinetti, Ph.D., Institute of Transportation Studies, U. California, Davis: *A Behavioral Review of Eco-driving*

Kanok Boriboonsomsin, Ph.D., College of Engineering, Center for Environmental Research and Technology, UC Riverside: *Evaluating Real World Impacts of Eco-driving*

Rae Zimmerman, Ph.D., NYU Wagner Graduate School of Public Service: *Issues of Intermodal Connectivity and Eco-mobility*

WIFI **NYIT_Theater** **Password: CobaltBlue77**

A behavioral review of eco-driving

DR. ANGELA SANGUINETTI, BOARD CERTIFIED BEHAVIOR ANALYST
INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, DAVIS

What is eco-driving?

What is eco-driving?

An effective behavioral definition

What is eco-driving?

An effective behavioral definition

- Comprehensive

What is eco-driving?

An effective behavioral definition

- Comprehensive
- Consistent and Precise

What is eco-driving?

An effective behavioral definition

- Comprehensive
- Consistent and Precise
- Behavior

What is eco-driving?

- Comprehensive
  - Restricted to driving (Barkenbus) or extended to maintenance and even vehicle selection (Sivak & Schoettle, 2012)

What is eco-driving?

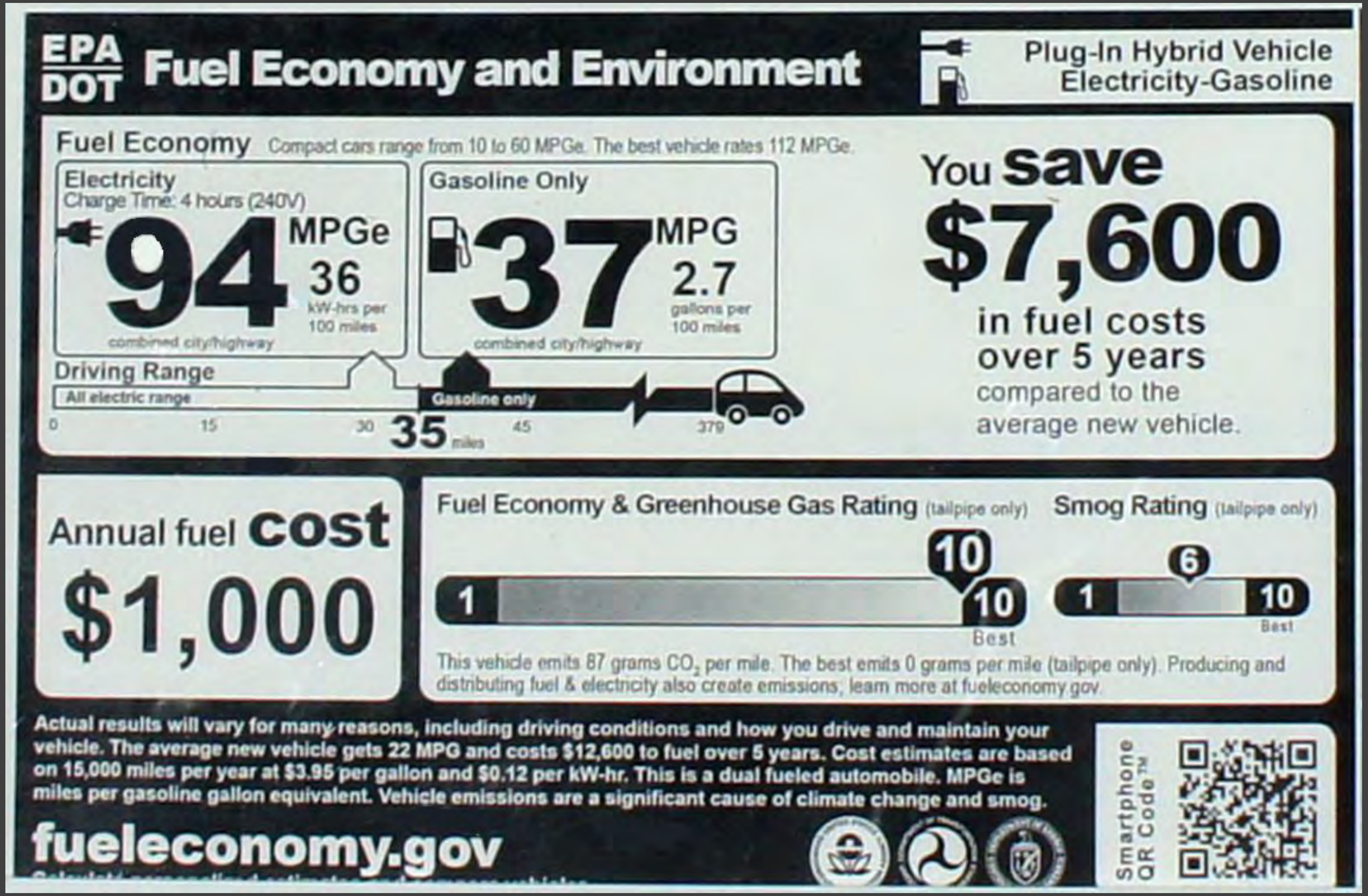
- Comprehensive
  - Restricted to driving (Barkenbus) or extended to maintenance and even vehicle selection (Sivak & Schoettle, 2012)
- Consistent and Precise
  - Sources recommend accelerating gently (AA, 2014), moderately (Barkenbus, 2010; Dogan, Steg, & Delhomme, 2011), or quickly to reach cruising speed (Birrell, 2014; Wahlberg, 2007).

What is eco-driving?

- Comprehensive
  - Restricted to driving (Barkenbus) or extended to maintenance and even vehicle selection (Sivak & Schoettle, 2012)
- Consistent and Precise
  - Sources recommend accelerating gently (AA, 2014), moderately (Barkenbus, 2010; Dogan, Steg, & Delhomme, 2011), or quickly to reach cruising speed (Birrell, 2014; Wahlberg, 2007).
- Behavior
  - “If a dead man can do it, it ain’t behavior” (Lindsley, 1965)

What is eco-driving?

“Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle.”



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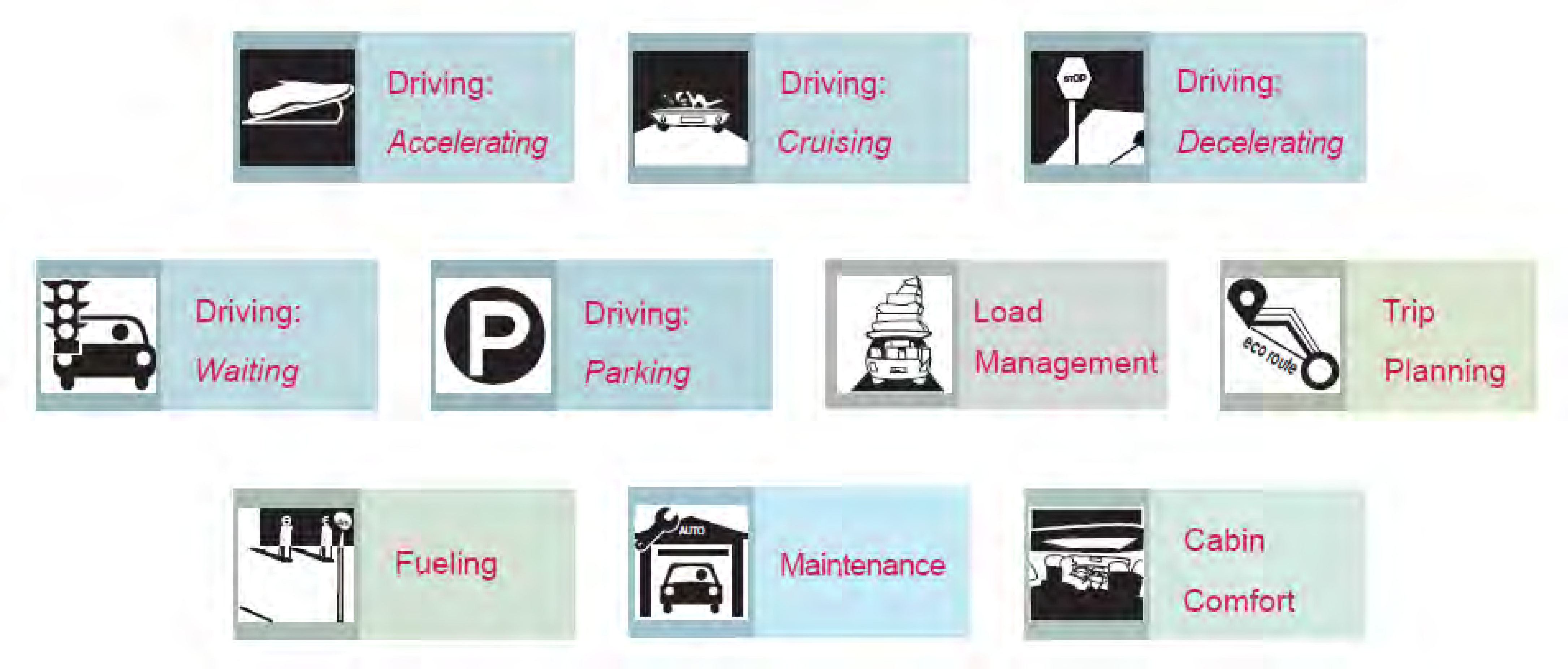


What is eco-driving?

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle, and how you manage cabin comfort, plan your trips, manage vehicle loads, and fuel your vehicle.

What is the potential impact of eco-driving?

What is the potential impact of eco-driving?

For any action that can mitigate climate change:

$$I = tpn$$

I = impact

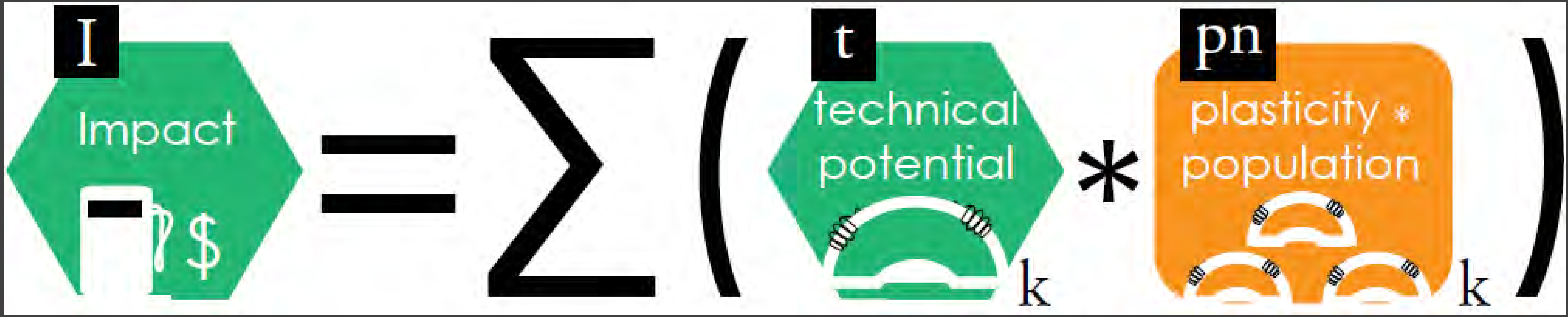
t = technical potential (savings impact of the behavior)

p = behavioral plasticity: proportion of population that can be induced to take the action

n = total population that could possibly take the action

(Stern, 2011)

What is the potential impact of eco-driving?



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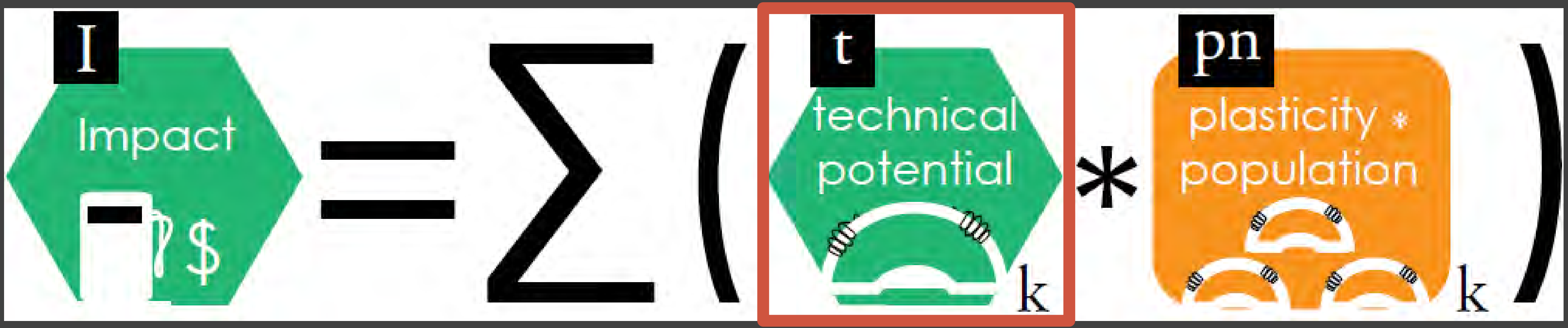
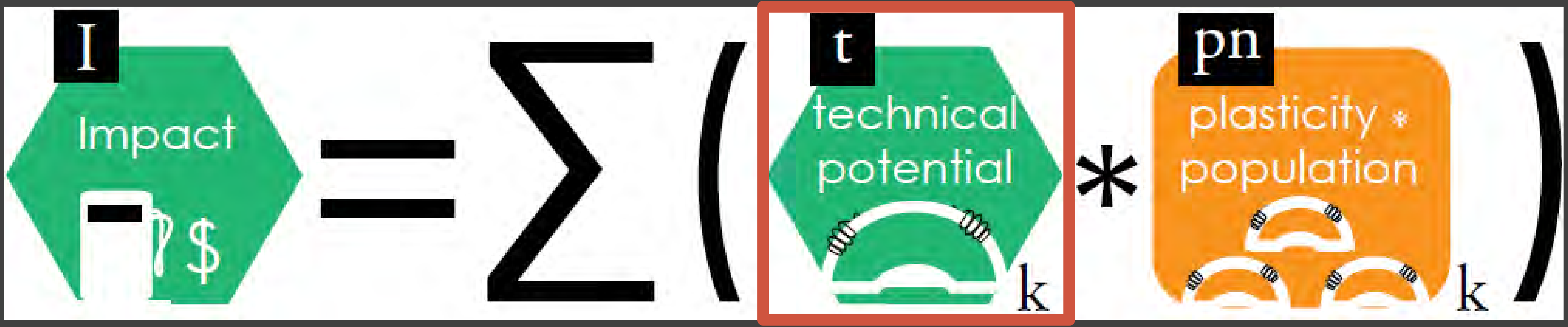
k = each eco-driving behavior

What is the potential impact of eco-driving?



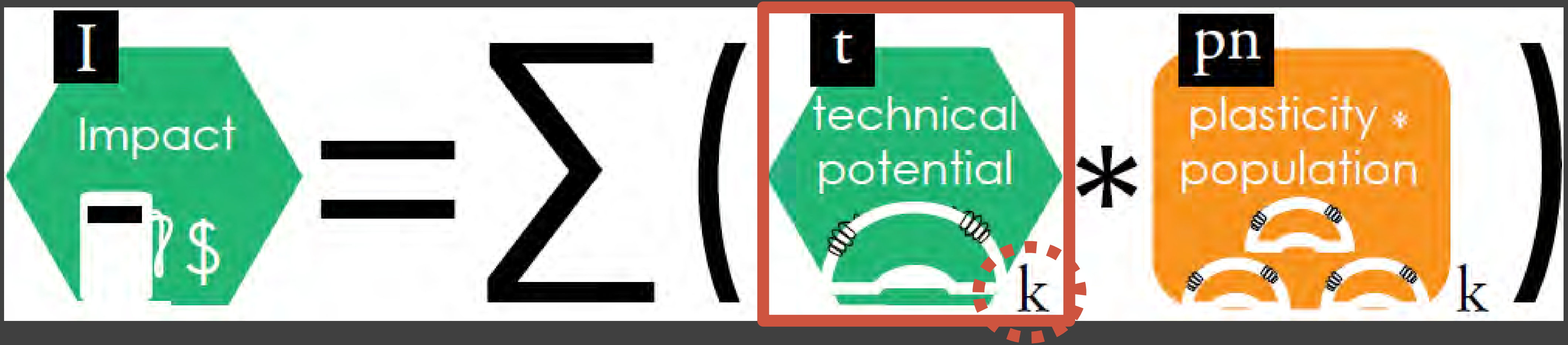
Simulations and modelling

What is the potential impact of eco-driving?



Neglecting eco-driving = 45% *decrease* in fuel economy (Sivak & Schoettle, 2012)

What is the potential impact of eco-driving?



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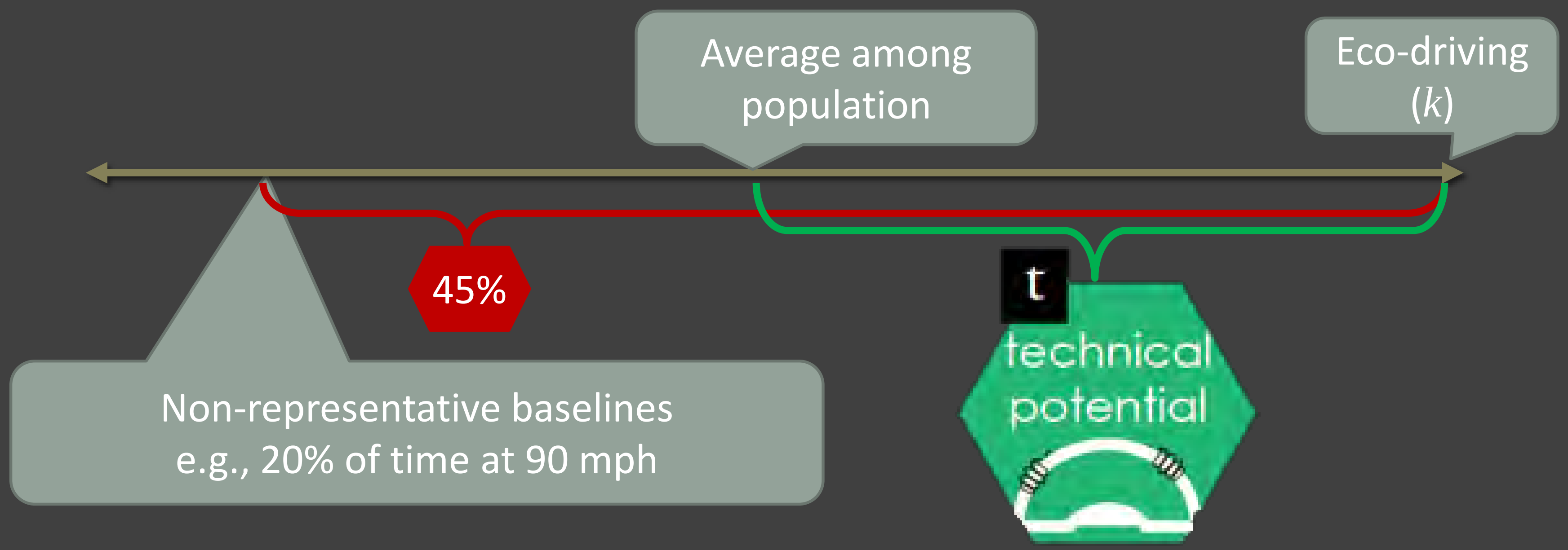

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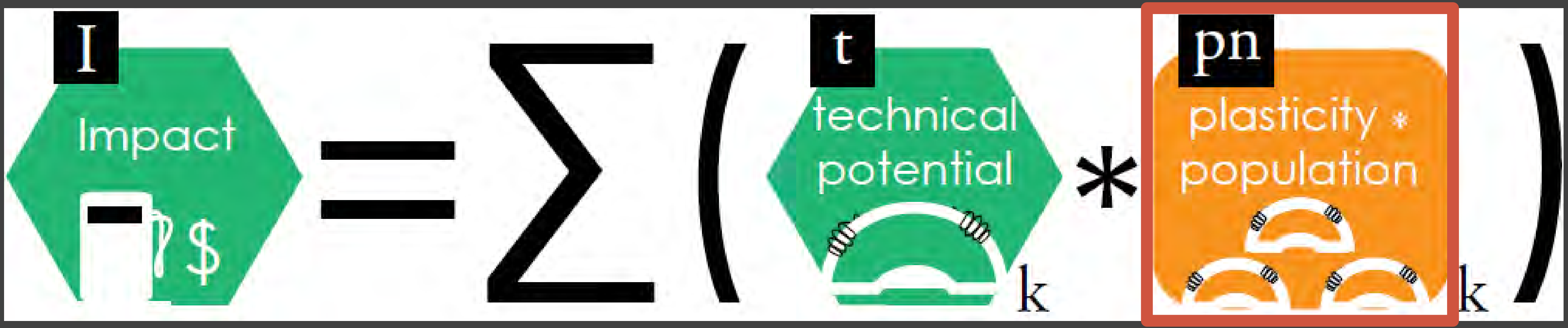
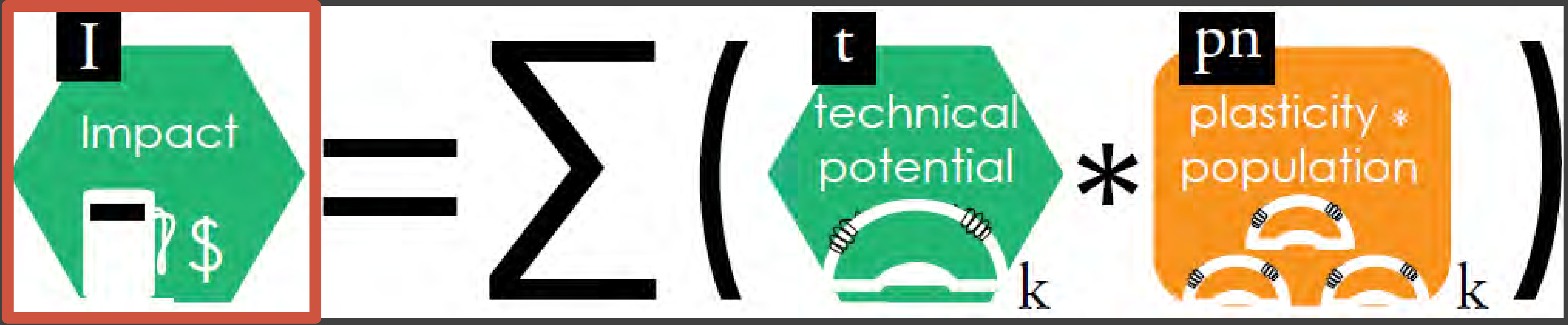


Real world/field studies

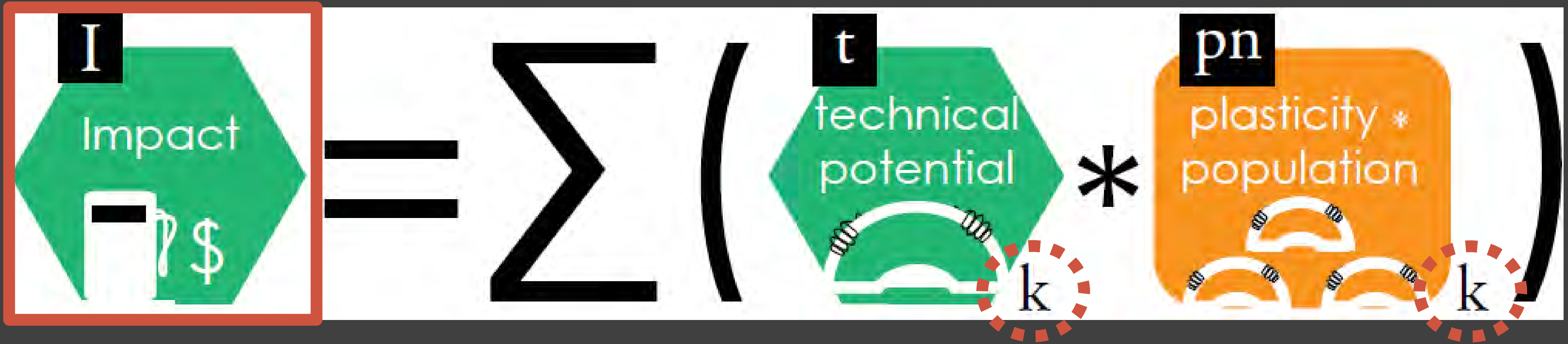
In-vehicle feedback

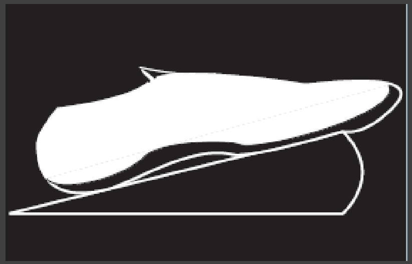
In-vehicle feedback



Average Impact = 6% increase in fuel economy

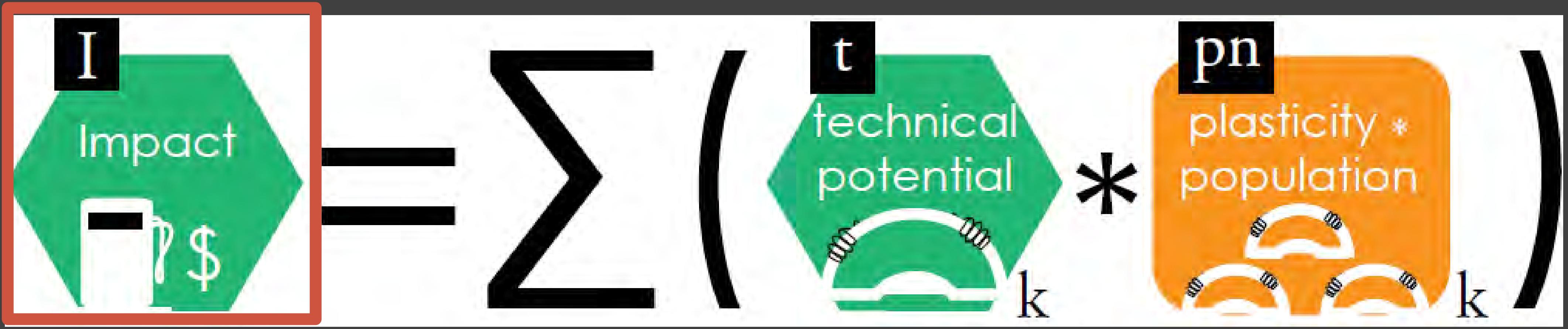
In-vehicle feedback





= 6% increase in fuel economy

In-vehicle feedback

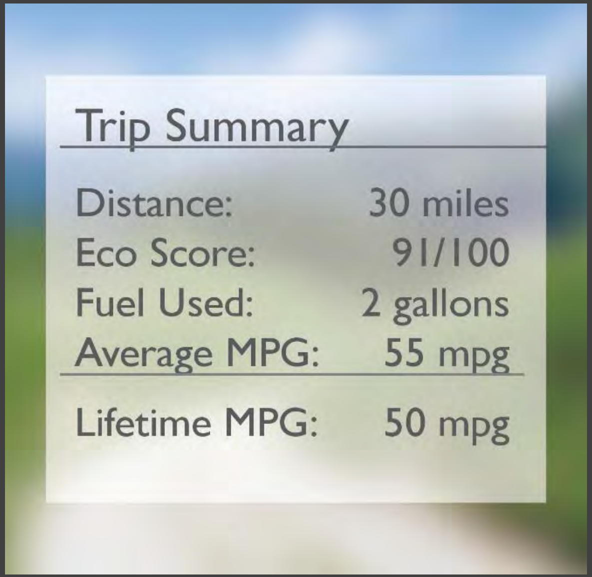


Average fuel savings (I) = 6%, ranging from negative effects to over 18%

In vehicle feedback

Why the variation?

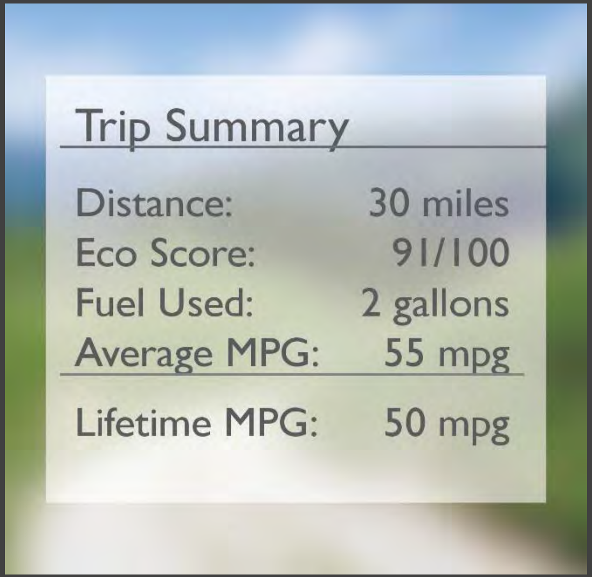
- Variation in feedback provided
  - Few comparative studies



In vehicle feedback

Our current research

- Typology of in-vehicle feedback
- Meta-analysis of existing studies



Takeaways

- Define your target behaviors
- Assess baselines and behavioral plasticity
- Measure eco-driving, not just fuel economy
- Experiment (compare treatments)

Thank you

asanguinetti@ucdavis.edu

cenergi.ucdavis.edu

PI: Ken Kurani

Research funded by the National Center for Sustainable Transportation (NCST) and UC Multicampus Research Programs and Initiatives (MRPI)

Evaluating Real-World Impacts of Eco-Driving

Kanok Boriboonsomsin

University of California at Riverside

Transportation Transformed: Advancing Eco-Friendly Mobility

Manhattan, NY

April 7, 2016

Introduction

- Many studies have been conducted to evaluate fuel savings potential of eco-driving.
- Evaluation settings:
  - Controlled environment
    - Driving simulator
    - Closed driving course
  - Real-world environment
    - Prescribed route
    - Actual route

- Often use before-and-after study design
  - Low cost, convenient, simple
  - Need to account for temporal changes in real-world evaluation

Your Mileage May Vary

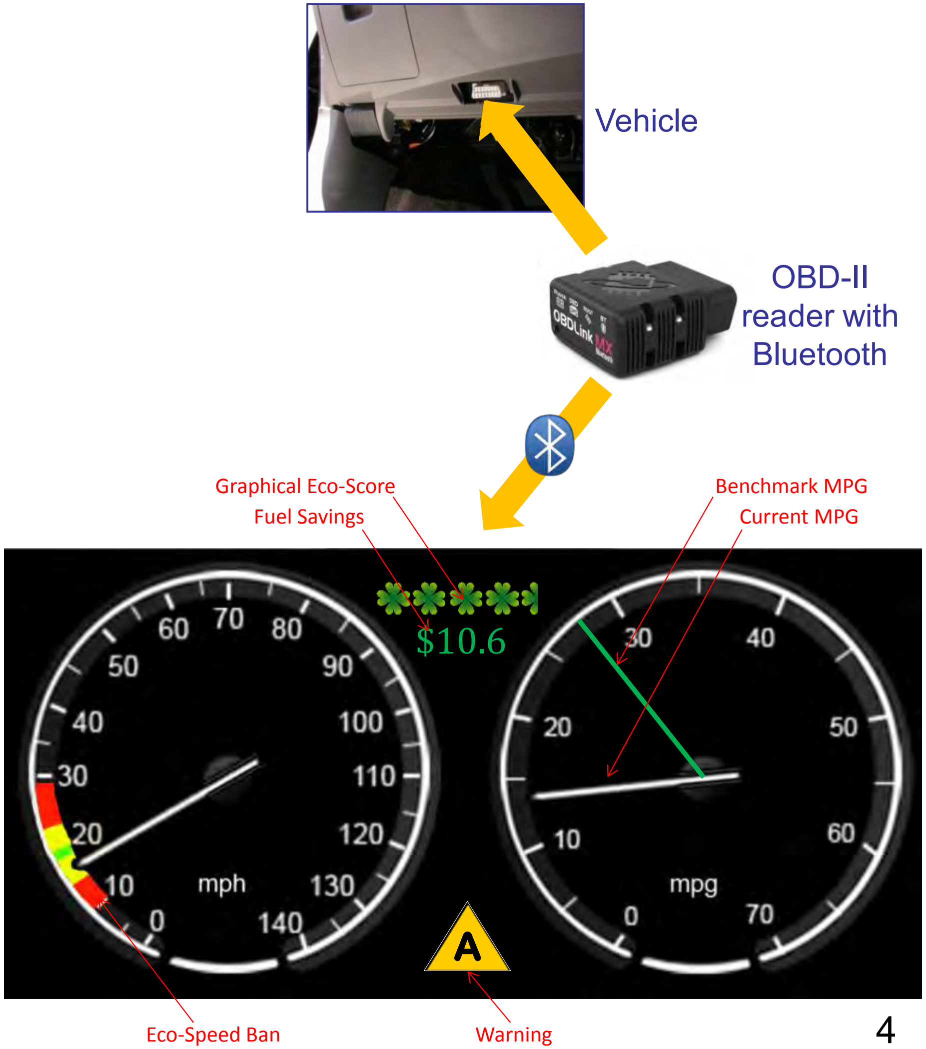
- Real-world fuel economy can be affected by:
  - Driving behavior
  - Fuel type/quality
  - Extra weight carried (e.g. passengers)
  - Tire pressure
  - Road geometry (e.g., vertical grade)
  - Road surface
  - Weather
  - Accessory loads used (e.g., A/C)
  - Trip type/purpose
  - Travel route
  - Traffic condition

Impact vehicle fuel consumption rates (Fuel type/quality through Accessory loads used)

Influence vehicle operating patterns (Trip type/purpose through Traffic condition)

Example Eco-Driving Feedback System

- Real-time feedback
  - Eco-speed band
  - Warnings
    - Aggressive acceleration
    - Hard braking
    - Excessive idling
  - Fuel economy
  - Cumulative fuel savings
- Data collection
  - GPS data
  - OBD-II data
  - 1 Hz data frequency



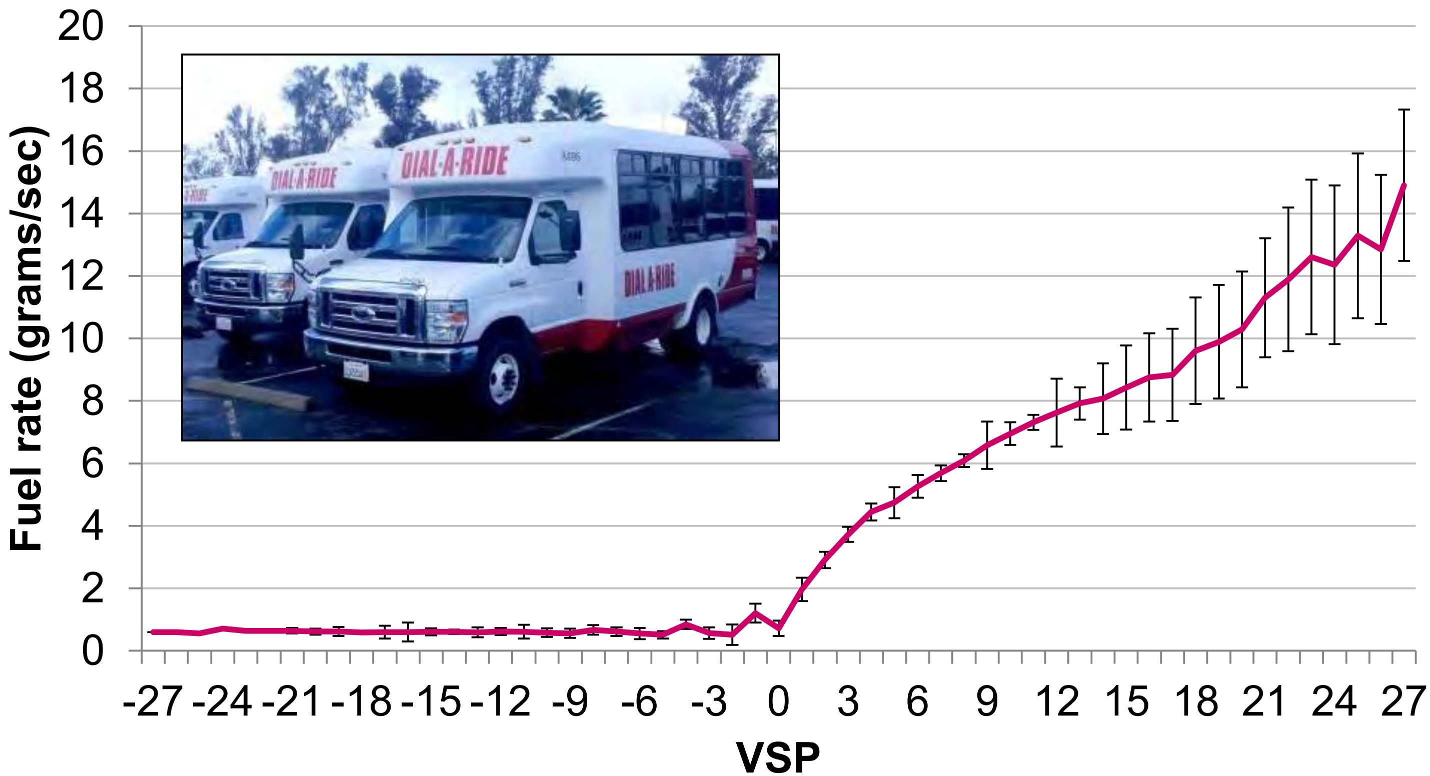
Vehicle Specific Power

$$VSP = \frac{A}{m} \cdot v + \frac{B}{m} \cdot v^2 + \frac{C}{m} \cdot v^3 + (a + g \cdot \sin\theta) \cdot v$$

- A is road load coefficient for rolling resistance $(\mathrm{kW \cdot s/m})$
- B is road load coefficient for rotating resistance $(\mathrm{kW \cdot s^2/m^2})$
- C is road load coefficient for aerodynamic drag $(\mathrm{kW \cdot s^3/m^3})$
- v is vehicle speed (m/s)
- m is fixed mass factor for the vehicle type (metric ton)
- a is vehicle acceleration (m/s^2)
- g is acceleration due to gravity (9.8 m/s^2)
- sin θ is fractional road grade
- Typical values for passenger cars
  - *A* = 0.156461; *B* = 0.00200193; *C* = 0.000492646; and *m* = 1.4788

Normalized Fuel Consumption Rates

- The mean fuel consumption rate for a specific VSP value (which is a function of speed and acceleration alone).



Adjustments for Differences in Vehicle Operating Patterns

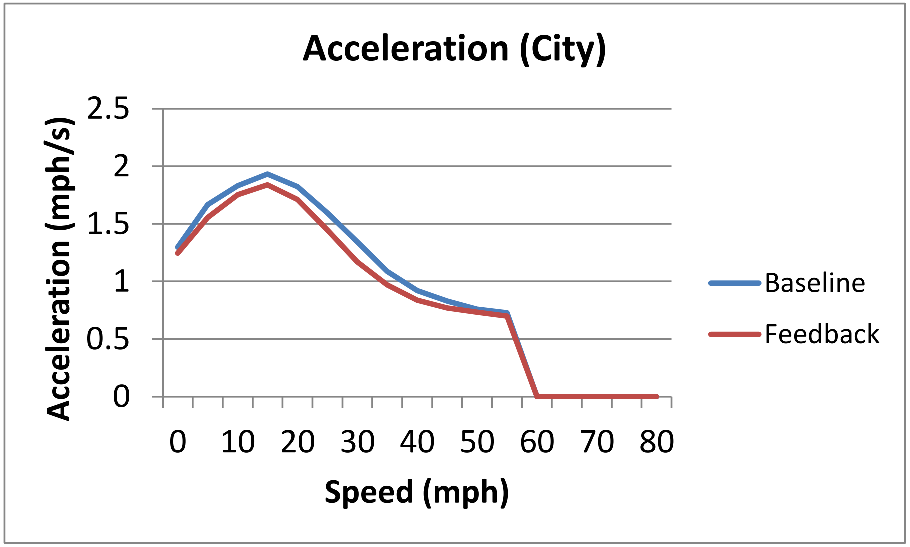
- Adjusted for driving behaviors that are influenced by the Eco-Driving Feedback system:
  - Acceleration
  - Braking
  - Idling
- Analyze the impact of each driving behavior on fuel consumption as if the vehicle was subject to the same operating pattern.

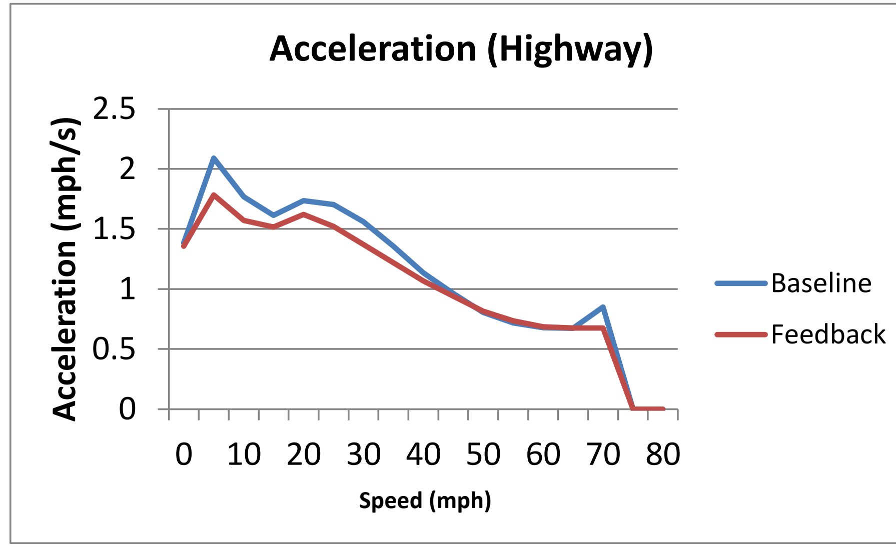
Vehicle Operating Patterns

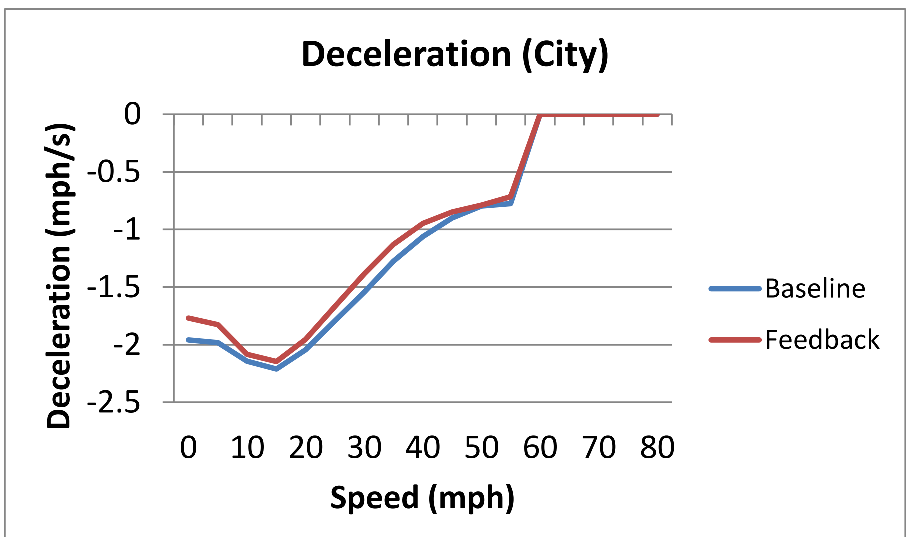
- Fraction of time spent under each of 16 driving scenarios
  - 2 road types x 8 speed groups

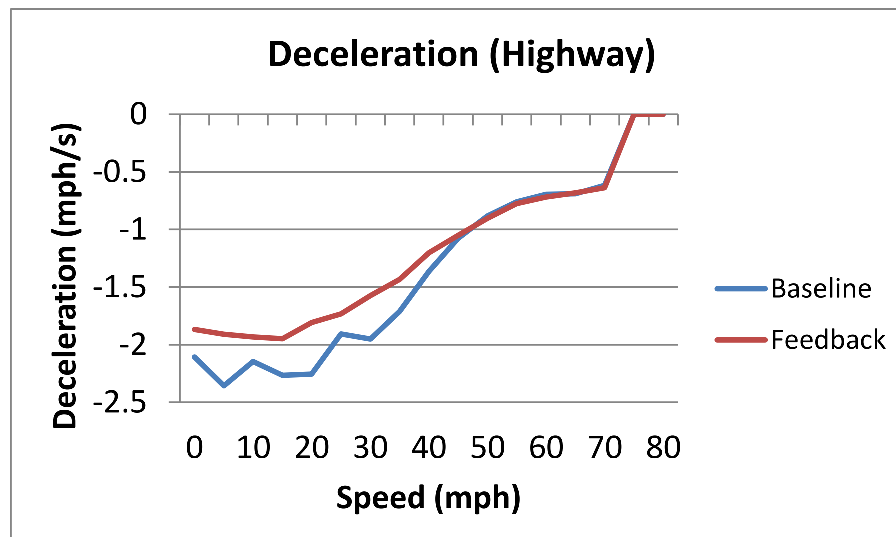
Driving Scenario	Road Type	Speed Range (mph)
1	Highway	<7.5
2	Highway	7.5-17.5
3	Highway	17.5-27.5
4	Highway	27.5-37.5
5	Highway	37.5-47.5
6	Highway	47.5-57.5
7	Highway	57.5-67.5
8	Highway	>67.5
9	City Street	<7.5
10	City Street	7.5-17.5
11	City Street	17.5-27.5
12	City Street	27.5-37.5
13	City Street	37.5-47.5
14	City Street	47.5-57.5
15	City Street	57.5-67.5
16	City Street	>67.5

Impacts on Acceleration & Braking

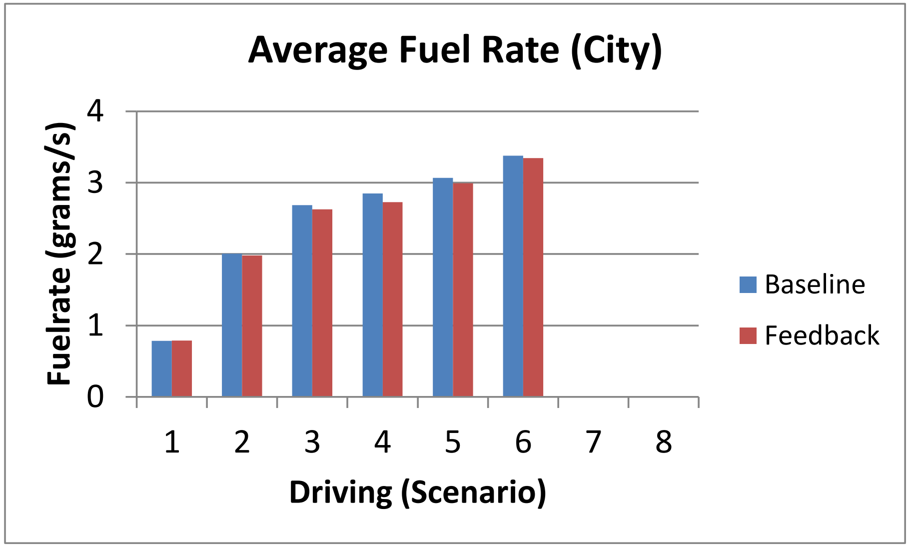


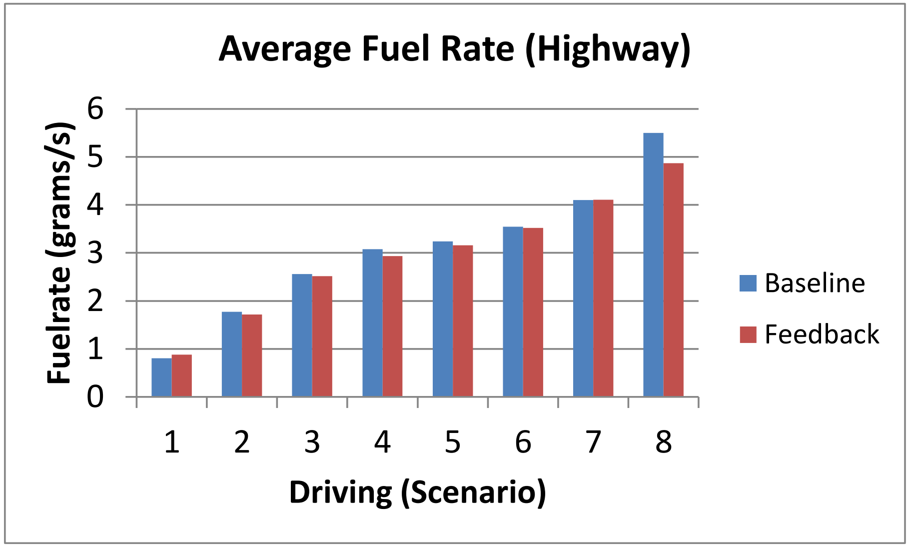


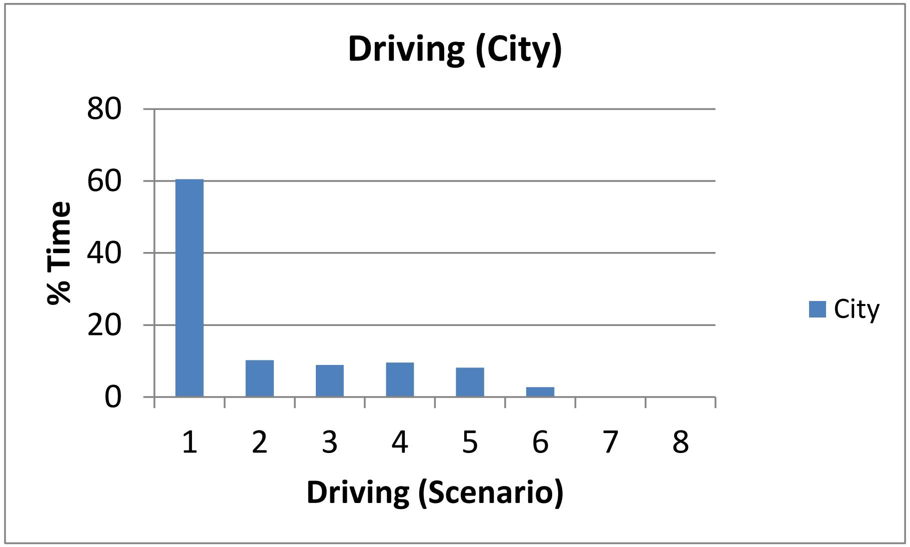


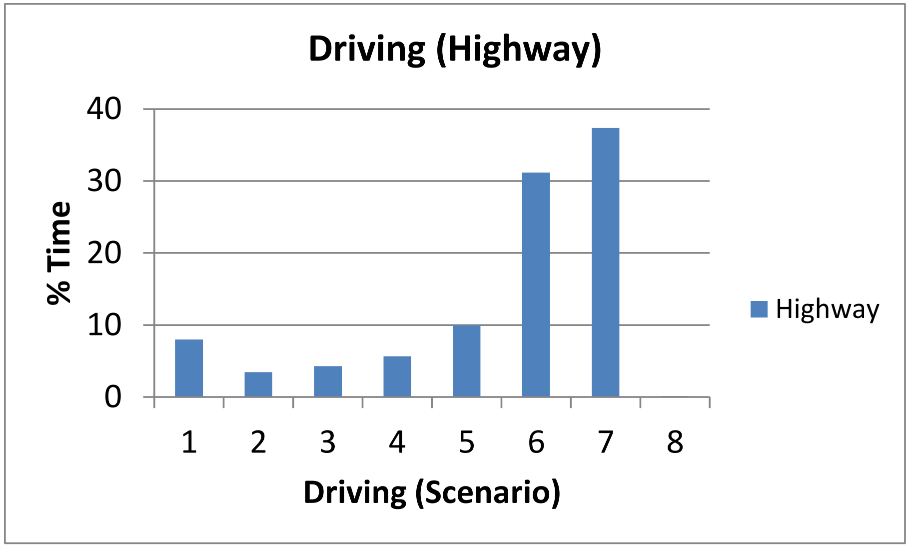


Adjustments for Acceleration & Braking



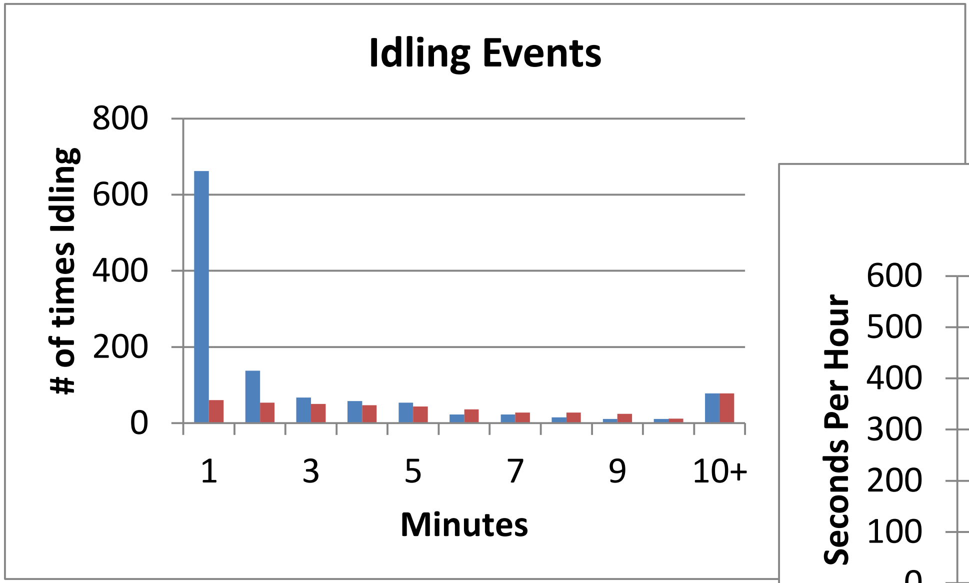


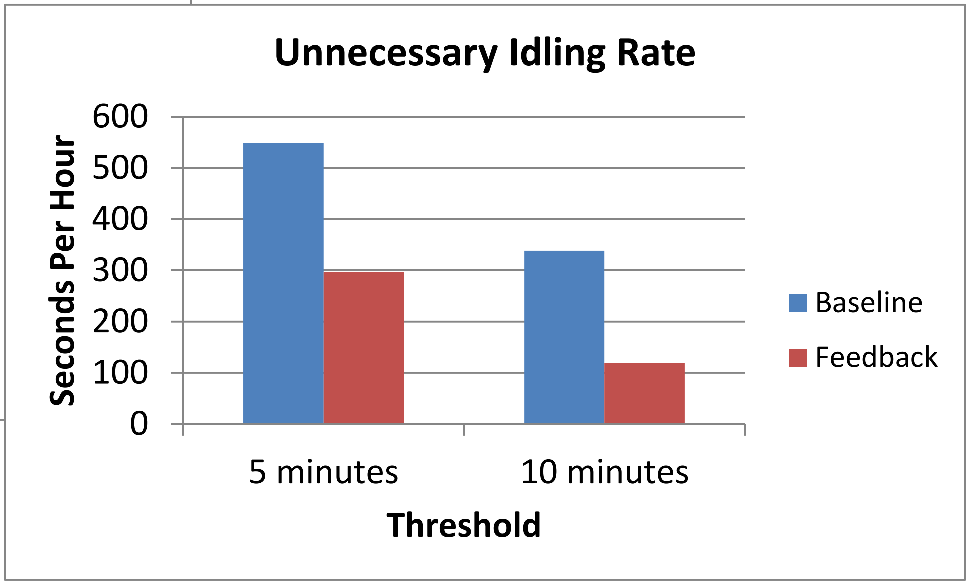




Impacts on Idling

- Based on *unnecessary idling rate*, defined as the total idling time beyond a threshold value per hour of vehicle operation time.





Adjustment for Idling

1) $uF = f^{VSP=0} \cdot \sum_j uT_j$

2) $uF'_j = f^{VSP=0} \cdot uR_j \cdot \sum_j VOT_j$

3) $F(a,b,i)_j = F(a,b)_j - uF + uF'_j$

- *uF* is actual fuel consumption due to unnecessary idling in both periods combined (grams)
- $f^{VSP=0}$ is idling fuel consumption rate which is when VSP is 0 (grams/s)
- *uT* is total unnecessary idling time beyond the threshold (s)
- *uF'* is adjusted fuel consumption based on period-specific unnecessary idling rate (grams)
- *uR* is unnecessary idling rate (s/hr)
- *VOT* is vehicle operating time (hr)
- *F(a,b)* is total fuel consumption adjusted for accelerating and braking behaviors (grams)
- *F(a,b,i)* is total fuel consumption adjusted for accelerating, braking, and idling (grams)
- *j* is period of data collection; *j* = {baseline, feedback}

Results for Example Vehicle

	Baseline	Feedback	% Change
Distance (mi)	2,863	3,920	
Fuel consumption (gal)	405	541	
Fuel economy, FE (mpg)	7.08	7.25	2.4%
FE adjusted for acceleration & braking (mpg)	6.21	6.29	1.4%
FE adjusted for acceleration, braking, & idling (mpg)	7.00	7.30	4.2%

Conclusions

- Real-world evaluation of eco-driving needs to account for factors that affect vehicle fuel economy
  - Impact vehicle fuel consumption rates
  - Influence vehicle operating patterns
- Vehicle specific power can be used as a basis for normalizing vehicle fuel consumption rates.
  - As a function of speed and acceleration alone
- Adjustments for differences in vehicle operating patterns can be performed for individual driving behaviors.
  - Acceleration
  - Braking
  - Idling

Closure

- Acknowledgements
  - US Department of Energy
  - Project partners

ESRI · NAVTEQ · Beat the Traffic · earthrise TECHNOLOGY · automatiks · Caltrans · RTA Riverside Transit Agency · University of California Berkeley Transportation Sustainability Research Center

  - Research team at UC Riverside

- For more info:
  - Kanok Boriboonsomsin (kanok@cert.ucr.edu)
  - Matthew Barth (barth@ee.ucr.edu)

Issues of Intermodal Connectivity and Eco-mobility

Rae Zimmerman

Professor of Planning and Public Administration

NYU-Wagner

UTRC

Transportation Transformed - Advanced Eco-Friendly Mobility

April 7, 2016

I. The Modes

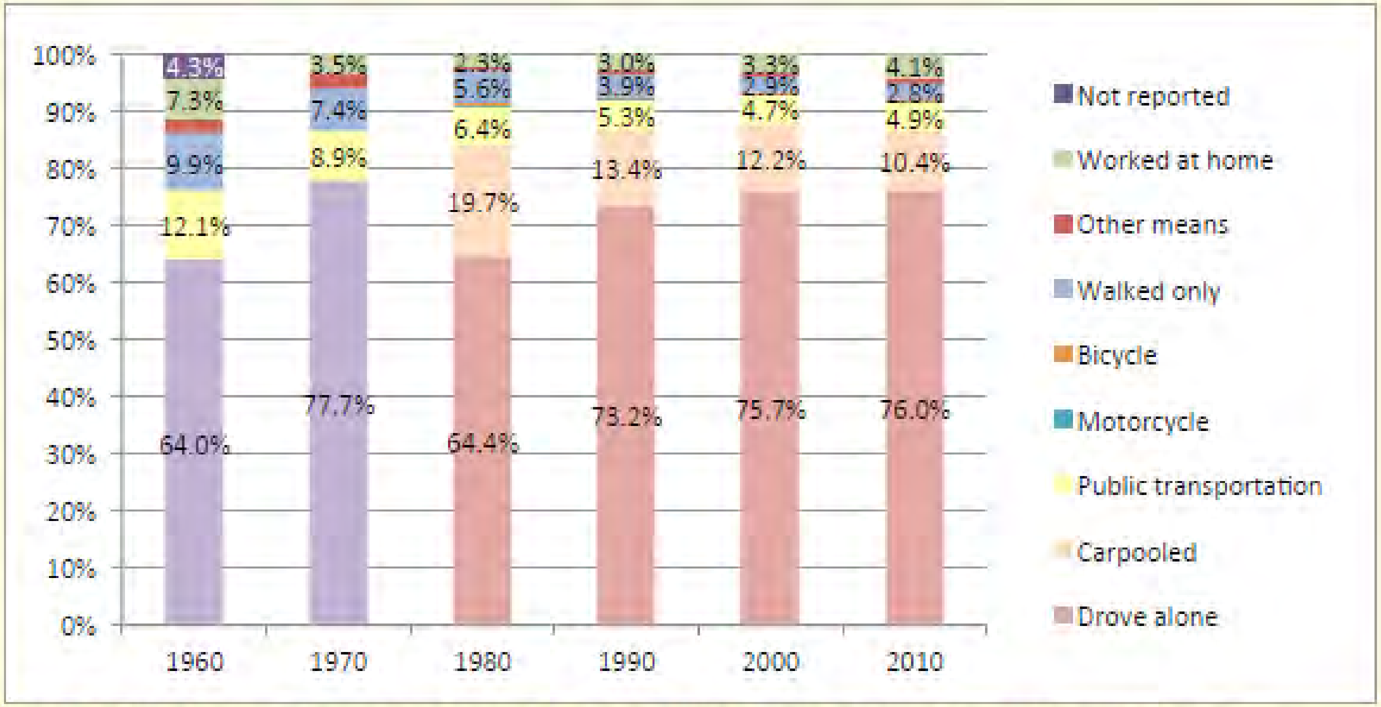


Exhibit 2-26: Means of transportation to work, 1960 to 2010. Data for 1960 and 1970 group carpooling and driving alone together and do not include bicycle or motorcycle use. Data for 1960 only include a "not reported" category.

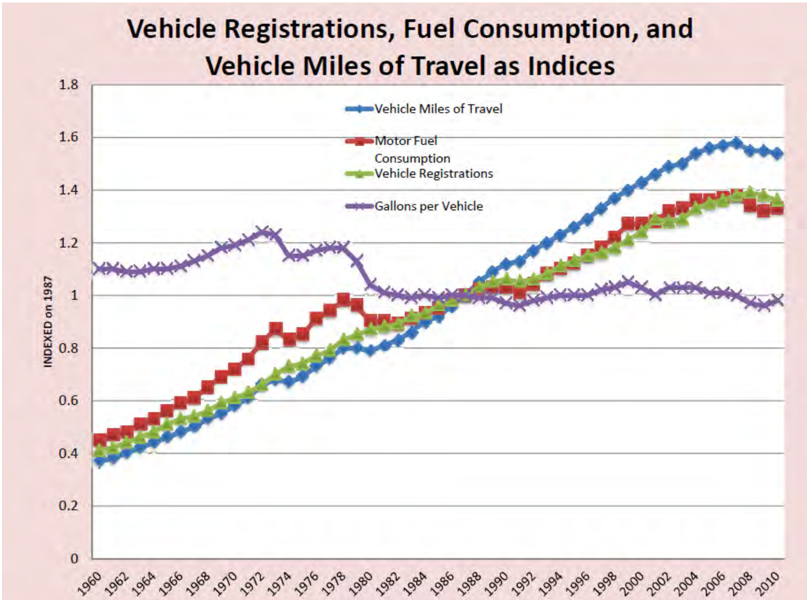
Sources: Davis, Diegel, and Boundy 2012, Table 8.16 and U.S. Census Bureau, *Means of Transportation to Work for the U.S.* n.d.

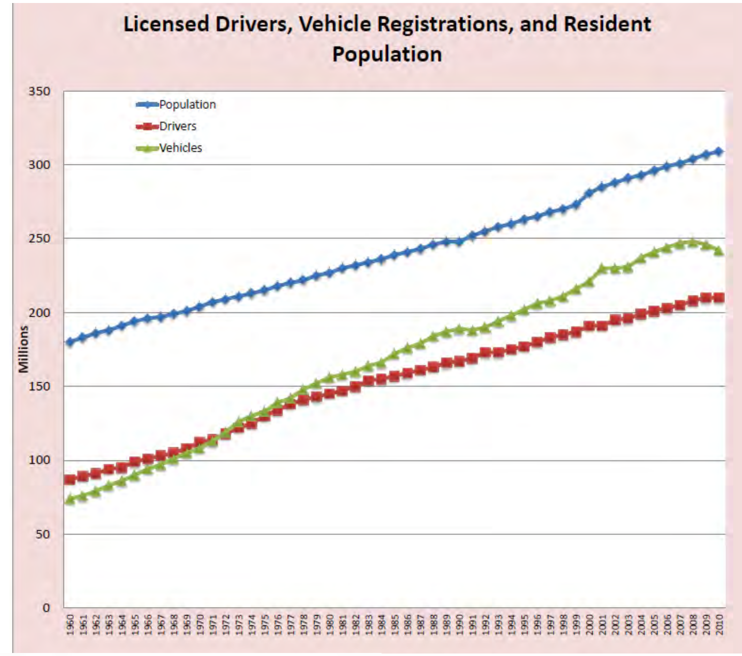
Source: U.S. EPA (2013) Our Built and Natural Environments: A Technical Review of the Interactions among Land Use, Transportation, and Environmental Quality, Second edition. Washington, D.C.: EPA http://www.epa.gov/dced/pdf/b-and-n/b-and-n-EPA-231K13001.pdf, p. 29

Road Transportation Usage and Capacity

Vehicle Usage, Population, and Roads, 1960-2011

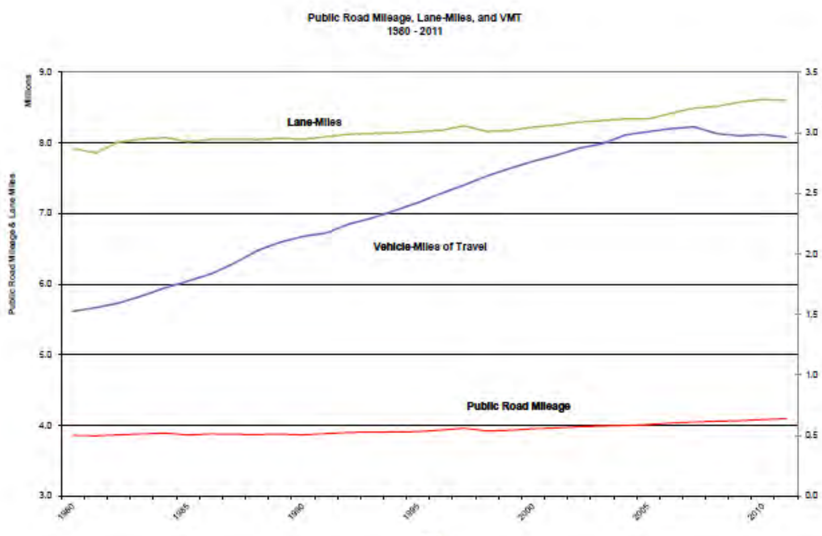
Use





U.S. DOT, FHWA (April 2013) Highway Statistics 2011, Chart RC-1C; http://www.fhwa.dot.gov/policyinformation/statistics/2011/pdf/rc1c.pdf

U.S. DOT, FHWA (April 2013) Highway Statistics 2011, VMT-422 http://www.fhwa.dot.gov/policyinformation/statistics/2011/pdf/vmt422c.pdf

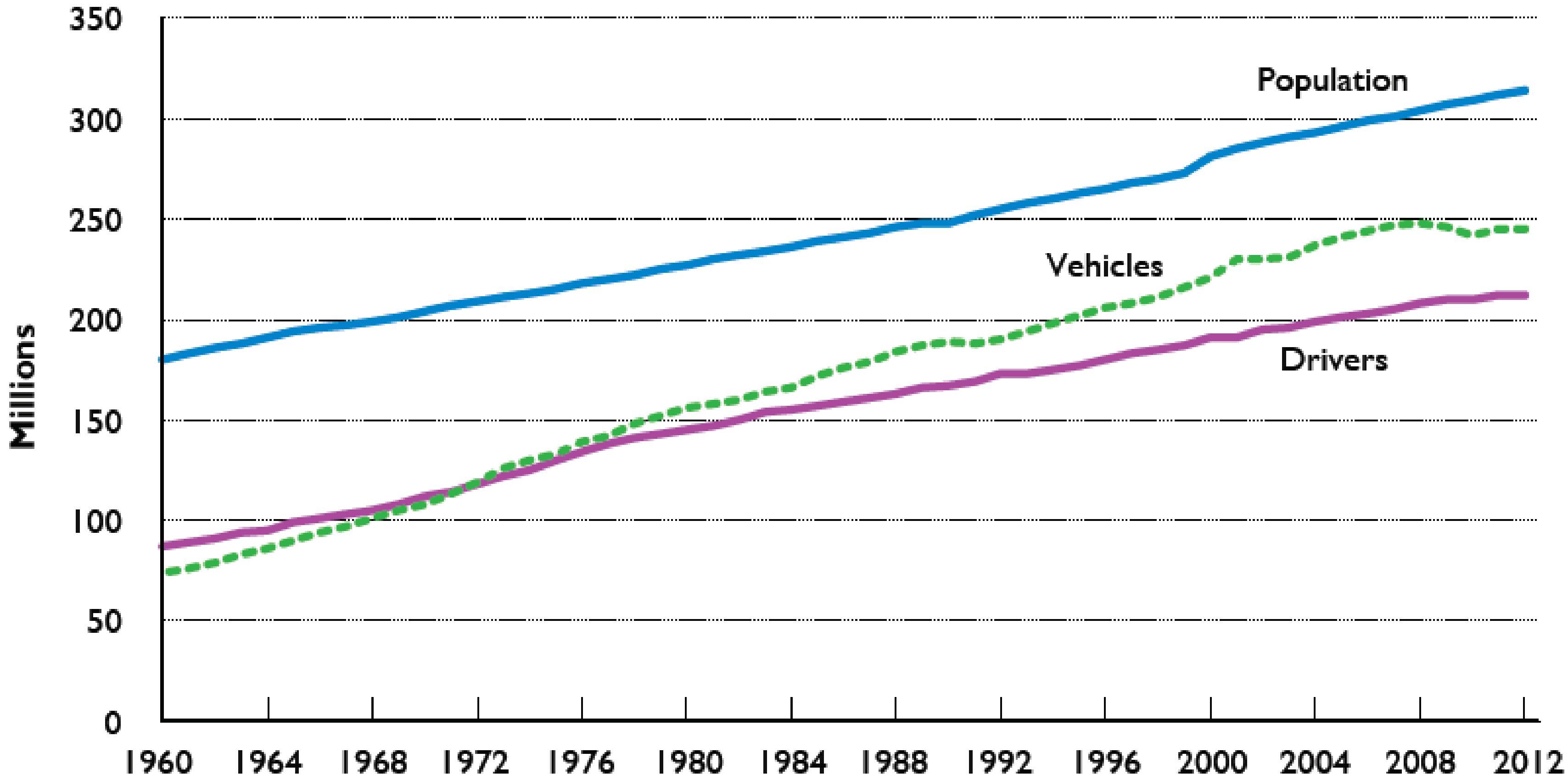


U.S. DOT, FHWA (2011) Highway Statistics 2010, Chart dv1c http://www.fhwa.dot.gov/policyinformation/statistics/2010/pdf/dv1c.pdf.

Capacity

Private Transportation Trends

Figure 2-7 Licensed Drivers, Vehicle Registrations, and Resident Population: 1960–2012



SOURCE: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2012*. Chart DV-1C, available at www.fhwa.dot.gov/policyinformation/statistics/2012 as of March 2015.

U.S. DOT BTS (2015) Passenger Travel Facts and Figures 2015, p. 16, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/PTFF_Complete.pdf

Public Transportation Patterns by Mode

Trips and Mileage

Table 5: Unlinked Passenger Trips and Passenger Miles by Mode, Millions
Report Year 2011

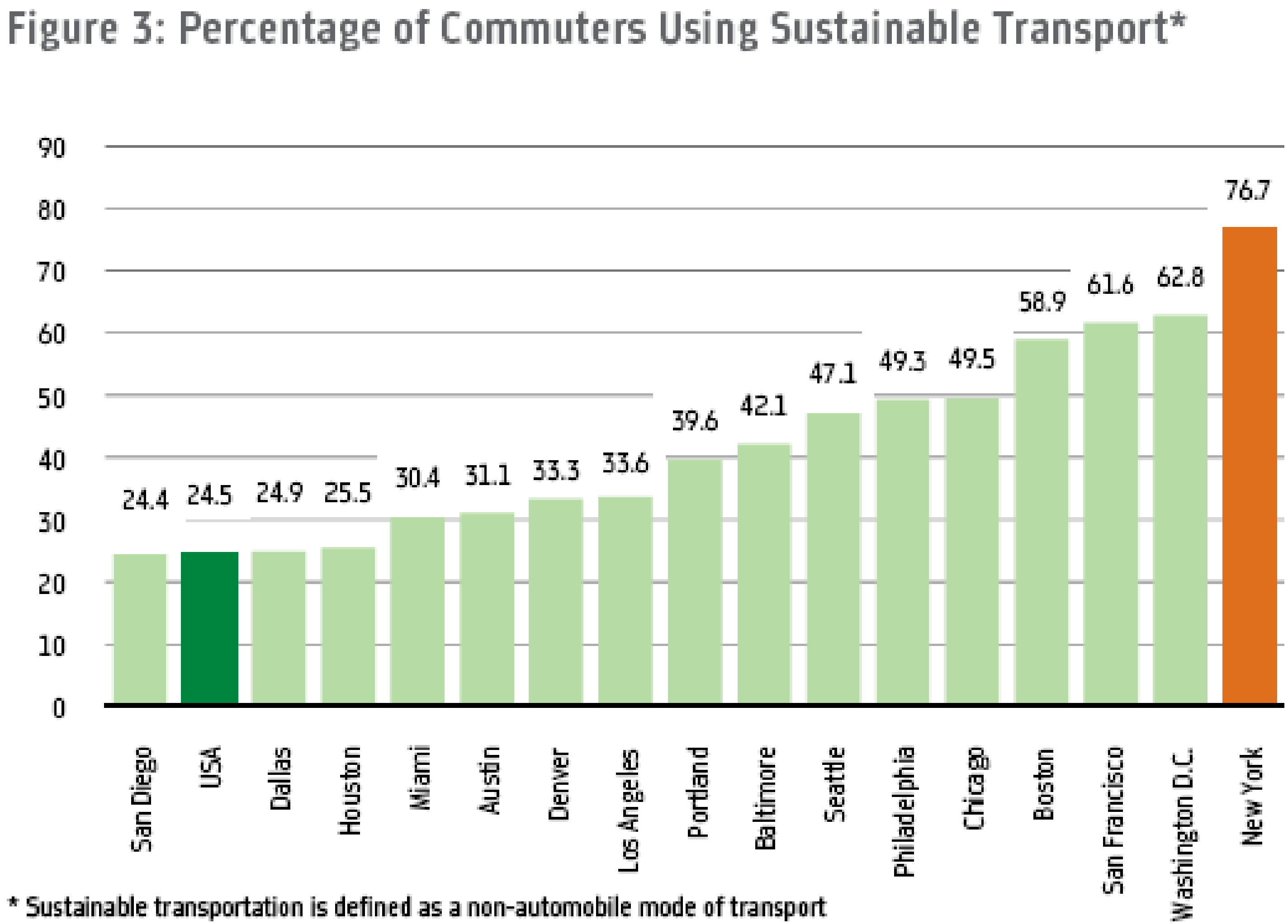
Mode of Service	Passenger Trips		Passenger Miles	
	Millions	Percent	Millions	Percent
Bus	5,191	50.3%	20,408	36.4%
Bus Rapid Transit	6	0.1%	23	< 0.1%
Commuter Bus	37	0.4%	984	1.8%
Commuter Rail	466	4.5%	11,427	20.4%
Demand Response	191	1.9%	1,580	2.8%
Ferryboat	80	0.8%	416	0.7%
Heavy Rail	3,647	35.3%	17,317	30.9%
Hybrid Rail	6	0.1%	70	0.1%
Light Rail	436	4.2%	2,203	3.9%
Other Rail Modes (a)	44	0.4%	47	0.1%
Publico	39	0.4%	172	0.3%
Streetcar	43	0.4%	96	0.2%
Transit Vanpool	34	0.3%	1,176	2.1%
Trolleybus	98	0.9%	160	0.3%
Total All Modes	10,319	100.0%	56,077	100.0%

(a) Aerial tramway, automated guideway transit, cable car, inclined plane, and monorail.
Unlinked Passenger Trips by Mode data from 1902 through 2011 can be found in the *2013 Public Transportation Fact Book, Appendix A: Historical Tables* at www.apta.com.

American Public Transportation Association (2013) 2013 Public Transportation Fact Book. Washington, DC: APTA, p. 10, 11.
http://www.apta.com/resources/statistics/Documents/FactBook/2013-APTA-Fact-Book.pdf

Non-Auto Transportation Mode Usage

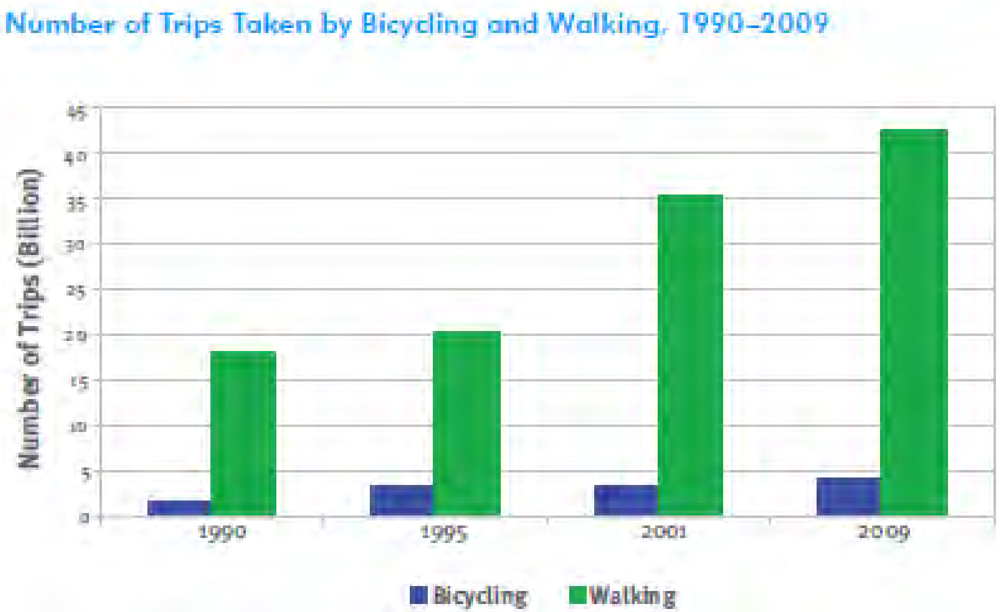
U.S. Cities Compared

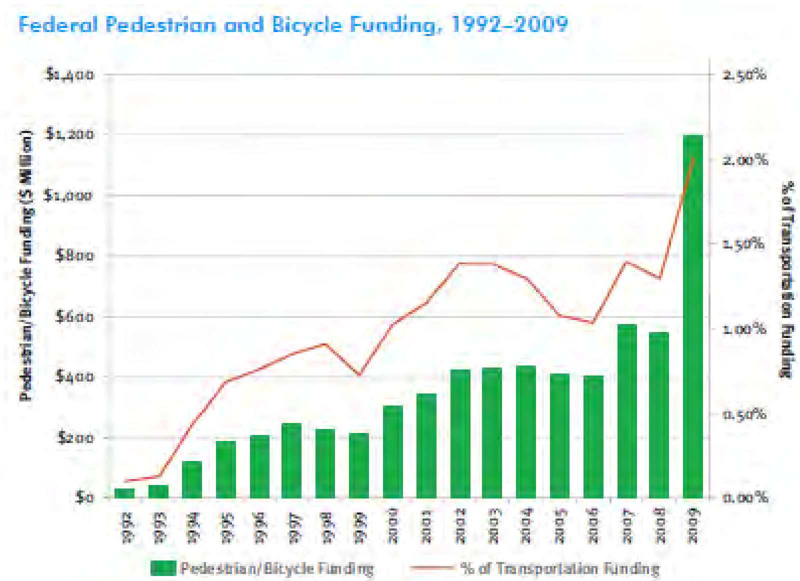


Source: New York City (September 2010) Inventory of NYC Greenhouse Gas Emissions, p. 7.

Biking

Trends in Biking Compared to Walking (Trips) and Funding, U.S., 1990-2009





USDOT, FHWA (May 2010) *The National Bicycling and Walking Study: 15-Year Status Report* p. 6, 5
http://drusilla.hsrc.unc.edu/cms/downloads/15-year_report.pdf

Bike Share, various cities

Source: Photos by R. Zimmerman.

II. Energy Use

Most of the fossil fuel contribution is driven by petroleum

- **Transportation accounts for 72% of petroleum usage**
- **Transportation's share of petroleum consumption has been increasing in absolute and relative terms until the late 2000s (p. 78):**
  - **Between 1973 and 2007 the share that transportation was of the petroleum sector increased from 52.3% to 68.7% (Davis et al. 2010, pp. 1-19).**
  - **Even though the absolute amount of petroleum consumption by transportation dropped between 2007 and 2008 the share still increased.**
  - **The CO2 emissions picture reflects this: Petroleum accounted for 98% of transportation emissions of CO2.**

- **Transportation does not use a large share of renewable energy resources (EIA Annual Energy Review 2011, p. 37 http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf)**
  - **Transportation accounts for <u>13% of all renewable energy consumption</u>**
  - **<u>Only 4% of the energy used in the transportation sector is from renewable energy</u> sources and most of that is accounted for by ethanol as fuel and biodiesel (EIA Annual Energy Review 2011 p. 44)**

Source: Summary from R. Zimmerman (2012) Transport, the Environment and Security. Making the Connection, Cheltenham, UK and Northampton, MA: Edward Elgar Publishing, Ltd., p. . http://www.e-elgar.com/bookentry_mainUS.lasso?id=13884

Energy Use: Transportation Compared to Other Sectors, Worldwide, 1990 and 2005

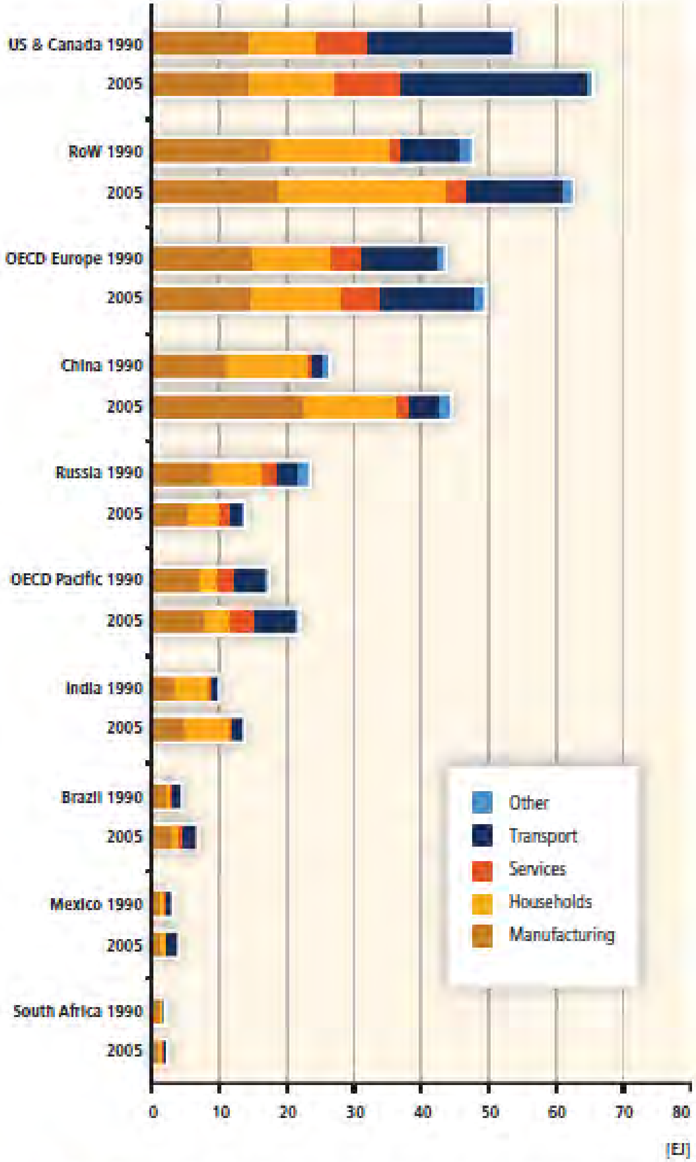
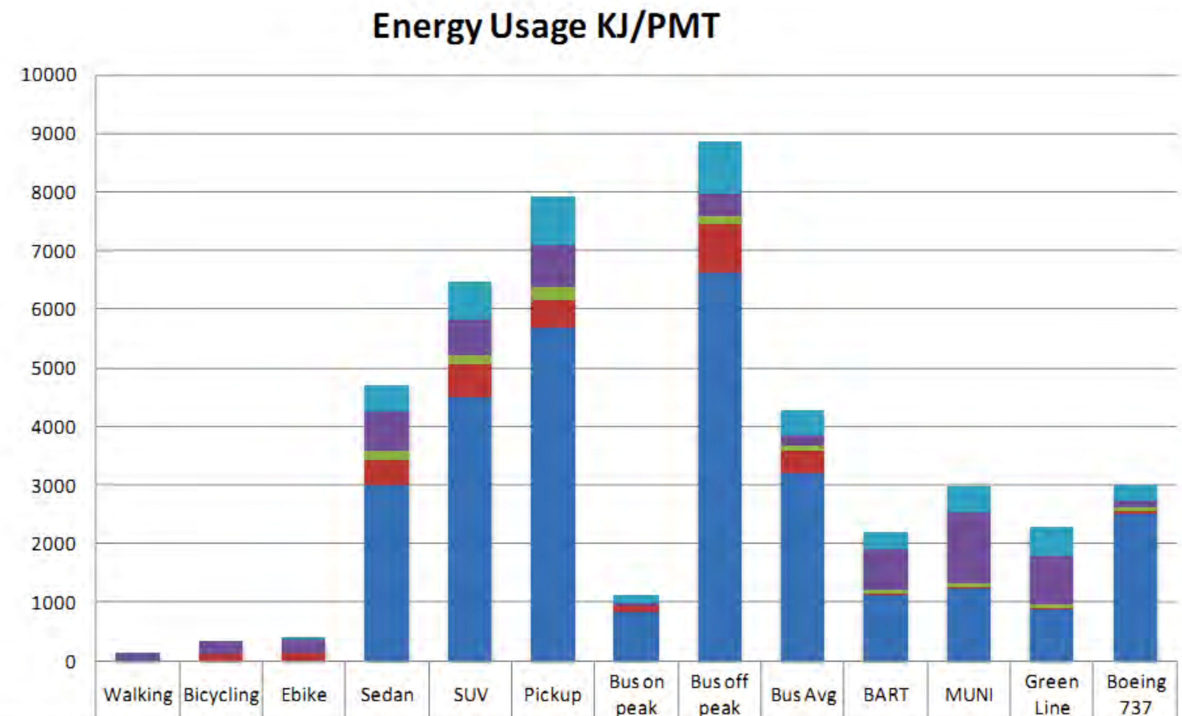


Figure 9.2 | Energy use (EJ) by economic sector. Note that the underlying data are calculated using the IEA physical content method, not the direct equivalent method[1] (IEA, 2008c). Note: RoW = Rest of World.

Note: 1. Historical energy data have only been available for energy use by economic sector. For a conversion of the data using the direct equivalent method, the different energy carriers used by each economic sector would need to be known.

Source: IPCC (2012) Renewable Energy Sources and Climate Change Mitigation, New York, NY: Cambridge U. Press, p. 719. http://srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf pp.662-672 is on transport

Energy Inputs by Transportation Mode

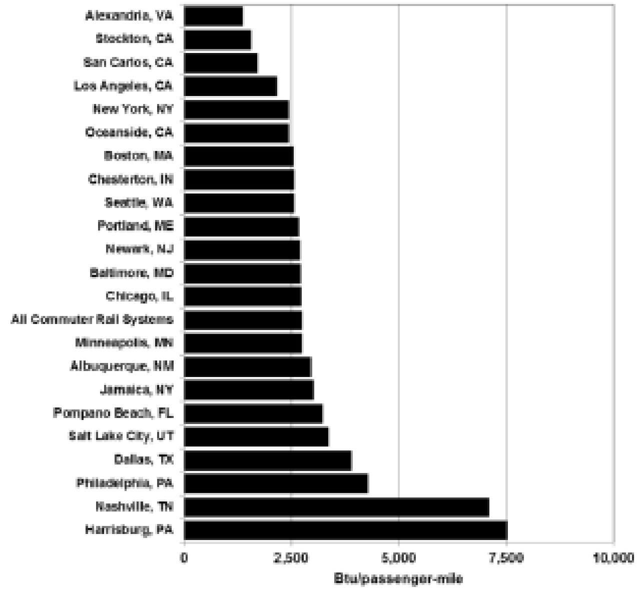


	Walking	Bicycling	Ebike	Sedan	SUV	Pickup	Bus on peak	Bus off peak	Bus Avg	BART	MUNI	Green Line	Boeing 737
Total	102	319	356	4694	6474	7914	1108	8837	4260	2187	2970	2270	2996
Fuel Production	0	0	2	430	640	810	110	840	400	274	418	487	250
Infrastructure	102	204	204	667	607	728	51	406	189	700	1233	829	119
Maintenance	0	9	9	184	180	208	18	144	68	41	51	54	56
Manufacturing	0	106	141	413	547	468	101	827	393	37	38	21	49
Operation	0	0	0	3000	4500	5700	828	6620	3210	1136	1230	879	2522

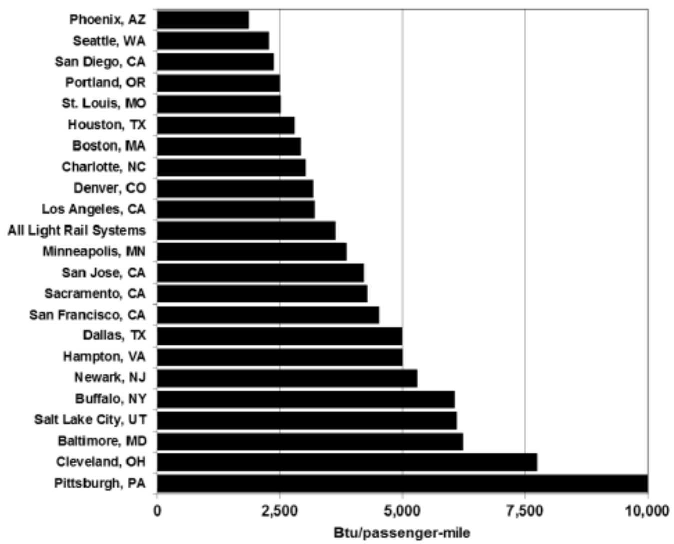
Figure 1: Energy input per PMT for commuter transport options

Shreya Dave (February 10, 2010) Life Cycle Assessment of Transportation Options for Commuters, Cambridge, MA, MIT, p. 10. PMT=Passenger Mile Traveled and is defined as VMT x occupancy per vehicle (p. 4). http://files.meetup.com/1468133/LCAwhitepaper.pdf

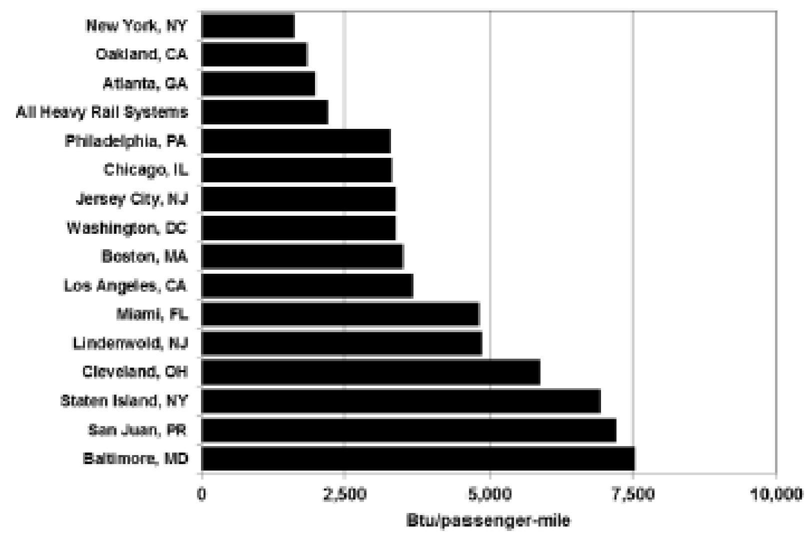
Energy Intensity for Alternative Rail Systems by City, 2013



Commuter Rail



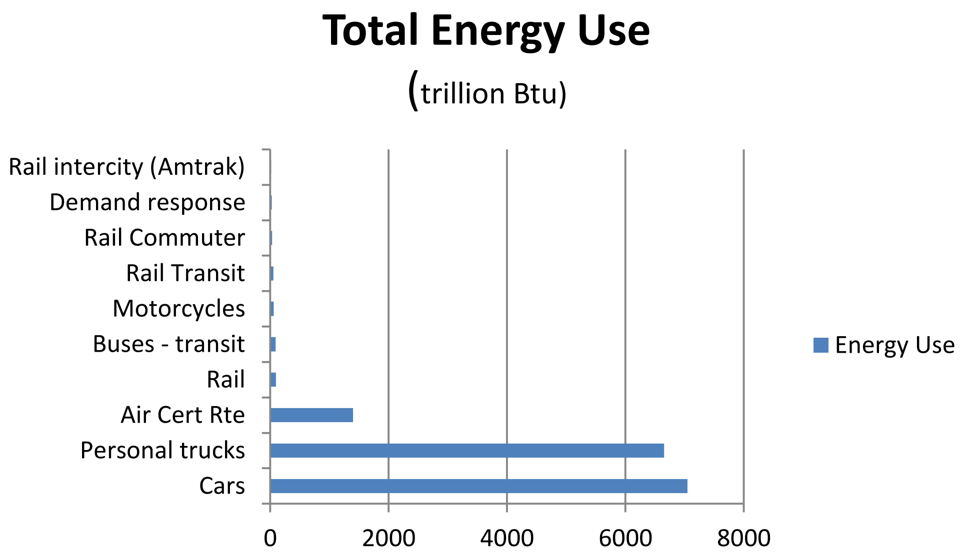
Light Rail

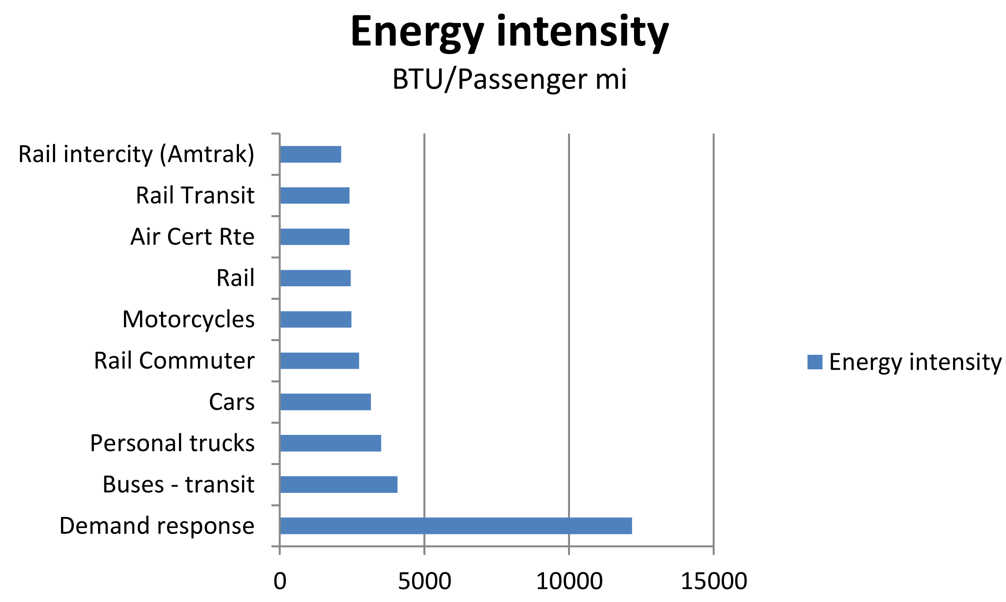


Heavy Rail

Source: Davis, S.C., S.W. Diegel, and Boundy, R.G. (2015) Transportation Energy Data Book Edition 34, Oak Ridge, TN: Oak Ridge National Laboratories, referencing the U.S. DOT National Transit Database. pp. 2-22 to 2-23, http://cta.ornl.gov/data/tedb34/Edition34_Full_Doc.pdf.

Energy Use and Energy Intensity of Alternative Transportation Modes, U.S., 2013





Source: Graphed from Davis, S.C., S.W. Diegel, and Boundy, R.G. (2015) Transportation Energy Data Book Edition 34, Oak Ridge, TN: Oak Ridge National Laboratories, referencing U.S. DOT National Transit Database. Graphed from p.2-19, http://cta.ornl.gov/data/tedb34/Edition34_Full_Doc.pdf.

III. Patterns and Trends in Transportation Emissions Worldwide

Emission patterns

- **“Cities account for over 70 percent of greenhouse gas emissions with a significant proportion due to urban transport choices.**
- **The transport sector directly accounted for nearly 30% of total end-use energy-related CO2 emissions.**
- **Of these, direct emissions from urban transport account for 40%.**

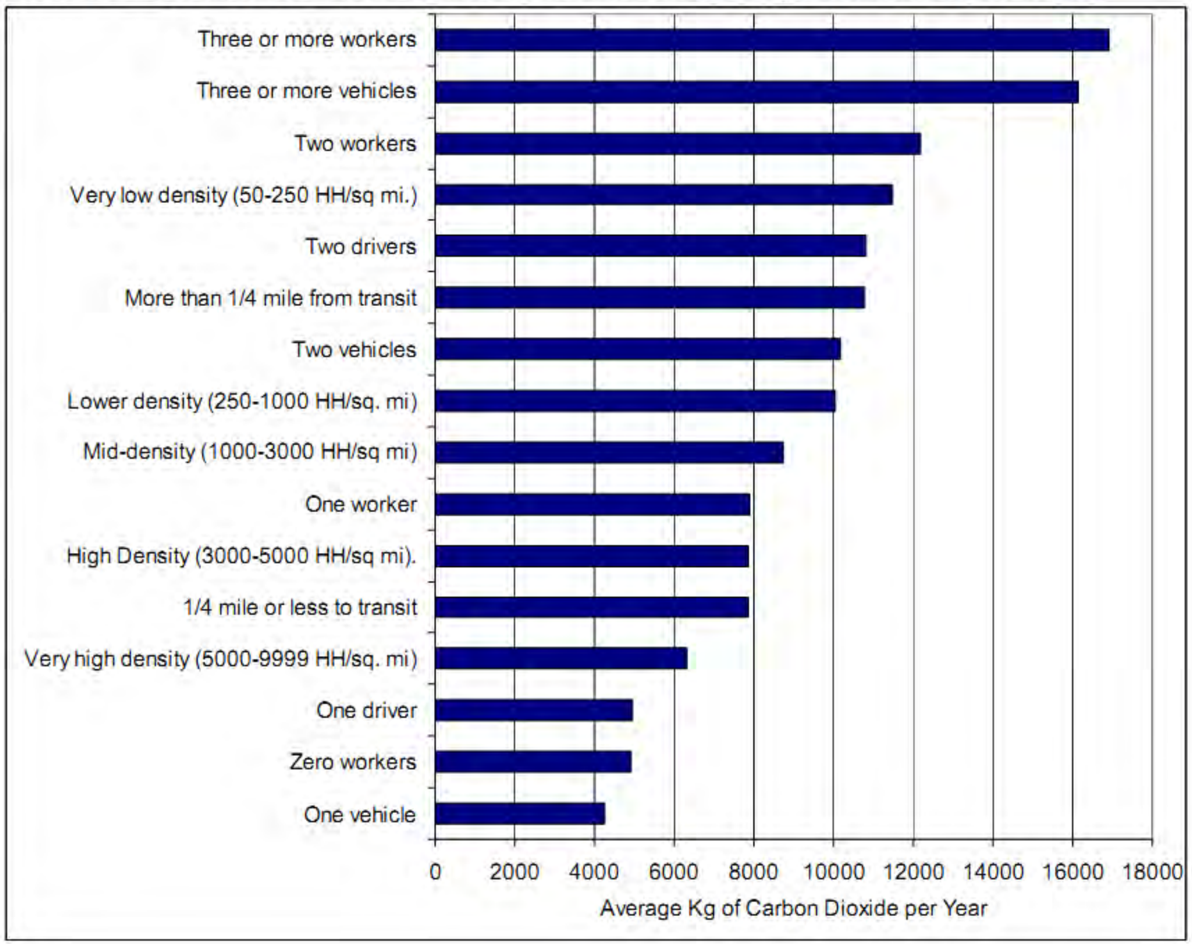
Growth rate patterns and trends

- **Urban transport emissions are growing at two to three percent annually.**
- **The majority of emissions from urban transport is from higher-income countries. In contrast, 90% of the growth in emissions is from transport systems in lower-income countries.”**

Source: Rosenzweig C., W. Solecki, P. Romero-Lankao, S. Mehrotra, S. Dhakal, T. Bowman, and S. Ali Ibrahim (December 2015). ARC3.2 Summary for City Leaders. Urban Climate Change Research Network. Columbia University. New York. P. 16. http://uccrn.org/files/2015/12/ARC3-2-web.pdf.

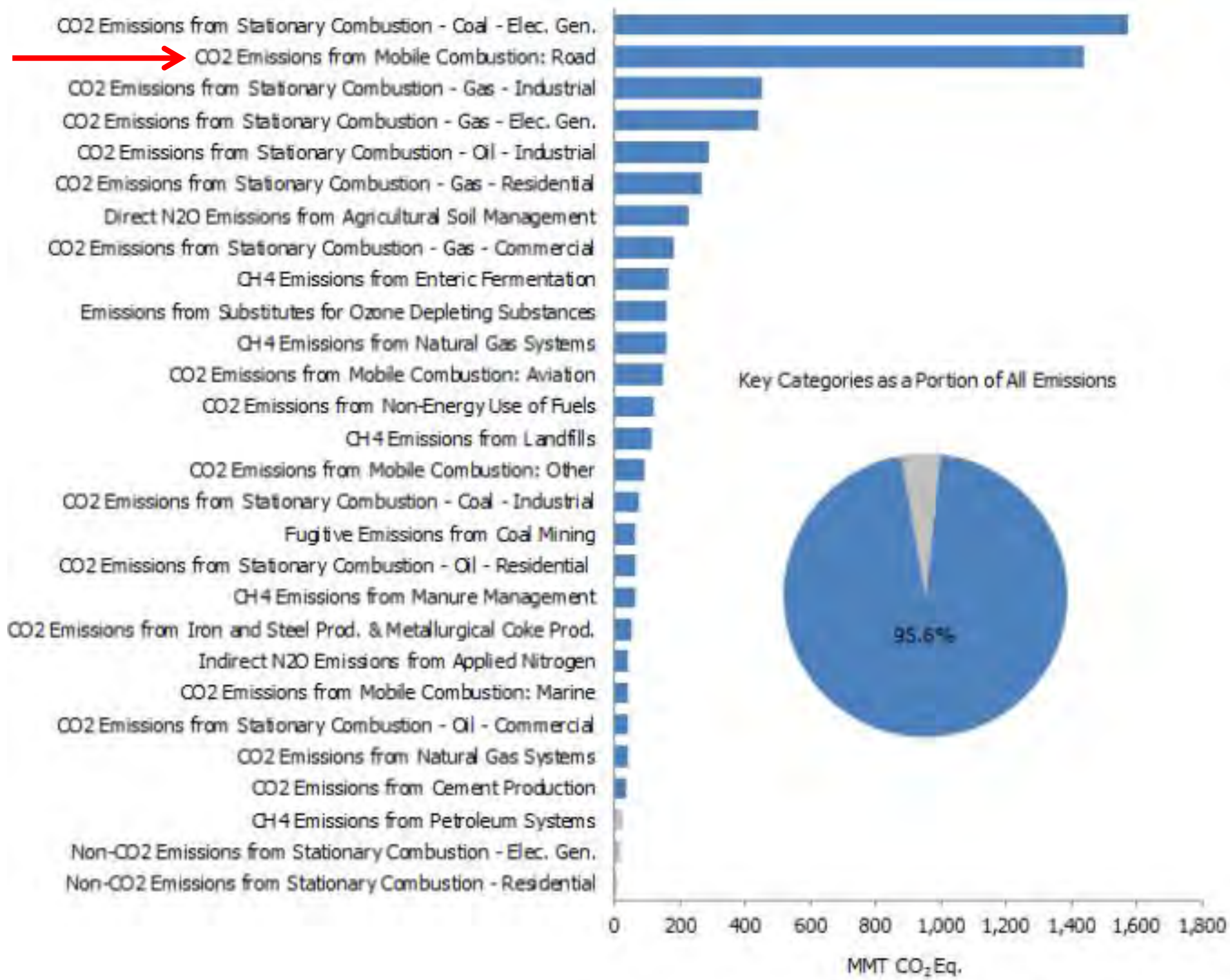
Population Density, Household Characteristics and Transportation Per Household CO2 Emissions, U.S.

Exhibit 2 – Household Characteristics and Est. Annual CO_2 Emissions from Travel



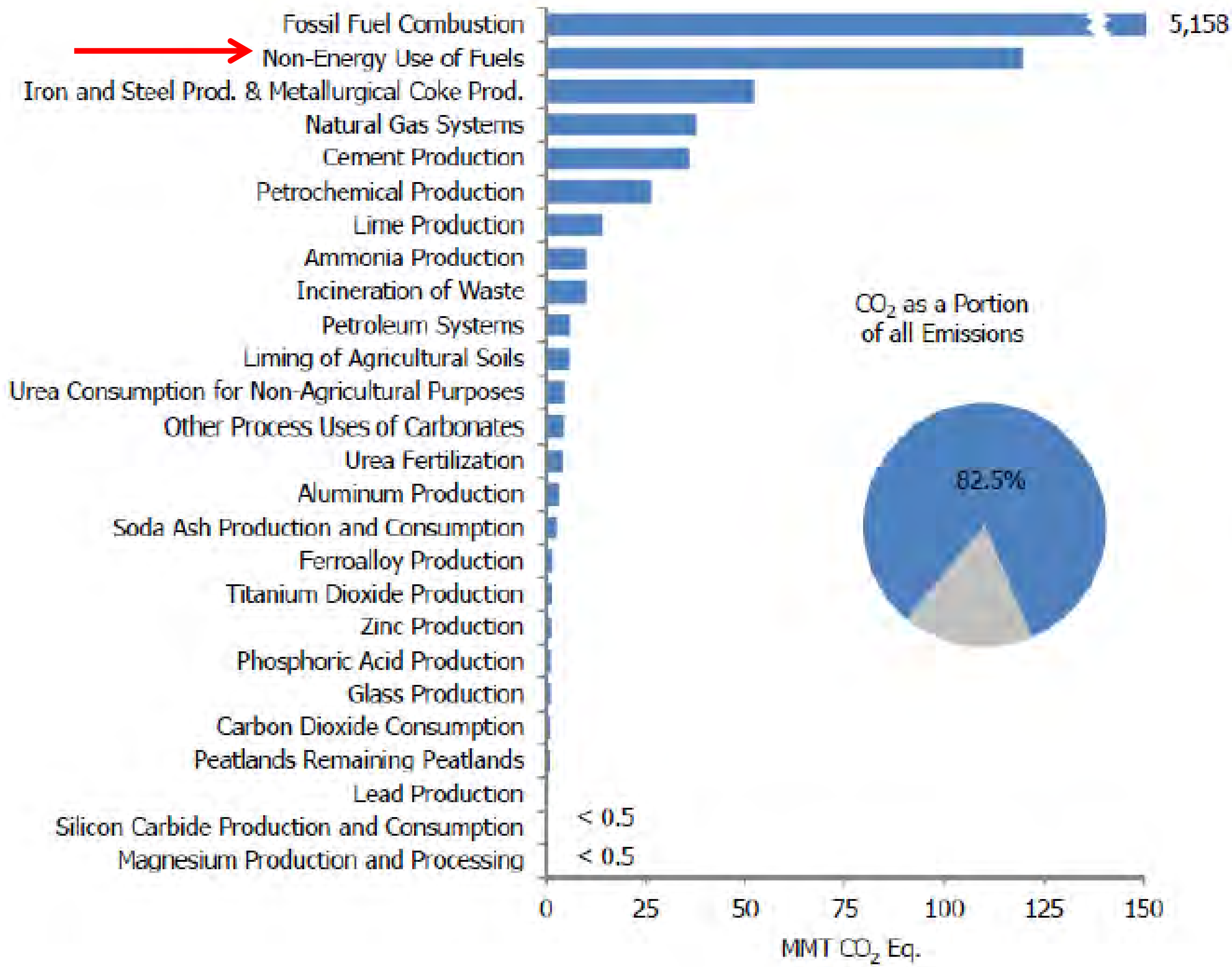
U.S.DOT, FHWA (March 2009) NHTS Brief. "The Carbon Footprint of Travel," 3 pp., p. 2
http://nhts.ornl.gov/briefs/Carbon%20Footprint%20of%20Travel.pdf

GHGs: Distribution of All GHG Emissions by Source



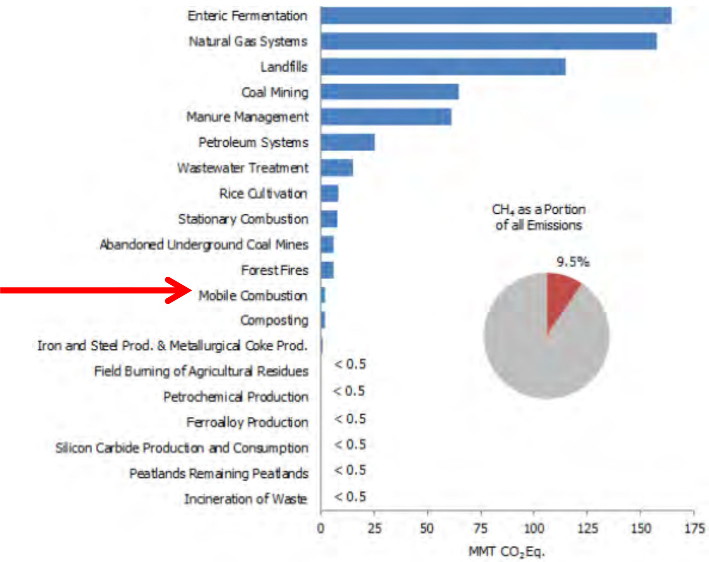
U.S. Environmental Protection Agency (April 2015) Inventory of Greenhouse Gases and Sinks 1990–2013, p. ES-26, available at http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf

Distribution of GHG Emissions of CO2 by Source

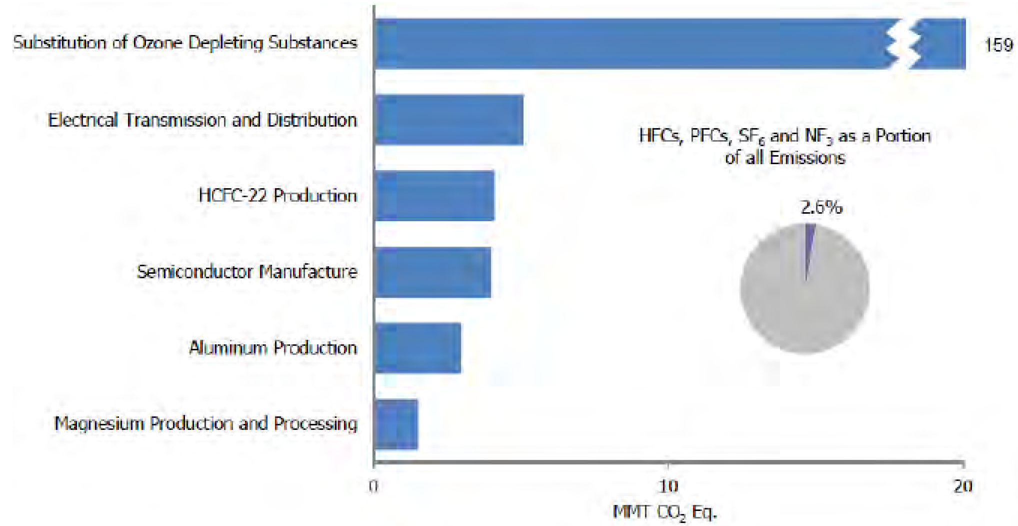


U.S. Environmental Protection Agency (April 2015) Inventory of Greenhouse Gases and Sinks 1990–2013, p. ES-9, available at http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf

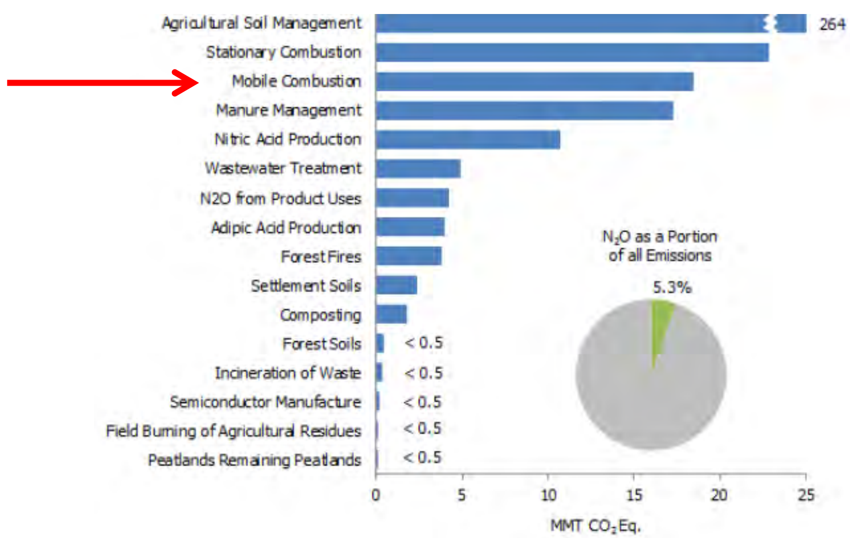
Sources of Individual GHG Emissions other than Carbon Dioxide



Methane



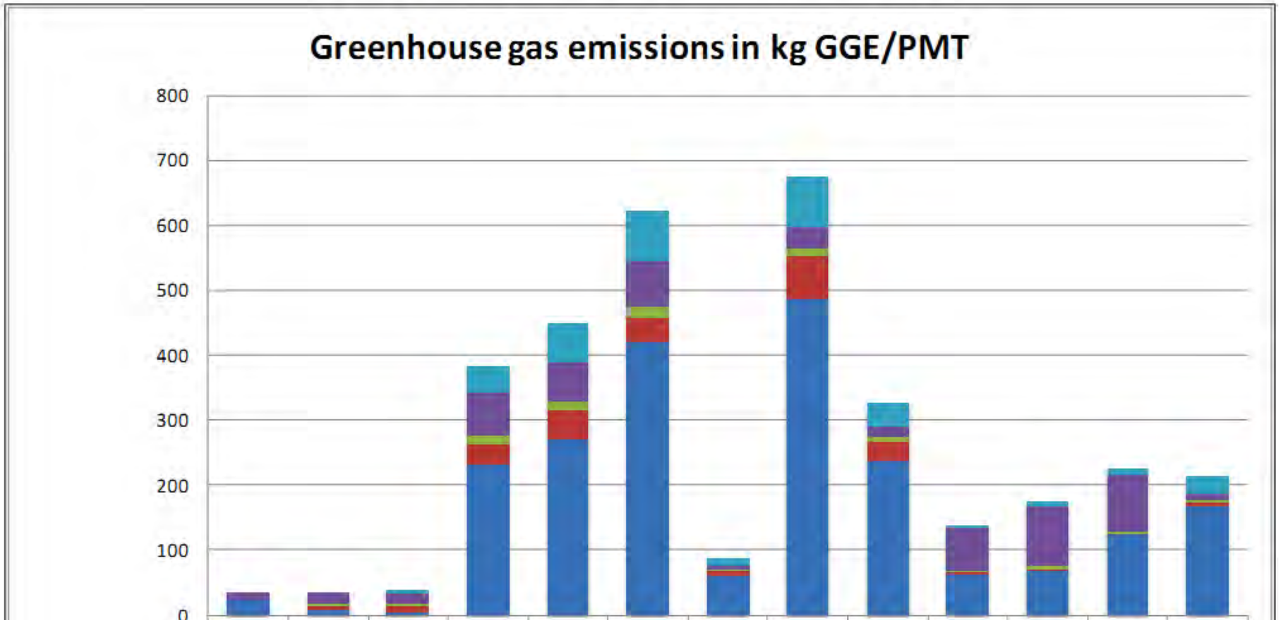
Synthetic Chemical Alternatives to Ozone



Nitrogen oxide

U.S. Environmental Protection Agency (April 2015) Inventory of Greenhouse Gases and Sinks 1990–2013, p. ES-13, 15, 16, available at http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf

Greenhouse Gas Outputs by Transportation Mode

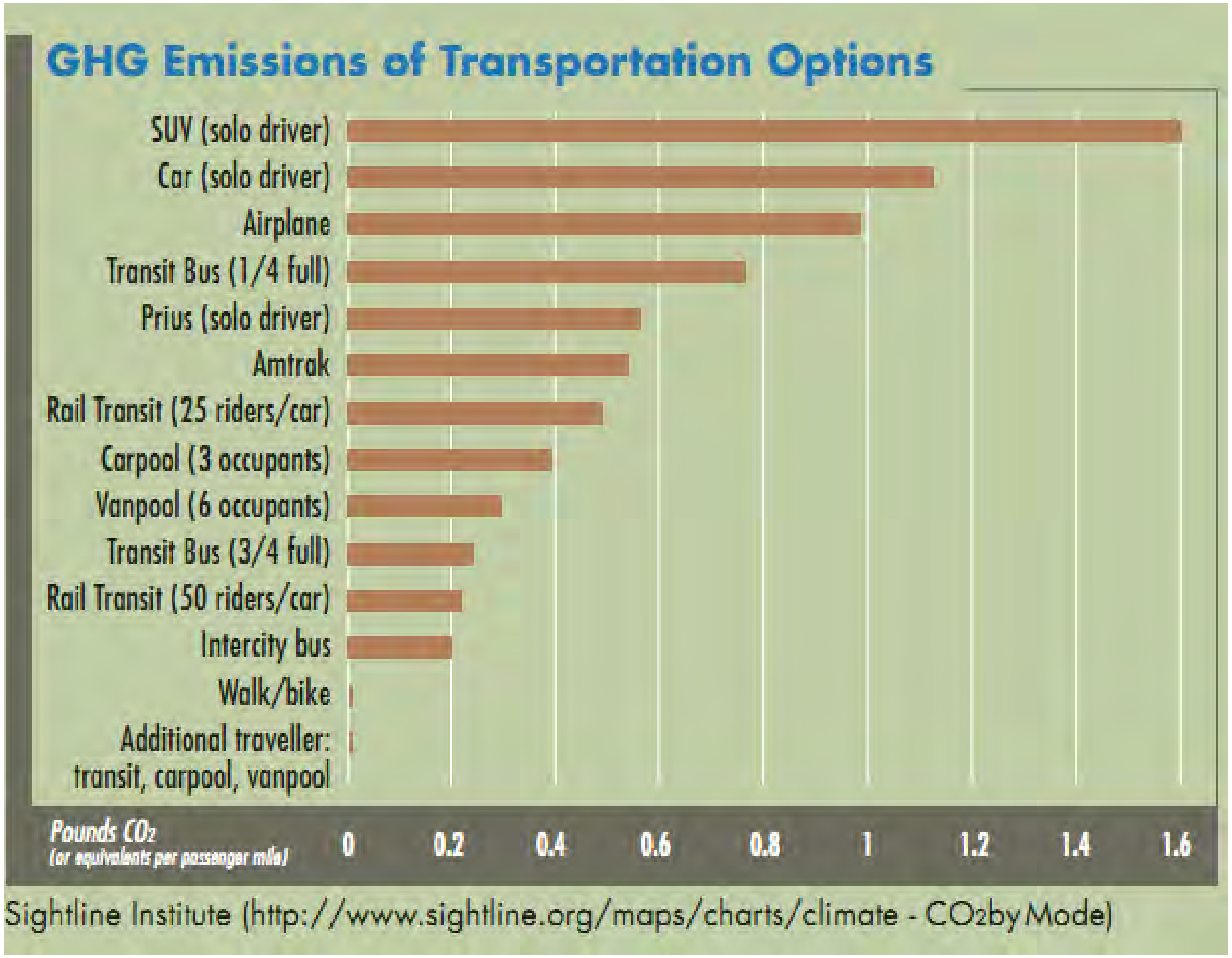


	Walking	Bicycling	Ebike	Sedan	SUV	Pickup	Bus on Peak	Bus off Peak	Bus Average	BART	MUNI	Green Line	Boeing 737
Total	33	33	33	382	446	619	85	674	326	136	173	224	210
Fuel Production	0	0	0.33	39	58	74	10	77	36	3	4	8	23
Infrastructure	9	17	17	65	59	71	4	34	16	64	94	87	11
Maintenance	0	1	1	15	14	17	1	12	6	2	4	4	4
Manufacturing	0	8	11	34	45	38	8	66	31	2	2	1	4
Operation	24	7	4	230	270	420	61	486	237	64	69	123	168

Figure 2: Greenhouse gas emissions per PMT for commuter transport options.

Shreya Dave (February 10, 2010) Life Cycle Assessment of Transportation Options for Commuters, Cambridge, MA, MIT, p. 11. PMT=Passenger Mile Traveled and is defined as VMT x occupancy per vehicle (p. 4). GGE=Greenhouse Gases Emitted. http://files.meetup.com/1468133/LCAwhitepaper.pdf

GHG Emissions and Travel Modes: The Transit Advantage



MTA (2009) Greening Mass Transit & Metro Regions. Final Report of the Blue Ribbon Commission on Sustainability and the MTA. New York, NY: The MTA, p. 7. http://www.mta.info/sustainability/pdf/SustRptFinal.pdf

Relative Share of Clean Air Act Criteria Air Pollutants

Total National Emissions of the Criteria Air Pollutants by Sector, 2013
(millions of short tons/percentage)

Sector	CO	NOx	VOC	PM-10	PM-2.5	SO_2
Highway vehicles	24.80	5.01	2.16	0.27	0.19	0.03
	33.8%	*38.2%*	*12.2%*	*1.3%*	*3.0%*	*0.6%*
Other off-highway	14.65	2.73	1.99	0.20	0.18	0.08
	19.9%	*20.8%*	*11.2%*	*0.9%*	*2.9%*	*1.5%*
Transportation total	39.45	7.74	4.15	0.47	0.37	0.11
	53.7%	*59.0%*	*23.4%*	*2.2%*	*5.9%*	*2.1%*
Stationary source fuel combustion	4.63	3.69	0.63	0.98	0.83	4.24
	6.3%	*28.1%*	*3.6%*	*4.7%*	*13.3%*	*82.1%*
Industrial processes	1.98	1.18	6.97	0.94	0.39	0.58
	2.7%	*9.0%*	*39.3%*	*4.5%*	*6.3%*	*11.3%*
Waste disposal and recycling total	1.11	0.08	0.13	0.20	0.17	0.02
	1.5%	*0.6%*	*0.7%*	*1.0%*	*2.7%*	*0.3%*
Miscellaneous	26.26	0.44	5.87	18.28	4.49	0.22
	35.8%	*3.3%*	*33.0%*	*87.6%*	*71.8%*	*4.2%*
Total of all sources	73.43	13.13	17.75	20.87	6.26	5.17
	100.0%	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*

Note: CO = Carbon monoxide. NO_x = Nitrogen oxides. VOC = Volatile organic compounds. PM-10 = Particulate matter less than 10 microns. PM-2.5 = Particulate matter less than 2.5 microns. SO_2 = Sulfur dioxide.

Source:
U. S. Environmental Protection Agency, National Emission Inventory Air Pollutant Emission Trends website www.epa.gov/ttn/chief/trends. (Additional resources: www.epa.gov/oar/oaqps)

Source: Davis, S.C., S.W. Diegel and R.G. Boundy (2014) Transportation Energy Data Book: Edition 33, Oak Ridge, TN: ORNL, p. 12-2. http://cta.ornl.gov/data/tedb33/Edition33_Full_Doc.pdf

III. Selected Intermodal Connectivity, NYC and NJ

Table 14 IPCD Bus Connectivity Summary, New York City, 2012

Facility Type	Bus Transit		Intercity Bus		Rail Heavy		Total
	#	row %	#	row %	#	row %	#
Airport	2	100%	2	100%	1	50%	2
Intercity bus	38	97%	39	100%	17	44%	39
Transit or local area ferries	7	64%	0	0%	4	36%	11
Heavy rail transit	337	72%	13	3%	469	100%	469
Intercity trains	20	91%	1	5%	7	32%	22
Total	404	74%	55	10%	498	92%	543

Note: New York City has no light rail facility so that row is not shown.

Table 15 IPCD Bus Connectivity Summary, New Jersey, 2012

Facility Type	Bus Transit		Intercity Bus		Rail Heavy		Rail Light		Total
	#	row %	#	row %	#	row %	#	row %	#
Airport	2	67%	1	33%	0	0%	0	0%	3
Intercity bus	7	50%	14	100%	1	7%	2	14%	14
Intercity passenger ferries	1	100%	0	0%	0	0%	0	0%	1
Transit of local area ferries	6	43%	1	7%	2	14%	5	36%	14
Light rail transit	31	51%	2	3%	5	8%	61	100%	61
Heavy rail transit	12	75%	3	19%	16	100%	5	31%	16
Intercity trains	95	64%	2	1%	2	1%	4	3%	149
Total	154	60%	23	9%	26	10%	77	30%	258

Source: Zimmerman, R. et al. (2014), "Promoting Transportation Flexibility in Extreme Events through Multi-Modal Connectivity," New York, NY: NYU-Wagner. Funded by the U.S. DOT Region 2 UTRC. GIS constructed diagram by Joshua Sellers. Poorer areas are defined here as having higher percentages of their populations below poverty (census tract level). Page25. Calculated from the Intermodal Passenger Connectivity Database.

Multimodal Transportation on September 11, 2001

	Initial	Ultimate
Walk	92.6% (1,257/1,358)	77.0% (1,045/1,358)
Car/taxis	2.9% (39/1,358)	23.3% (316/1,358)
Bus	2.1% (28/1,358)	12.7% (173/1,358)
Emergency vehicle	1.8% (24/1,358)	2.5% (34/1,358)
Rail	1.0% (14/1,358)	20.8% (283/1,358)
Subway	4.9% (66/1,358)	13.9% (189/1,358)
Ferry	2.0% (27/1,358)	16.9% (229/1,335)
Other	0.6% (8/1,358)	1.0% (13/1,358)

Source: R. Zimmerman and M. Sherman, "To Leave An Area After Disaster: How Evacuees from the WTC Buildings Left the WTC Area Following the Attacks," Risk Analysis, Vol. 31, Issue 5, 2011, pp. 787-804. P. 794. Modes used in initial and ultimate destinations (regardless of how many modes checked).

Multimodal Transportation on September 11, 2001

Number of Modes Used for the Initial Destination

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	1,270	88.0%	93.0%	93.0%
	2.00	76	5.3%	5.6%	98.5%
	3.00	17	1.2%	1.2%	99.8%
	4.00	3	0.2%	0.2%	100.0%
Total		1,366	94.6%	100.0%	
Missing		78	5.4		
Total		1,444	100.0		

Number of Modes Used for the Ultimate Destination

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	778	53.9%	55.3%	55.3%
	2.00	376	26.0%	26.7%	82.0%
	3.00	184	12.7%	13.1%	95.1%
	4.00	59	4.1%	4.2%	99.3%
	5.00	9	0.6%	0.6%	99.9%
	6.00	1	0.1%	0.1%	100.0%
Total		1,407	97.4%	100.0%	
Missing		37	2.6%		
Total		1,444	100.0%		

Source: R. Zimmerman and M. Sherman, "To Leave An Area After Disaster: How Evacuees from the WTC Buildings Left the WTC Area Following the Attacks," Risk Analysis, Vol. 31, Issue 5, 2011, pp. 787-804. P.

Connectivity Within Rail Systems
Rail Transit Systems in All Shapes and Sizes (and Vehicle Types): U.S.

San Francisco

Chicago

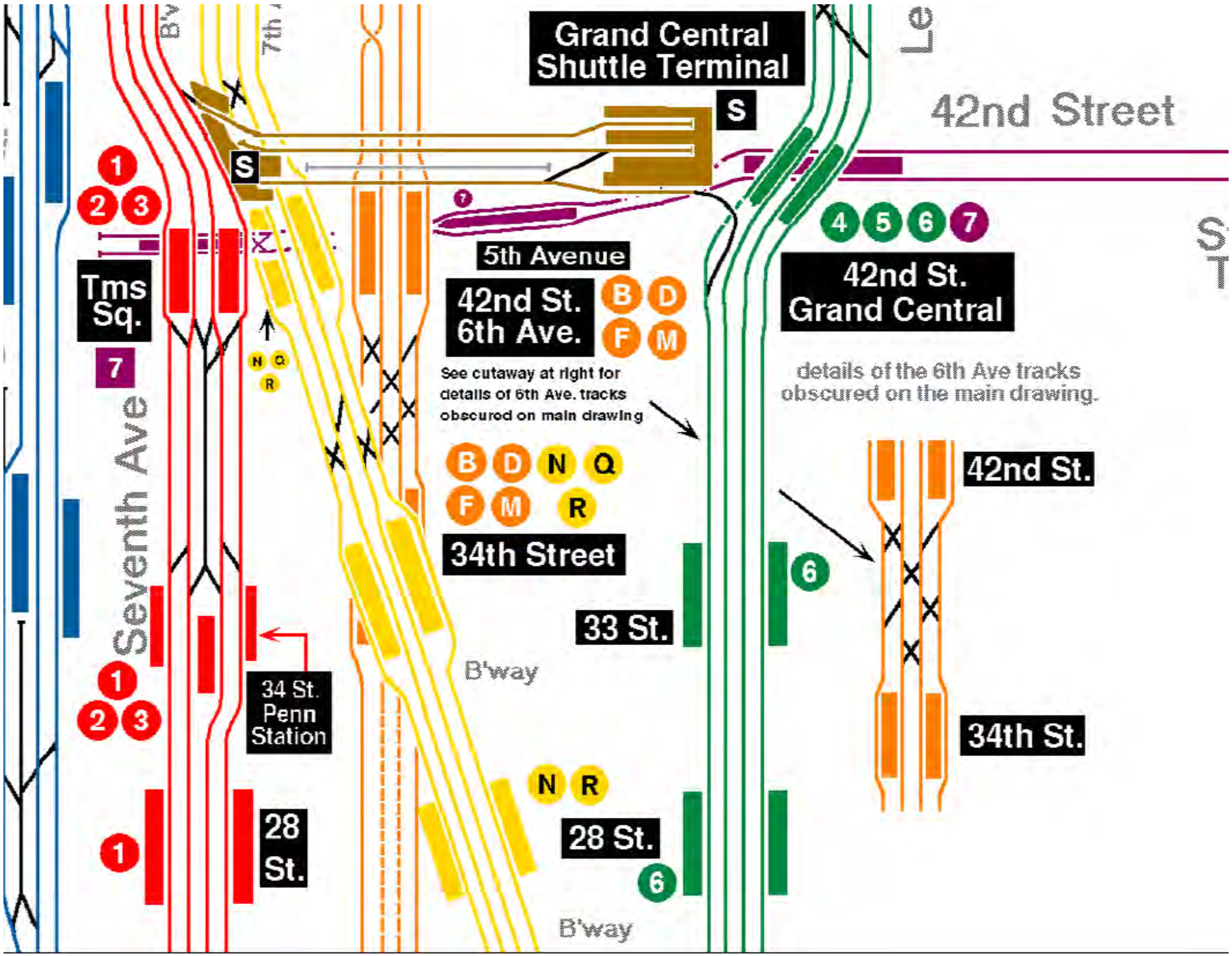
Washington DC

Los Angeles

Atlanta

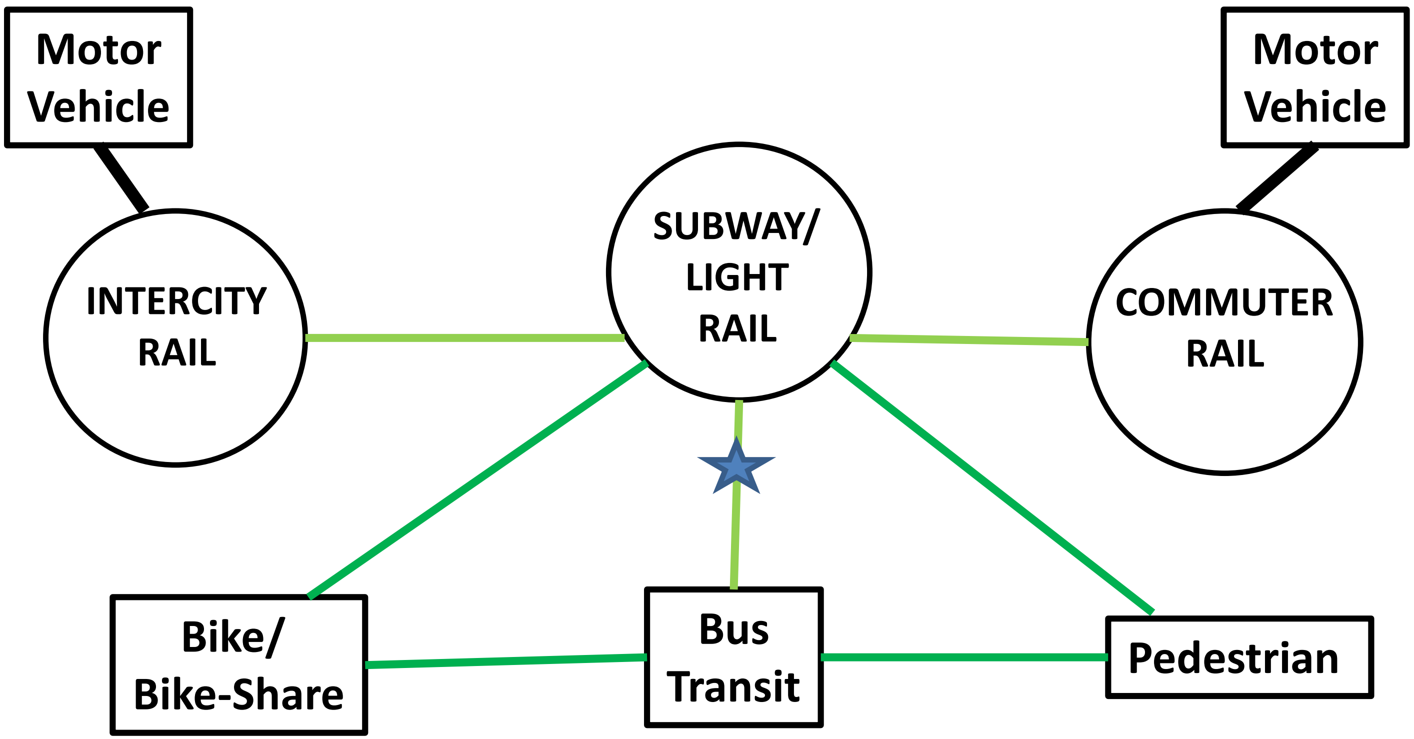
NYC Transit System: Dense Interconnected Core with Radial Spokes

NYC Subway Interchanges: 34th-42nd Streets

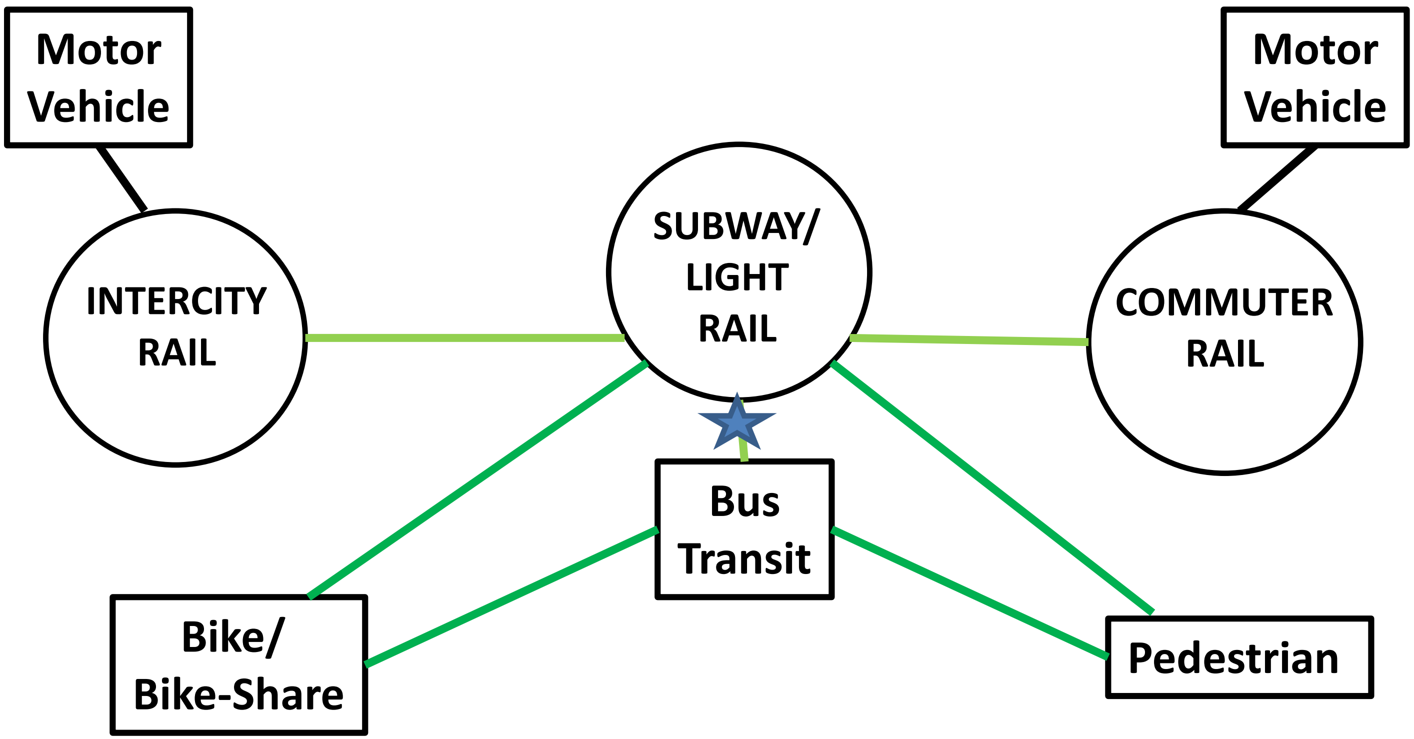


Source: Peter Dougherty, updates by Matthew Shull and Patrick Michel

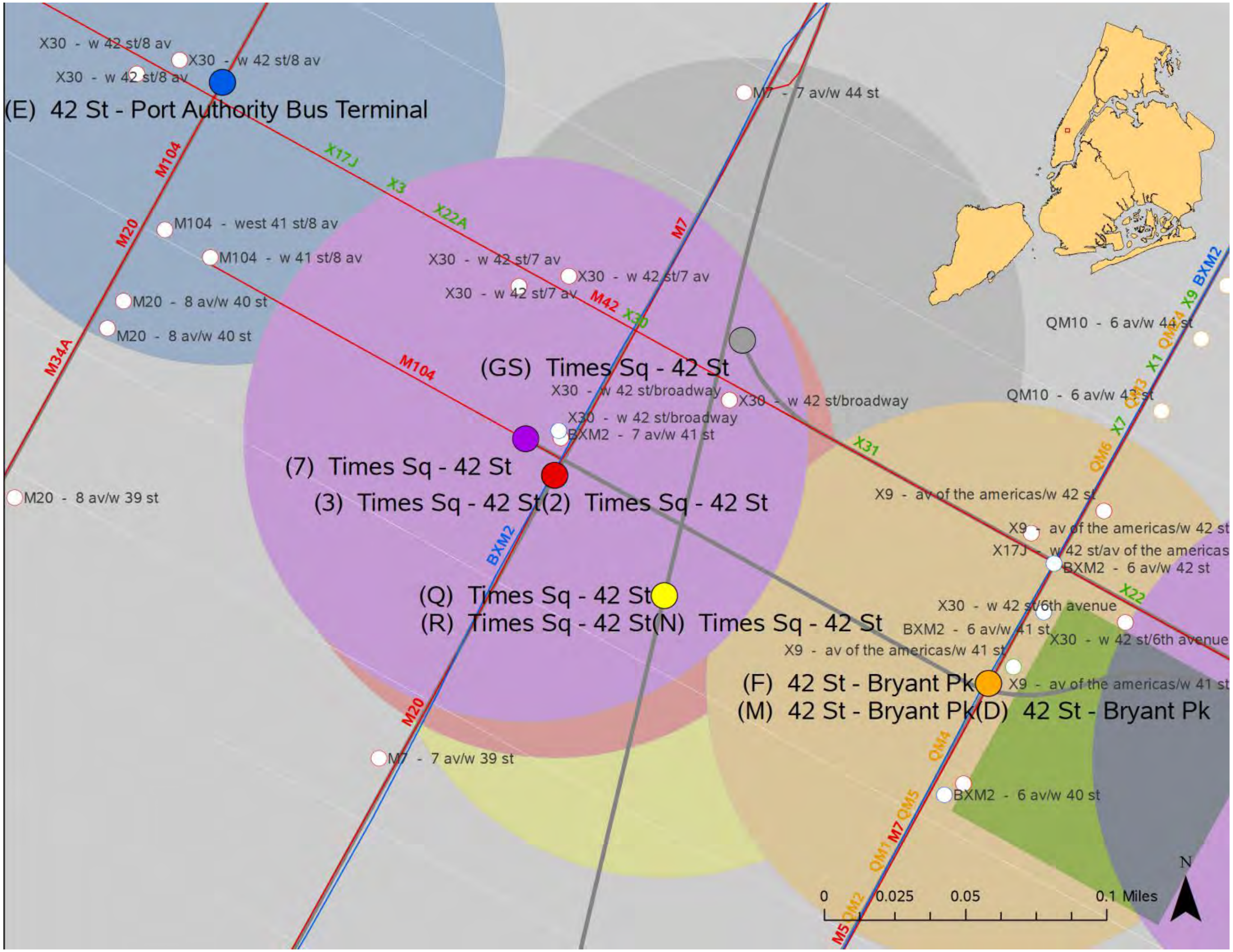
Multimodal Connectivity: A Framework to Move from Gray to Green



Multimodal Connectivity: A Framework to Move from Gray to Green – Bring Them Closer

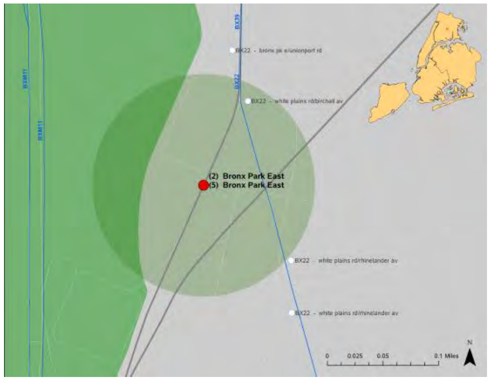


Flexibility Through Multi-Modal Connections: Bus Connections at Subway Stations, NYC

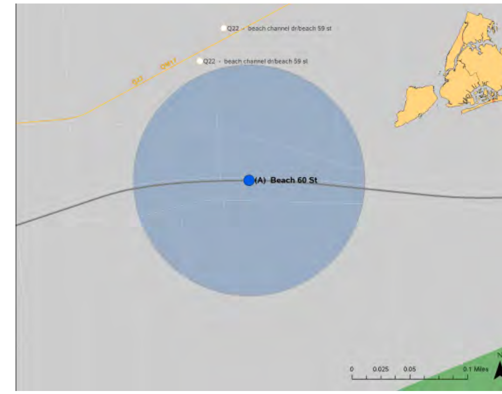


Source: Zimmerman, R. et al. (2014), "Promoting Transportation Flexibility in Extreme Events through Multi-Modal Connectivity," New York, NY: NYU-Wagner. Funded by the U.S. DOT Region 2 UTRC. GIS constructed diagram by Joshua Sellers.

Flexibility Through Multi-Modal Connections: Bus Connections at Subway Stations in Poorer Areas, NYC

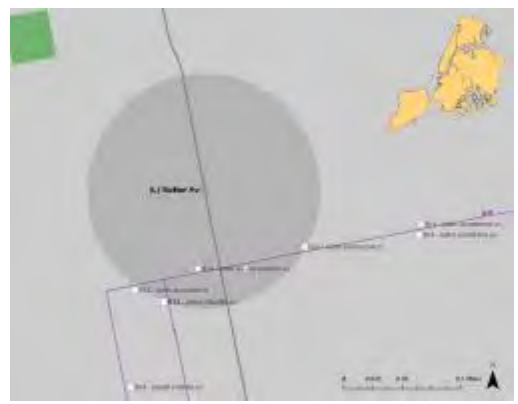


Bronx Park East, The Bronx
(64.4% below poverty)



Beach 60th Street, Queens
($16,714 median income)

East Broadway, Manhattan
($18,832 median income)



Sutter Ave., Brooklyn
(52.9% below poverty)

These illustrate stations in poorer areas with relatively few buses stopping, however, other poor areas exist that do have more numerous buses stopping depending how “poor” is defined. Poorer areas with little transit connections need to be prepared better for evacuation.

Source: Zimmerman, R. et al. (2014) “Promoting Transportation Flexibility in Extreme Events through Multi-Modal Connectivity,” New York, NY: NYU-Wagner. Funded by the U.S. DOT Region 2 UTRC. GIS constructed diagram by Joshua Sellers. Poorer areas are defined here as having higher percentages of their populations below poverty (census tract level) for Bronx and Brooklyn and median household income for Queens and Manhattan.

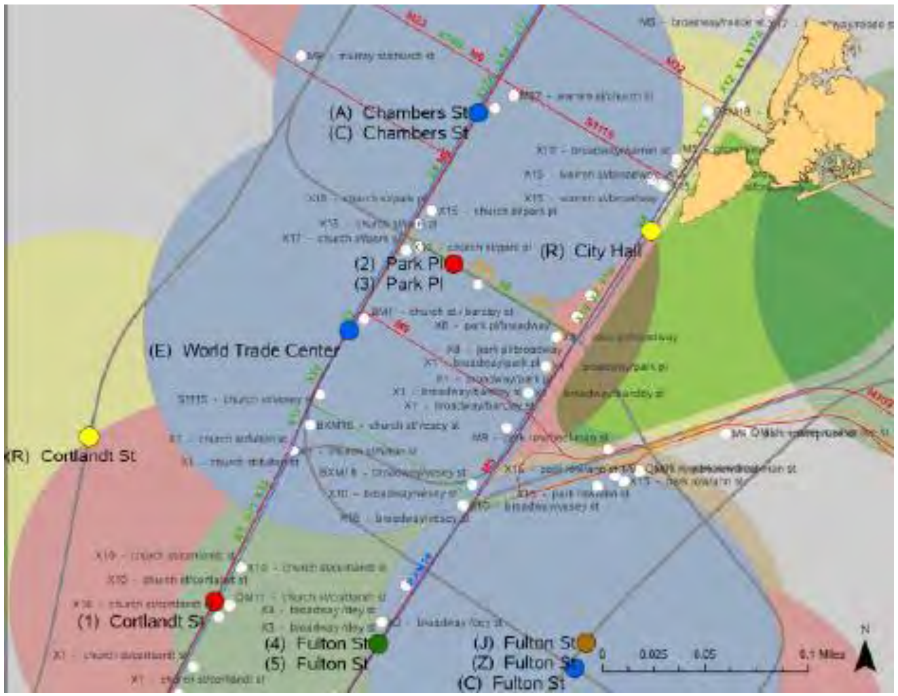
Intermodal Connectivity at Subway Terminuses where Connectivity is Greatest in Brooklyn and SI

Flatbush Ave-Brooklyn College, Brooklyn

Source: Zimmerman, R. et al. (2014), "Promoting Transportation Flexibility in Extreme Events through Multi-Modal Connectivity," New York, NY: NYU-Wagner. Funded by the U.S. DOT Region 2 UTRC. GIS constructed diagram by Joshua Sellers.

St. George, Staten Island

Intermodal Connectivity at Subway Terminuses where Connectivity is Greatest in Manhattan and Queens



World Trade Center, Manhattan

Flushing Main Street, Queens

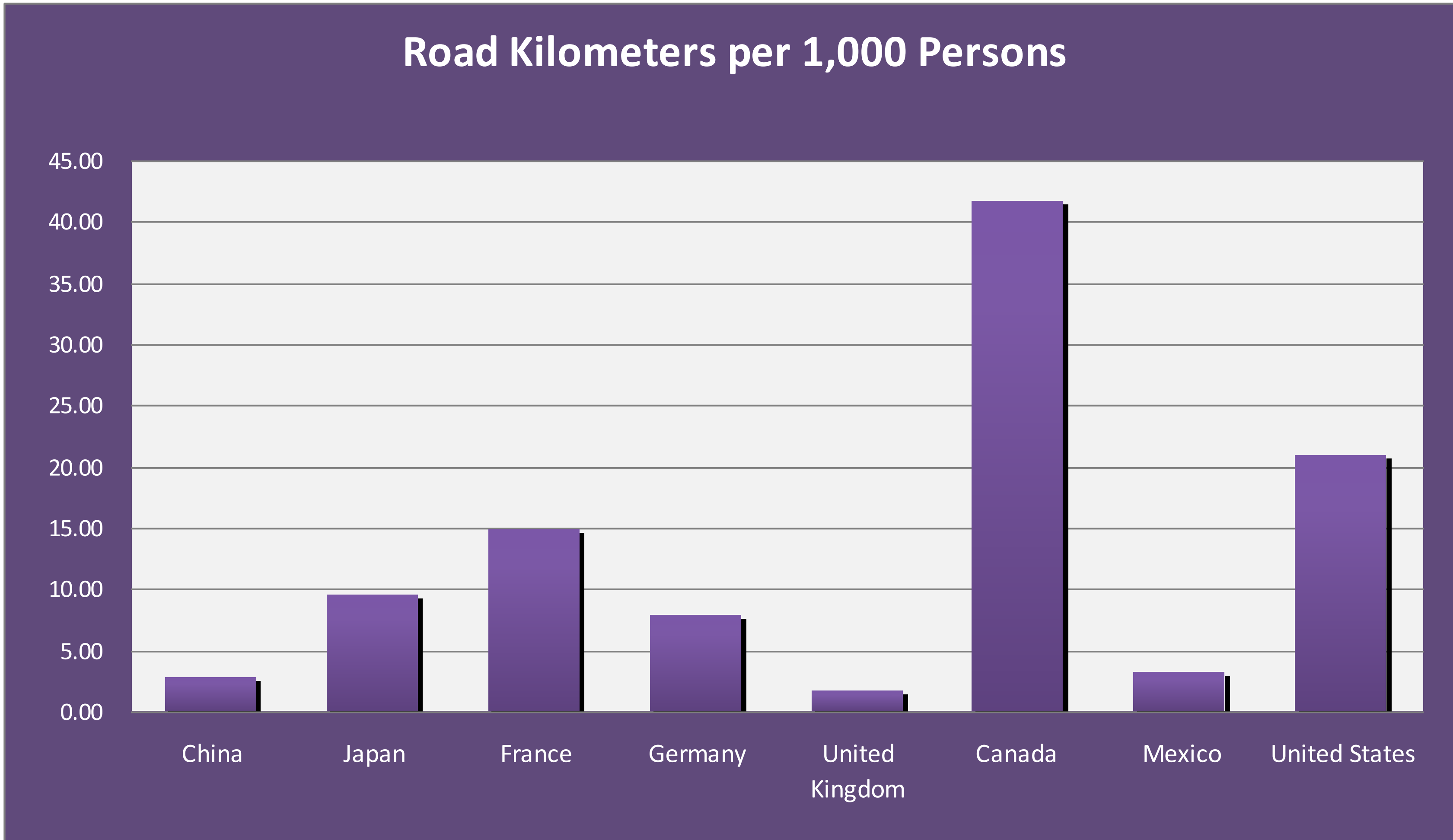
IV. Not Only Modes, But How Your Use Them

Roadway Extent - Land Consumption by Roads, U.S.

- **Land consumption by roads can be computed multiplying a curb length by a street width used to serve that land use (Litman March 2011)**
- **Litman (2011, p. 38) cites estimates from others:**
  - **Residential areas 10-30%**
  - **Commercial areas 50-70%**

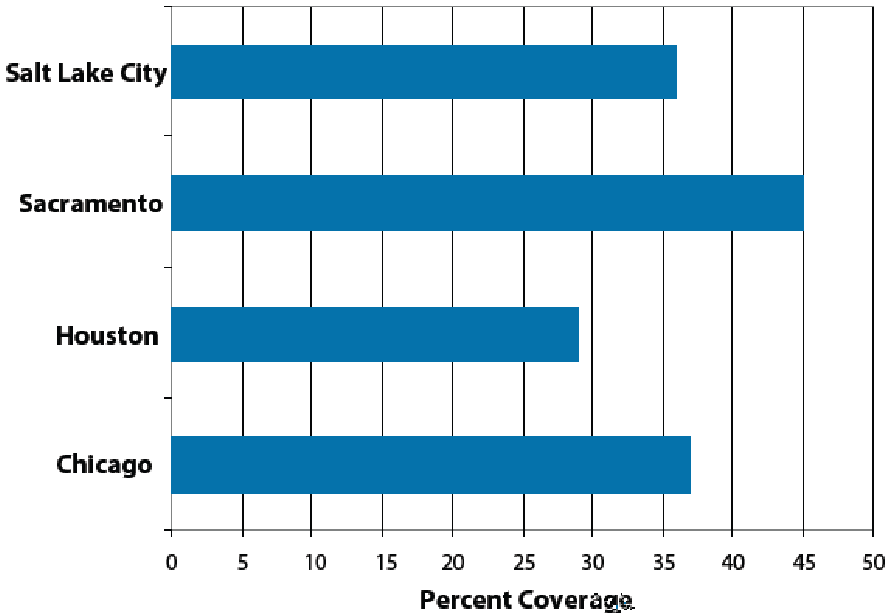
  Source: Litman, Todd (March 2011) 'Why and how to reduce the amount of land paved for roads and parking facilities', Environmental Practice 13 (1), 38-46.
- **According to Forman (2000, p. 31) roads and roadsides cover 1% of the US area, but the ecological effects extend much further. (Forman, R.T.T. (2000), 'Estimate of the area affected ecologically by the road system in the United States', Conservation Biology, 14 (1), 31-35.)**
- **New York City estimates that 18.6% of its land area is consumed by street surfaces which accounts for 24.3% of its impervious surfaces (NYC PlaNYC Sustainable Stormwater Management Plan 2008, p. 31)**
- **Land consumption by road type is another way of estimating land consumption by transportation and also the need for innovative approaches to reducing adverse effects of large paved areas.**

Land Consumption by Roads in Selected Countries, per capita, 2010

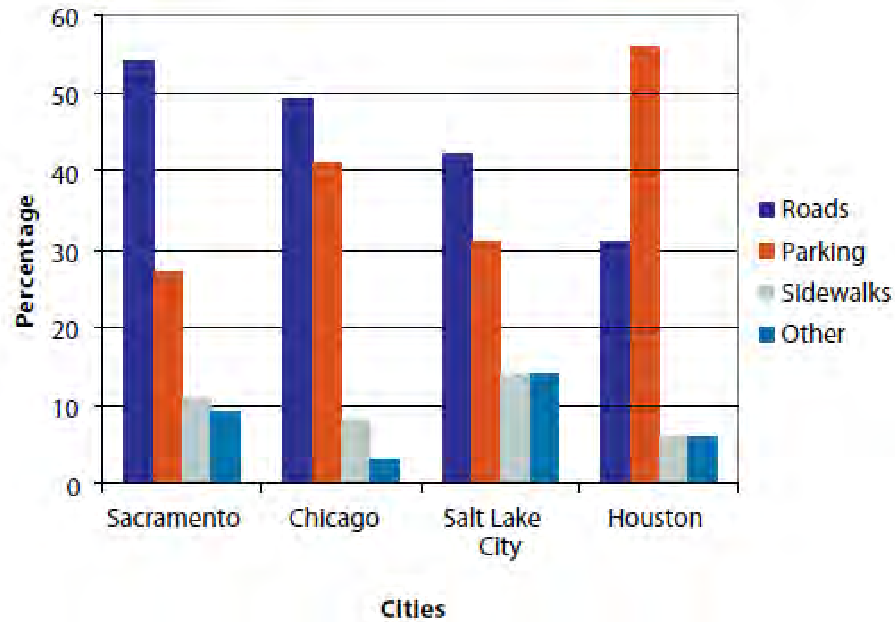


U.S. Department of Transportation, Federal Highway Administration (FHWA) (October 2010) Highway Statistics 2009 Road System Measures for Selected Countries (Metrics), Table IN-3
http://www.fhwa.dot.gov/policyinformation/statistics/2009/in3.cfm

Extent of Pavement in Selected Cities



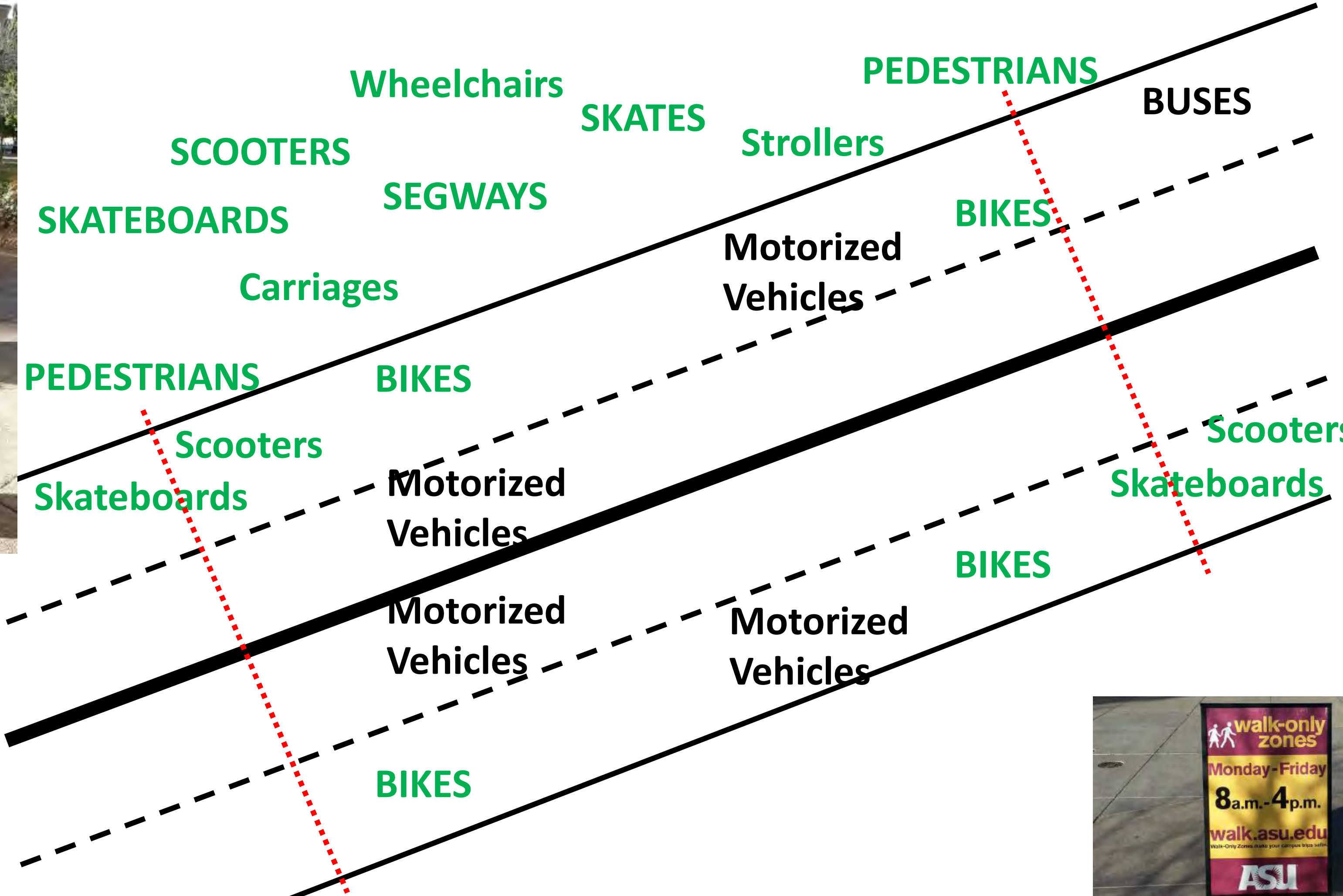
Extent of pavement coverage



Extent of pavement coverage by land use

Source: U.S. EPA (October 2008) Reducing Urban Heat Islands: Compendium of Strategies, Chapter 5, "Cool Pavements," p. 1 and p. 12, http://www.epa.gov/heatisld/resources/compendium.htm Lawrence Berkeley National Labs.

Sharing the Streets and Sidewalks . . .



Notes: Only road and sidewalk transportation is indicated (i.e., non-rail); Motorized Vehicles include cars, for-hire vehicles, trucks, and special purpose vehicles. Bikes can be non-motorized or motorized.

Re-Designing Streets for Bikes and Cars, NYC and other cities

Source: Photo by R. Zimmerman 2012, 2016

Greening Roadways Roadside Swale, Salt Lake City, Utah

Greening Rail: Corridors for Pedestrian Use

New (Existing and Proposed) Pedestrian Paths from Rail Lines

- Paris: Promenade Plantée
- Singapore Green Corridor
- Atlanta: BeltLine
- Chicago: Bloomingdale Trail
- New Orleans: Lafitte Greenway (proposed)
- New York: The High Line
- New York (Queens): QueensWay
- Philadelphia: The Reading Viaduct
- Seattle: Waterfront Seattle
- St. Louis: The Iron Horse Trestle

R. Zimmerman (2012) Transport, the Environment and Security. Making the Connection, Cheltenham, UK and Northampton, MA: Edward Elgar Publishing, Ltd., p. 19. http://www.e-elgar.com/bookentry_mainUS.lasso?id=13884

Greening Transit Corridors, Bordeaux, France

Sources: Photo by R. Zimmerman, June 2012.

Alternative, Distributed Energy Resources
Independent Energy Generation for Transit: Photovoltaics, NYCT Corona Maintenance Shop Roof

NYC Transit (2010) Corona Maintenance Shop. NYCT First LEED Certification. http://www.pcac.org/wp-content/uploads/2010/08/corona_leed_presentationac2ad_trb_print1.pdf

V. Eco-mobility is Also Responding to Disruptions, i.e., Resilience

Reinventing and Redistributing Buses for Special Purposes

Source: MTA and other photos

Vulnerability of Multimodal and Intermodal Transportation Systems to Sea Level Rise and Storm Flooding:
Critical Elevations of Selected PANYNJ Facilities Potentially Impacted by Flooding and Storm Surge from Storms and Sea Level Rise

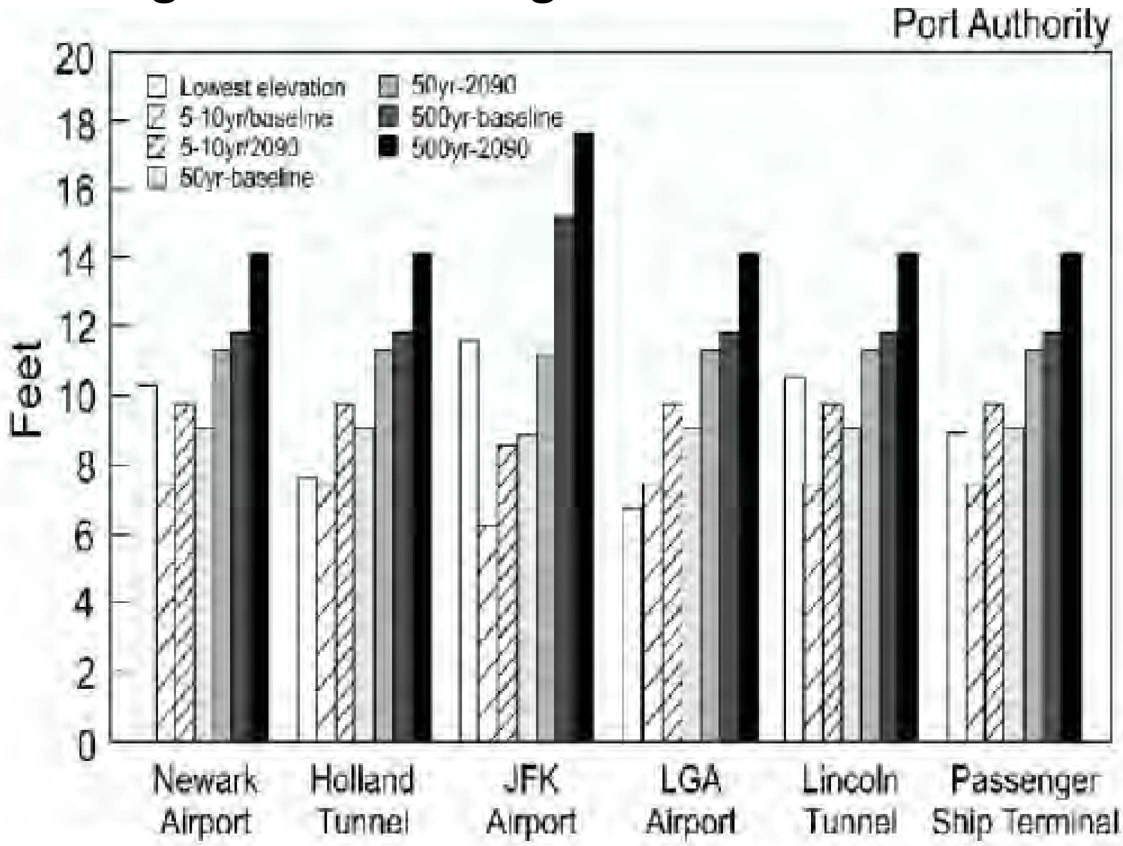
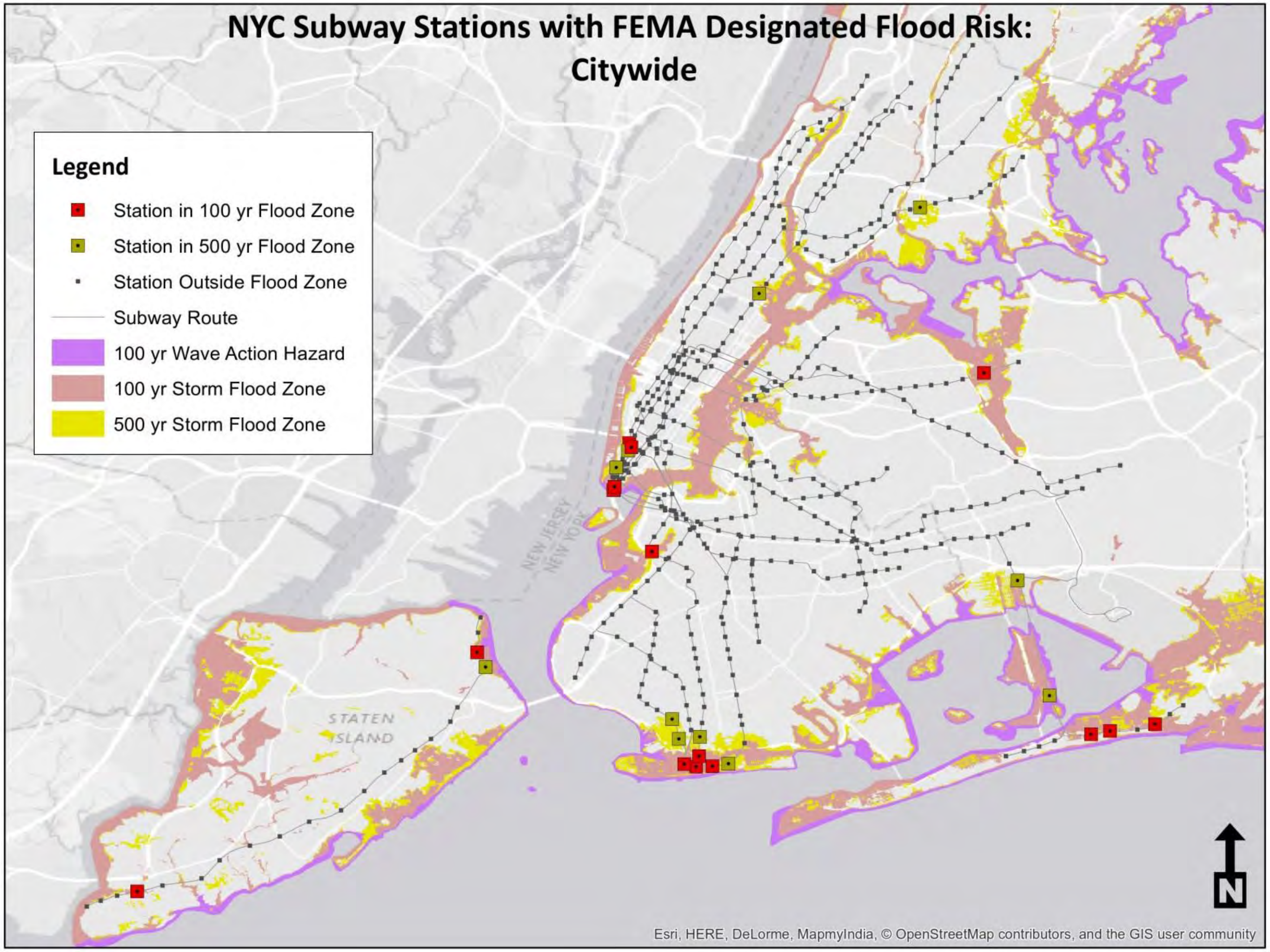


FIGURE 3-2 Current lowest critical elevations of facilities operated by the Port Authority of New York and New Jersey compared with changing storm elevations at these locations for surge recurrence periods of 10, 50, and 500 years between 2000 (baseline) and the 2090s. (Note that 10 ft equals approximately 3 m. Source: Jacob et al. 2007. [Copyright Elsevier 2007. Reprinted with permission of Elsevier Limited, Oxford, UK.])

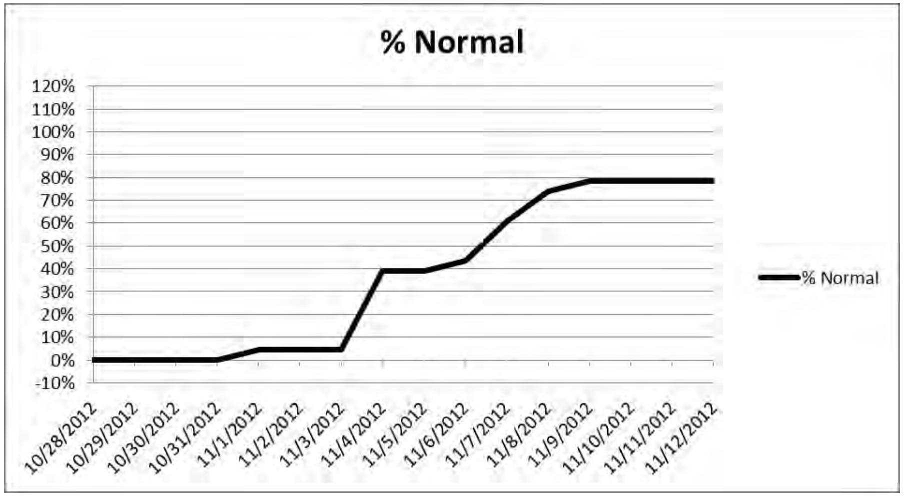
Source: TRB, Potential Impacts of Climate Change on U.S. Transportation, 2008, prepublication copy, http://onlinepubs.trb.org/onlinepubs/sr/sr290.pdf

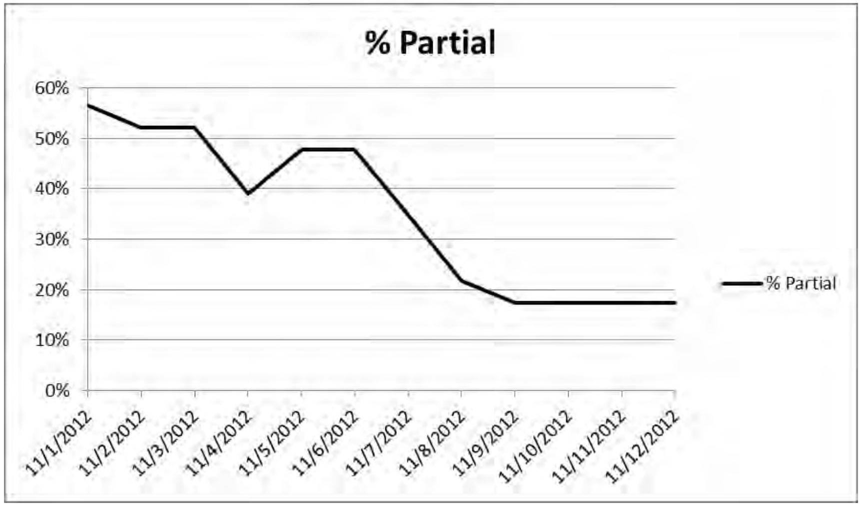
Subway Location and Flooding Risk



Source: R. Zimmerman, NSF Rapid Grant.

Full and Partial Restoration of New York City Subway Lines, Post-Hurricane Sandy, 10/28/12-11/12/12

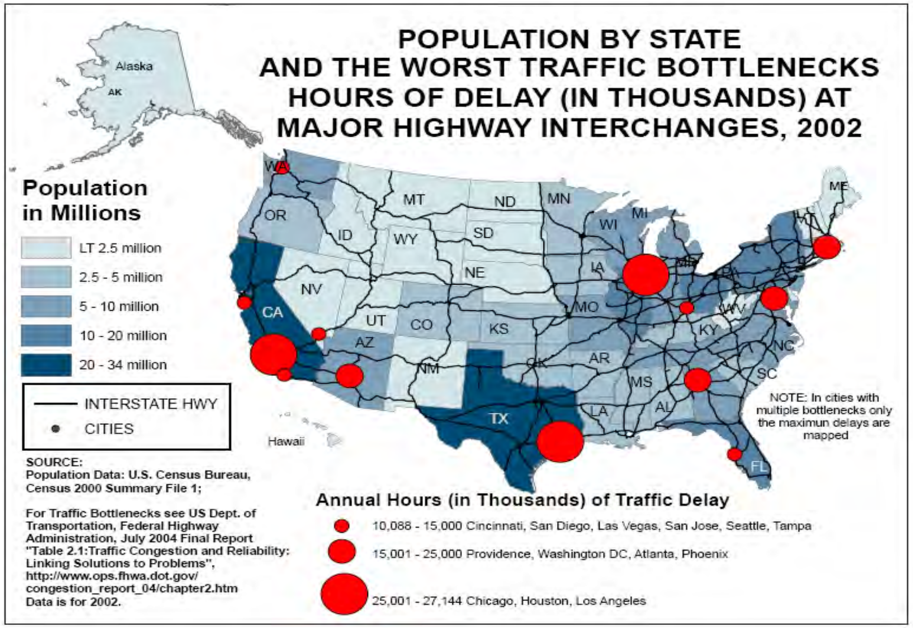


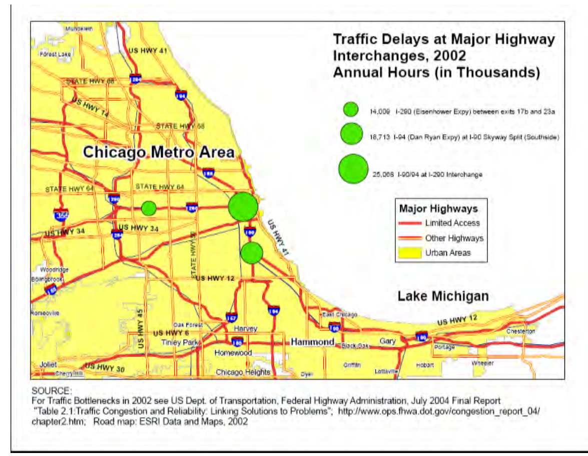


Picture: MTA. Fixing A Train Tracks on the “flats” near Jamaica Bay

Source: R. Zimmerman, RAPID/Collaborative Research: Collection of Perishable Hurricane Sandy Data on Weather-Related Damage to Urban Power and Transit Infrastructure,” National Science Foundation, the U. of Washington (lead), Louisiana State University, and New York University; R. Zimmerman (2014), “Planning Restoration of Vital Infrastructure Services Following Hurricane Sandy: Lessons Learned for Energy and Transportation,” J. of Extreme Events, Vol. 1, No. 1.

Roadway Concentrations - Usage: Nationally and Within Selected Urban Areas





By State

By Locality

Maps prepared by Dr. Zvia S. Naphtali

Rail Vulnerabilities from Concentration: LIRR

LIRR: Lightening Strike, September 29, 2011

- Initiating Conditions
  - A highly centralized network (most trains go through Jamaica station) with a high volume of traffic (81 million annually)
  - Few rail travel alternatives
  - Multiple failures at the same time and not all related increased the consequences dramatically: lightening strike disables trains west of Jamaica; programming error; third rail shut
  - 17 stranded trains, 9 standing trains
  - Need for training on what was a relatively new computer system
- Opportunities for Intervention
  - More communication would have rerouted or reduced travel, though some of those actions were taken to prevent travel from the city
  - Protective action to secure facilities from natural hazards
  - Future system design to reduce burden on single stations

Source: Metropolitan Transportation Authority (MTA) (October 2011), 'Preliminary review September 29, 2011 lightning strike at Jamaica', New York, NY, USA: MTA.

Source: http://www.mta.info/lirr/Timetable/lirrmap.htm

Small-Scale Technological Fixes for Flooding of Underground Transit: Street and Subway Flooding Protection Using Elevated Grate Barriers, NYC

Source: Photos from MTA

Source: Photo by R. Zimmerman 2012

Acknowledgements

UTRC Region 2 funded projects:

- Promoting Transportation Flexibility in Extreme Events through Multi-Modal Connectivity
- Suburban Poverty, Public Transit, Economic Opportunities and Social Mobility
- Public Transit and Mandatory Evacuations Prior to Extreme Weather Events in NYC

Partially supported by NSF funding

- Urban Resilience to Extreme Weather Related Events Sustainability Research Network (UREx SRN) NSF1444755 (sustainability and resilience concepts)
- RAPID grant on transit and electric power recovery after Hurricane Sandy
- RIPS I grant (interdependency concepts)

Gratefully acknowledged are those who worked on the UTRC funded projects:

- Dr. Carlos E. Restrepo and graduate students who provided support for this work: Joshua Sellers, T.R. Pearson, Arundathi Amirapu, Hannah Kates, and Robert Joseph.

TRANSPORTATION TRANSFORMED
ADVANCING ECO-FRIENDLY MOBILITY
8:45am to 5:00pm | Thursday, April 7, 2016

2:00 PM - 2:45 PM / Session 3 – Government Programs (City & State)

MODERATOR

Frank Mongioi
Senior Manager,
ICF International

Brenda Dix, ICF International:
Metropolitan Transportation Commission/San Francisco Bay Area Sustainability Programs

Alex Keating, NYCDOT: *Drive Smart Program*

John Lyons, Metropool: *Eco-driving Training of Municipal Fleet Drivers*

WIFI NYIT_Theater / Password: CobaltBlue77

MTC's Climate Initiatives Program

Meeting the San Francisco Bay Area's GHG Emission Reduction Goals

Prepared for:

Transportation Transformed: Advanced Eco-Friendly Mobility

April 7th, 2016

METROPOLITAN
TRANSPORTATION
COMMISSION

- **Created by the California Legislature in 1970**
- **Jurisdiction includes all 9 Bay Area counties**
- **Governed by 19-member board of primarily local elected officials**
- **Responsibilities include:**
  - Planning
  - Funding
  - Coordination
  - Operations
  - Advocacy

Climate Grant Program Evaluation

2009

- MTC Adopts the Climate Program: $80 million available for projects

2010

- MTC issues call for innovative projects
- Grant projects selected

2011

- Evaluation methodology designed
- Project implementation begins
- Data collection begins

2012-13

- Project implementation and data collection ongoing

2014-15

- Most projects complete implementation
- Program evaluation completed

Overview of Projects

Smart Driving

Innovative Climate Program

- Transportation Demand Management (TDM)
- Parking Pricing
- Ridesharing
- Bicycle Projects
- Electric Vehicle (EV) Deployment
- Other Innovative Projects

Safe Routes to School Projects

Experience Electric Campaign

What is Smart Driving?

- **Smart driving techniques include:**
  - Using smooth starts to minimize rapid acceleration, and drive at constant speed when possible
  - Anticipating traffic flows and coast when possible
  - Observing speed limits, and minimize speeds over 65 mph
  - Minimizing unnecessary idling
  - Closing windows and sunroofs when driving over 40 miles per hour
  - Minimizing use of air conditioning; open windows instead if driving under 40 mph
  - Use cruise control when driving on the highway
  - Using trip chaining to reduce miles traveled and vehicle trips
- **Smart driving also encompasses vehicle maintenance techniques such as:**
  - Maintaining proper tire pressure
  - Eliminating unnecessary weight in the vehicle
  - Removing roof-racks to improve vehicle aerodynamics
  - Conducting regularly scheduled vehicle maintenance

Smart Driving Programs and Research

- **Findings from Research on the effectiveness of smart driving:**
  - **Most rigorous studies:** 2%-4% fuel savings
  - **Full range:** 0%-18%
- **Other US Programs**

Drive Clean Texas

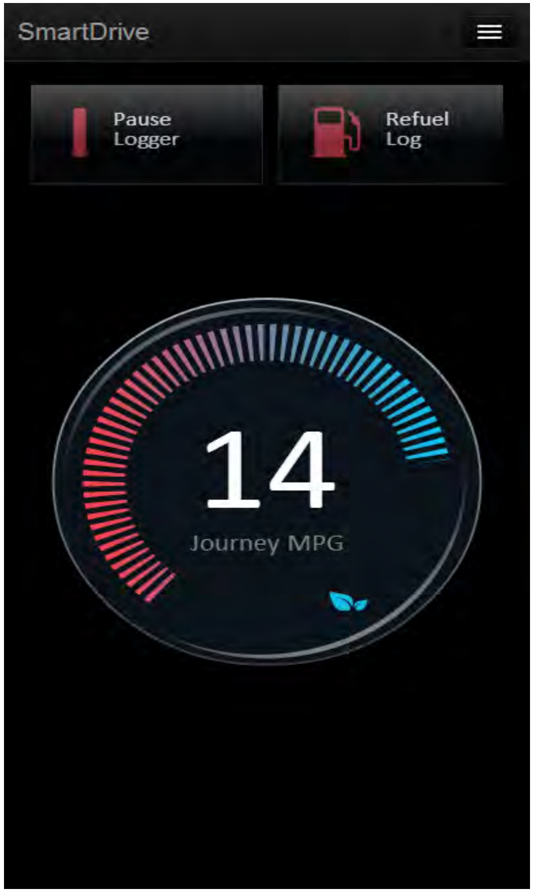
Roadcents

DRIVE GREEN, SAVE GREEN
create a lean, green, money-saving machine

Phase 1: Smart Driving Pilot

Smart Driving Pilot Project

Two pilot studies evaluated the impacts of real-time driving in-vehicle devices, smartphone apps, and educational elements on driver behavior and fuel economy. The pilot programs tested the ability to improve fuel efficiency.



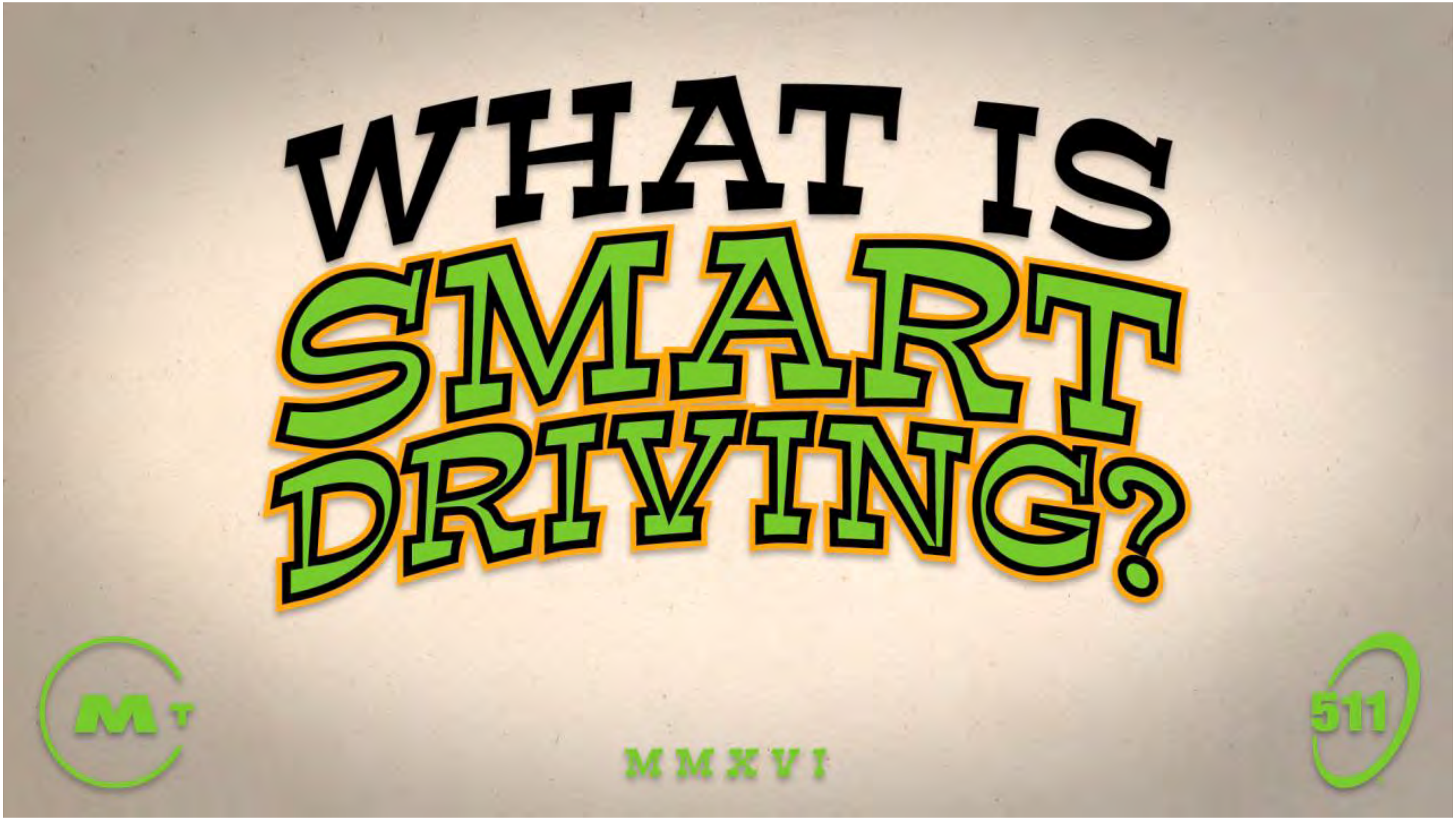
"Smart driving" refers to a set of strategies and techniques that maximize motor vehicle fuel efficiency by improving driving habits and vehicle maintenance.

Phase 2: Public Smart Driving Program

- **Two primary components:**
  - Education campaign
  - Automatic device giveaway

- **What is Automatic?**
  - Smart phone app and connected car adapter

Phase 2: Public Smart Driving Program



INNOVATIVE GRANT PROGRAM

Transportation Demand Management (TDM)

**SHUTTLES,
CAR SHARING,
VANPOOLING,
TARGETED OUTREACH,
EMPLOYER
COLLABORATIONS**

Connect, Redwood City!

Car sharing, bike sharing, short-distance vanpools, and telework/flex-schedules, and targeted outreach, with a focus on first / last mile connections

**GHG Emission Reductions:
1,100-2,790 tons/yr**

San Francisco Integrated Public/Private Partnership

Shuttle partners, employer collaborations, employer parking management, inter-agency TDM strategy

**GHG Emission Reductions:
5 tons/yr**

Parking Pricing

goBerkeley

Established time limits on parking and adjusted parking rates to increase parking efficiency and reduce circling; supplemented with a transit pass program, car sharing, and marketing.

GHG Emissions Reduction: 317 tons/yr

Percentage of surveyed drivers who found it "very easy" to find a parking space increased from 2% to 38%; percentage who found it "very" or "somewhat difficult" fell from 63% to 22%

Bicycle Projects

BikeMobile

Roving van that visits schools, recreation centers and community centers providing free bike repairs and safety education.

GHG Emissions Reduction: 201 tons/yr

Bay Area Bike Share

Bike sharing program deployed throughout 5 cities and 3 counties

GHG Emissions Reduction: 79 tons/yr

Electric Vehicle (EV) Deployment

Local Government EV Fleet

Deployment of nearly 90 EVs and 90 Level 2 chargers to local government agencies

GHG Emission Reduction: 172 tons/yr

eFleet: Car Sharing Electrified

Deployment of 16 PEVs in CityCarshare fleet

GHG Emissions Reduction: 4 tons/yr

Tribal Community EV Pilot

Deployment of four EVs and six Level 2 chargers on tribal lands

GHG Emissions Reduction: 3 tons/yr

Other Innovative Grants

Cold in Place Recycling

Repaved two roadways in Napa using Cold in Place Recycling.

GHG Emissions Reduction: 493 tons/yr

Shore Power

Installed shore power technology at two berths at the Port of Oakland.

GHG Emissions Reduction: 534 tons/yr

Enhanced Automatic Vehicle Locator System

AVL deployed within the Santa Rosa CityBus fleet.

GHG Emissions Reduction: not quantified

Safe Routes to School Projects

EDUCATIONAL PROGRAMS THAT TEACH STUDENTS ABOUT ALTERNATIVE TRANSPORTATION CHOICES

Bay Area School Transportation Collaborative

GHG Emissions Reduction: 297 tons/yr

Green Ways to School

GHG Emissions Reduction: 57 tons/yr

Regional Safe Routes to School (5 counties)

GHG Emissions Reduction: 202 tons/yr

Education and Encouragement School Route Maps

GHG Emissions Reduction: not quantified

“Experience Electric” Campaign

Experience Electric – The Better Ride

Ride-and-drive campaign that sought to build awareness and demand for plug-in electric vehicles.

Long Range Plan Climate Program

Policy Initiative	2035 Cost in YOE millions	Per Capita CO_2 Emissions Reductions in 2035	Cost per GHG Ton Reduced in 2035
Commuter Benefits Ordinance	$0	-0.3%	$0
Car Sharing	$13	-2.6%	$14
Vanpool Incentives	$6	-0.4%	$29
Clean Vehicles Feebate Program	$25	-0.7%	$108
Smart Driving Strategy	$160	-1.5%	$322
Vehicle Buy-Back & Plug-in or Electric Vehicle Purchase Incentive	$120	-0.5%	$684
Regional Electric Vehicle Charger Network	$80	-0.3%	$812
Climate Initiatives Innovative Grants	$226	TBD	TBD
Total	$630	-6.3%	

Brenda Dix
Brenda.Dix@icfi.com
212-656-9179

DriveSmart

Helping New Yorkers Save Money, Save Time, and Drive More Safely

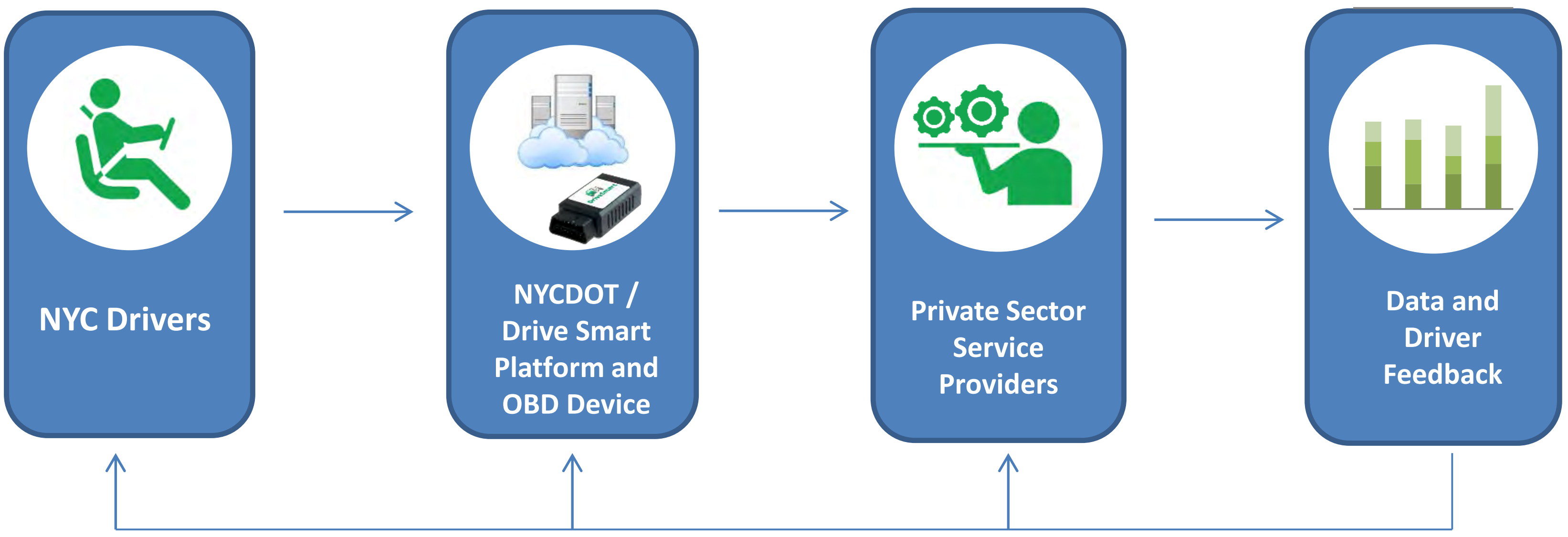
Transportation Transformed - Advanced Eco-friendly Mobility Conference

April 7, 2016

NEW YORK CITY DOT

Drive Smart is a public-sector platform to power private-sector innovations that help drives save money, save time, and drive more safely.

- Create a mutually beneficial marketplace for driver apps and services.
- Leverage driving data *that is already being produced* in order to better monitor and operate our streets.
- Generate new, data-driven insights on safety and system management.



Drive Smart Background

- **Funding:** Federal Value Pricing Pilot Program (VPPP) Grant
- **Program:** Participants use an in-vehicle device to access technology services from Drive Smart partners and generate data on safe driving behavior and network use.
- **Approach:** 1 year pilot with up to 400 drivers to test the system functionality and program impact on driver choices.

July, 2015:
Program Launch *(Build)*

→

August 2015 – July 2016:
Pilot Phase *(Measure)*

→

August 2016:
Program Evaluation and Reporting *(Learn)*

Program Goals

About Drive Smart

Drive Smart is a new technology pilot program from the New York City Department of Transportation (NYCDOT) that will help participants:

SAVE TIME: Tired of getting stuck in the same traffic every day? Drive Smart can help you find a better route to the office - and reward you for taking it.

SAVE MONEY: Owning a car in New York City is expensive, but Drive Smart can tell you exactly how much you're spending on driving, give you tips on how to save, and help you save money on your car insurance.

DRIVE MORE SAFELY: Drive Smart will help you be a safer driver by giving you in-vehicle feedback and a "safe driver score" all while never taking your eyes off the road.

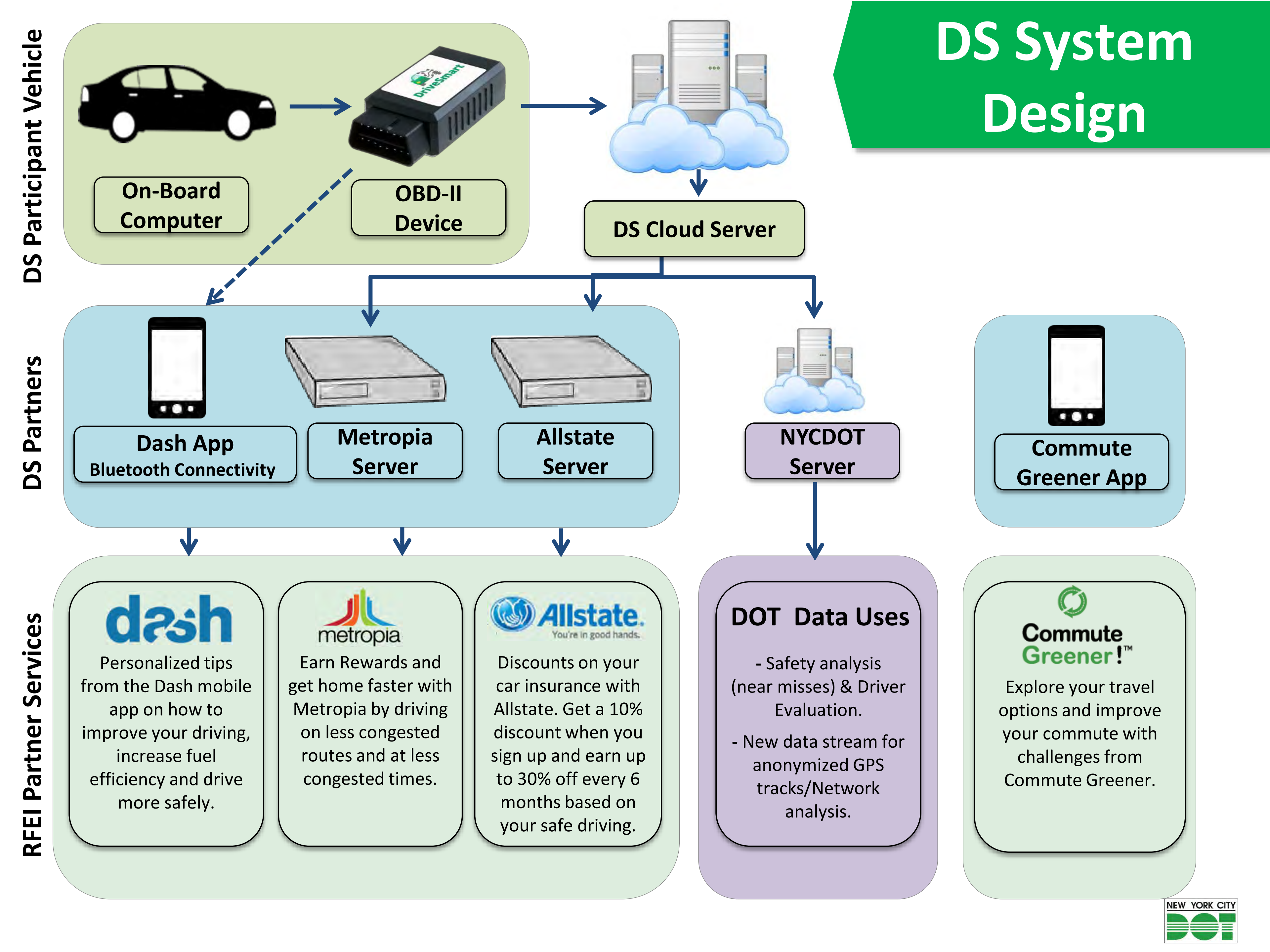
DRIVE GREENER: Help us clear the air - Drive Smart will give you pointers on how to be a more eco-friendly driver and even plant a tree or two every time you reach a milestone.

Contribute to Vision Zero goals:

- Provides input and incentives for safe drivers and contributes unique focus on "near misses."
- New probe data source to manage network and reduce crashes.

Evaluate impact of information and services on driver behavior, safety, and congestion:

- Impact will be evaluated based on 12 months of aggregated driver performance + before and after surveys


DS System Design
DS Participant Vehicle
On-Board Computer
OBD-II Device
DS Cloud Server
DS Partners
Dash App
Bluetooth Connectivity
Metropia Server
Allstate Server
NYCDOT Server
Commute Greener App
RFEI Partner Services
dash
Personalized tips from the Dash mobile app on how to improve your driving, increase fuel efficiency and drive more safely.
metropia
Earn Rewards and get home faster with Metropia by driving on less congested routes and at less congested times.
Allstate
You're in good hands.
Discounts on your car insurance with Allstate. Get a 10% discount when you sign up and earn up to 30% off every 6 months based on your safe driving.
DOT Data Uses
- Safety analysis (near misses) & Driver Evaluation.
- New data stream for anonymized GPS tracks/Network analysis.
Commute Greener!™
Explore your travel options and improve your commute with challenges from Commute Greener.
NEW YORK CITY DOT

DOT Analysis & Evaluation

NYCDOT Analysis

Anonymized Data Analysis (Full GPS Tracks)

- OBD-II device time stamp
- Trip start time (From OBD-II)
- Trip end time (From OBD-II)
- Accelerometer reading on x-axis
- Accelerometer reading on y-axis
- Accelerometer reading on z-axis
- GPS Latitude coordinate
- GPS Longitude coordinate
- Current driving speed

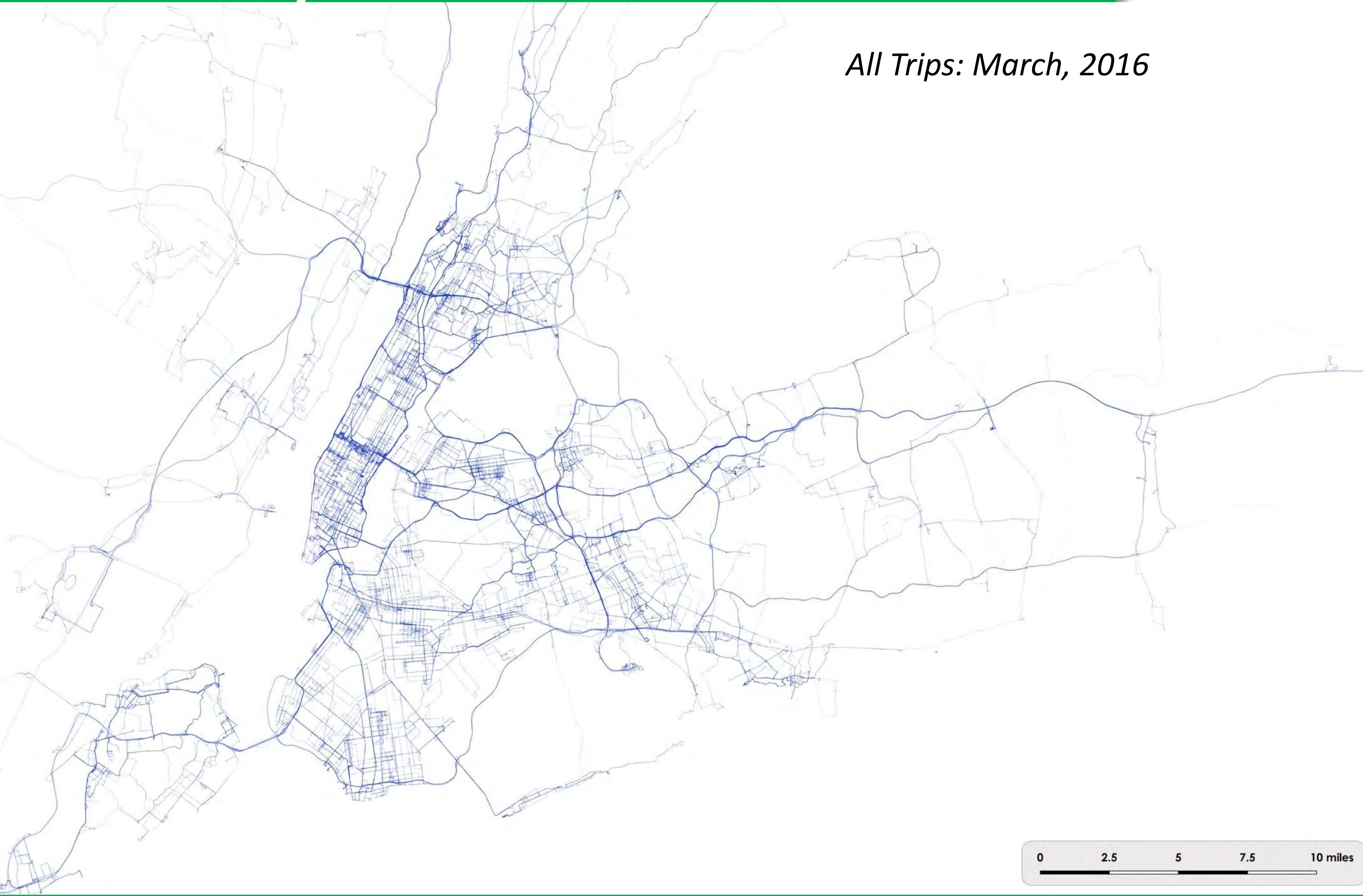
NYCDOT Evaluation

Program Evaluation (Trends in Driver Behavior)

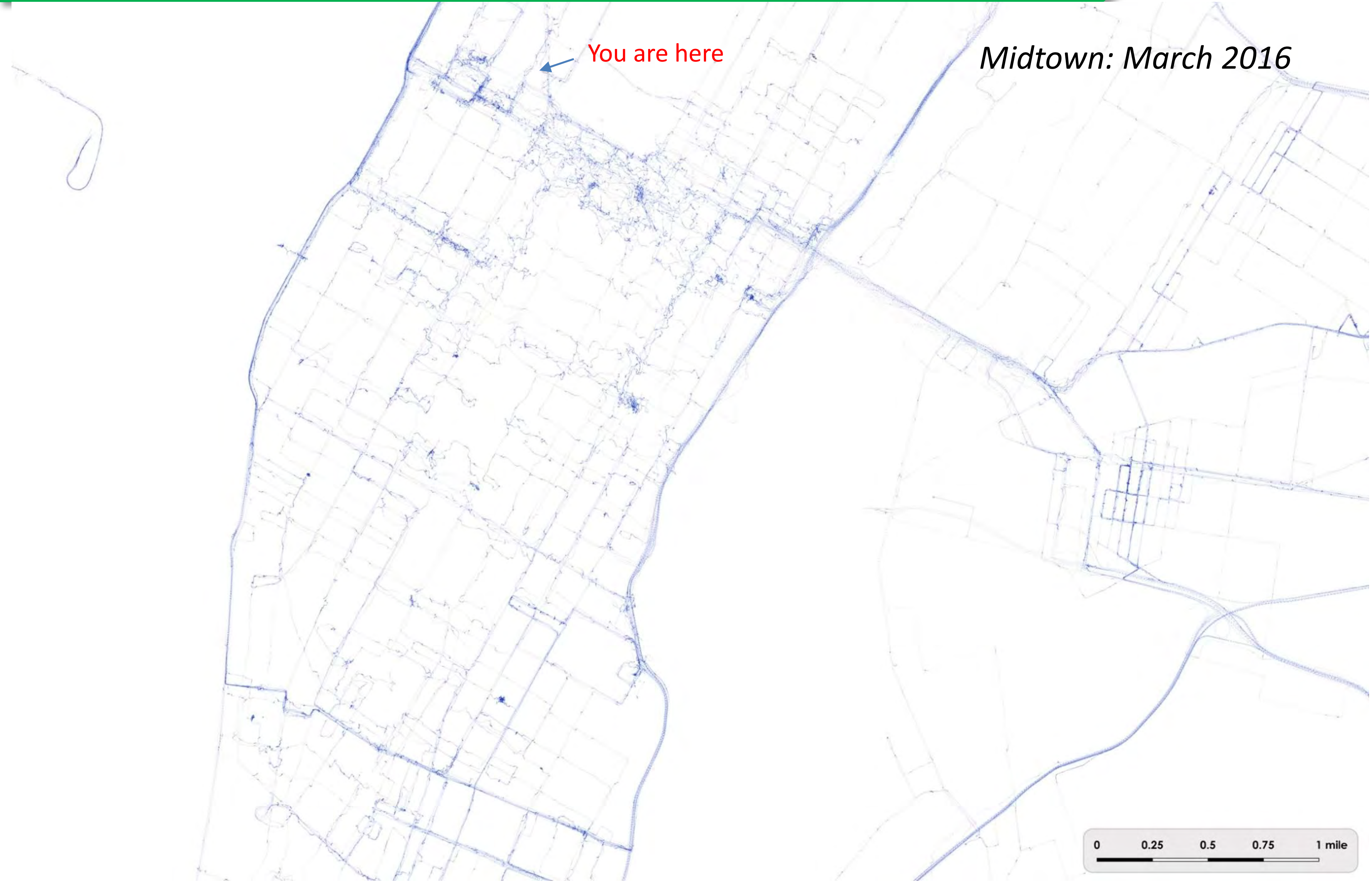
- User ID
- Trip start time (From OBD-II)
- Trip end time (From OBD-II)
- Time zone of trip start (From OBD-II)
- Number of Miles traveled at speed (0 - 100+)
- Number of miles traveled in zone (1-12)
- Number of hard breaking events during trip
- Number of hard turning events during trip
- Number of hard acceleration events during trip
- Total miles traveled during trip
- Average speed traveled during trip

DOT Analysis & Evaluation

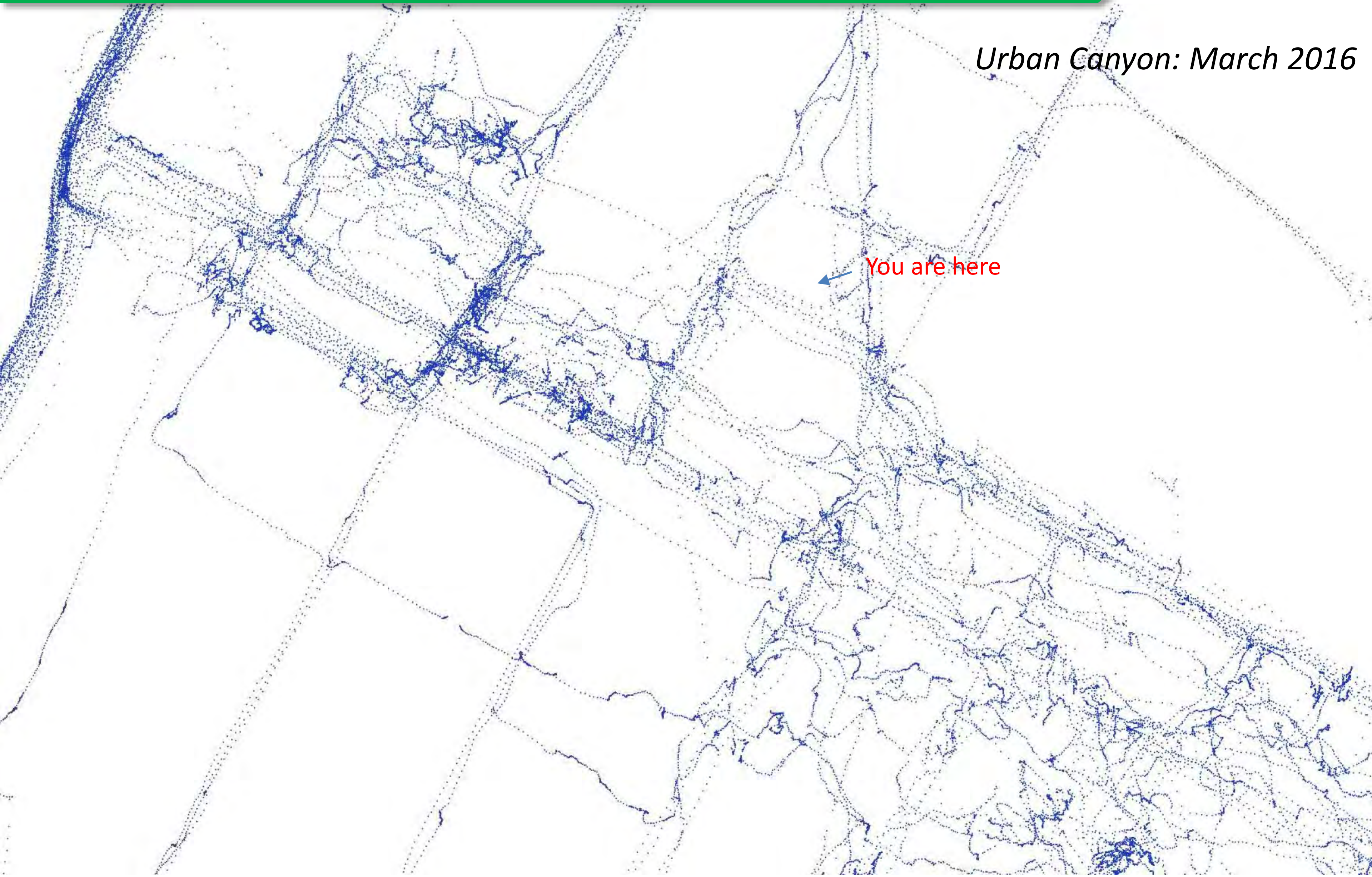
All Trips: March, 2016



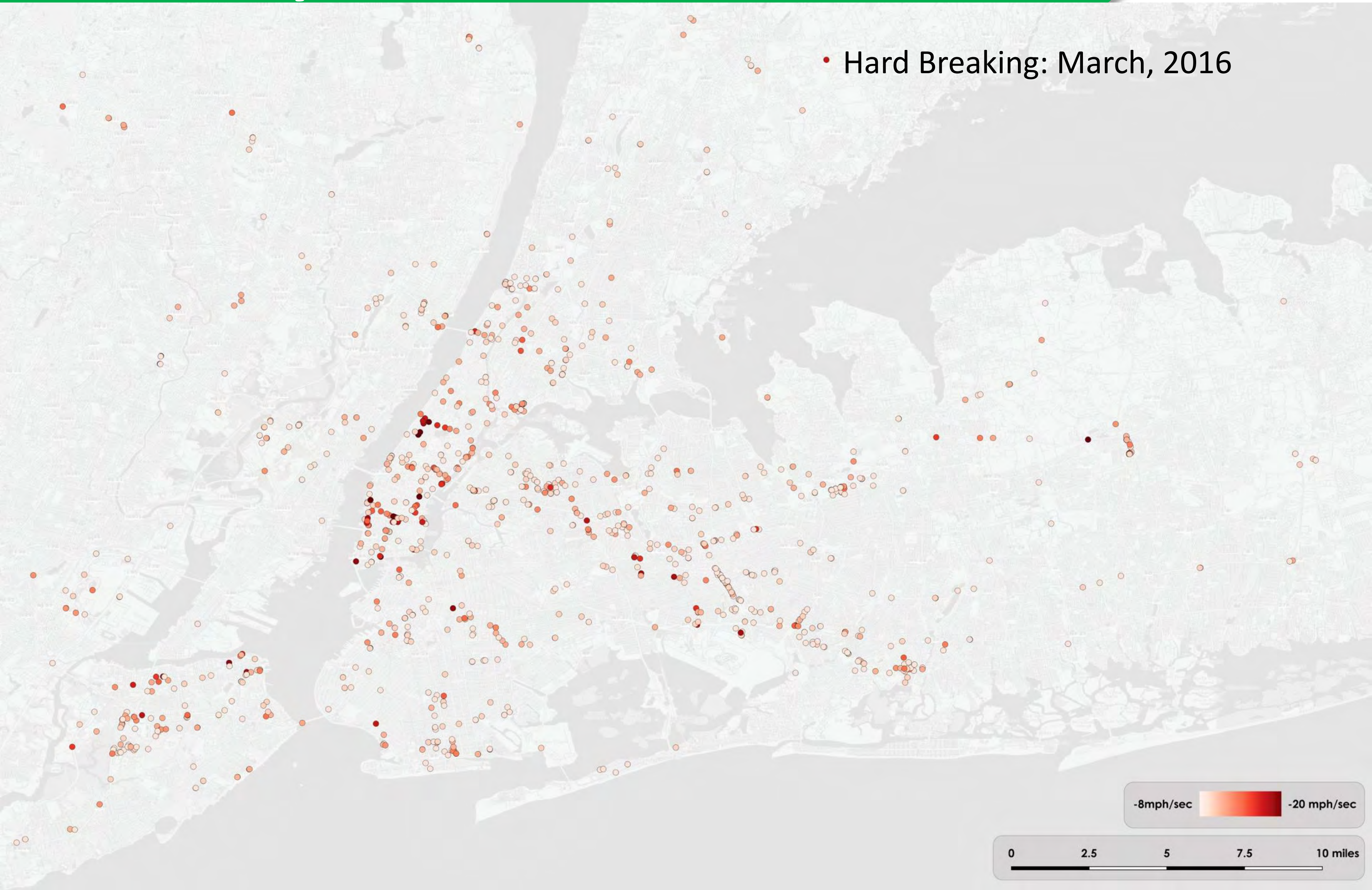
DOT Analysis & Evaluation



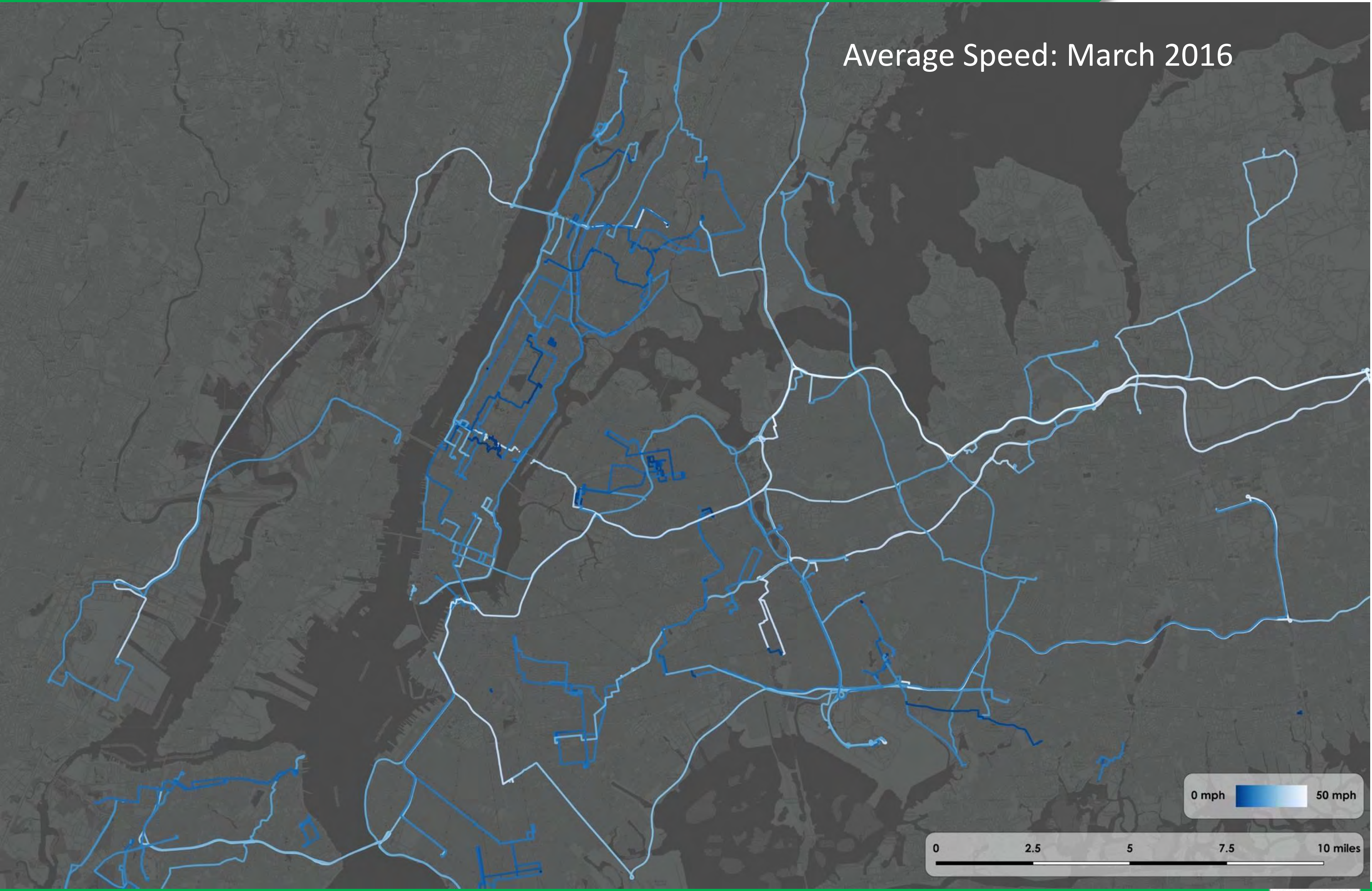
DOT Analysis & Evaluation



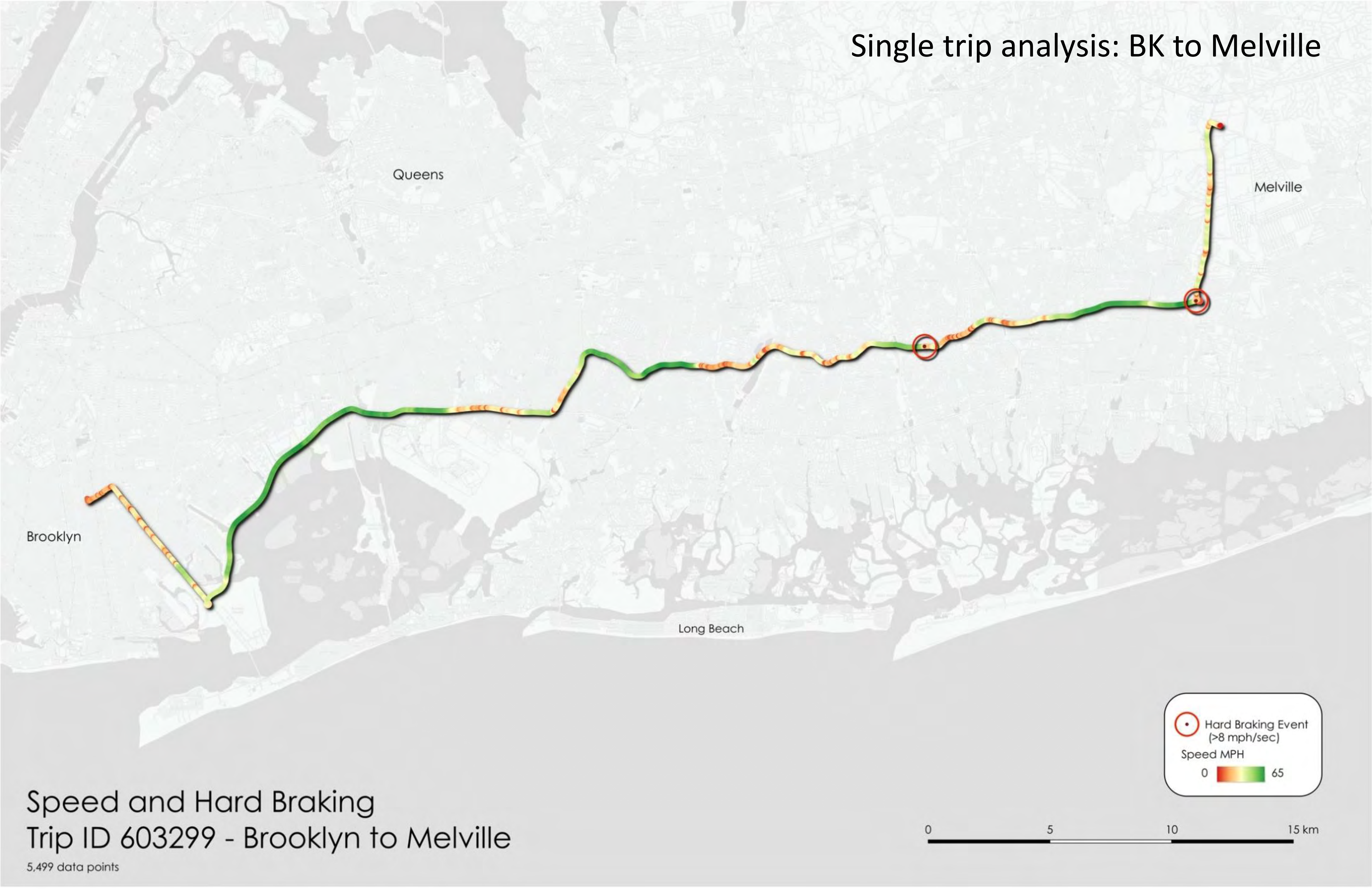
NEW YORK CITY DOT


• Hard Breaking: March, 2016
-8mph/sec
-20 mph/sec
0
2.5
5
7.5
10 miles

DOT Analysis & Evaluation

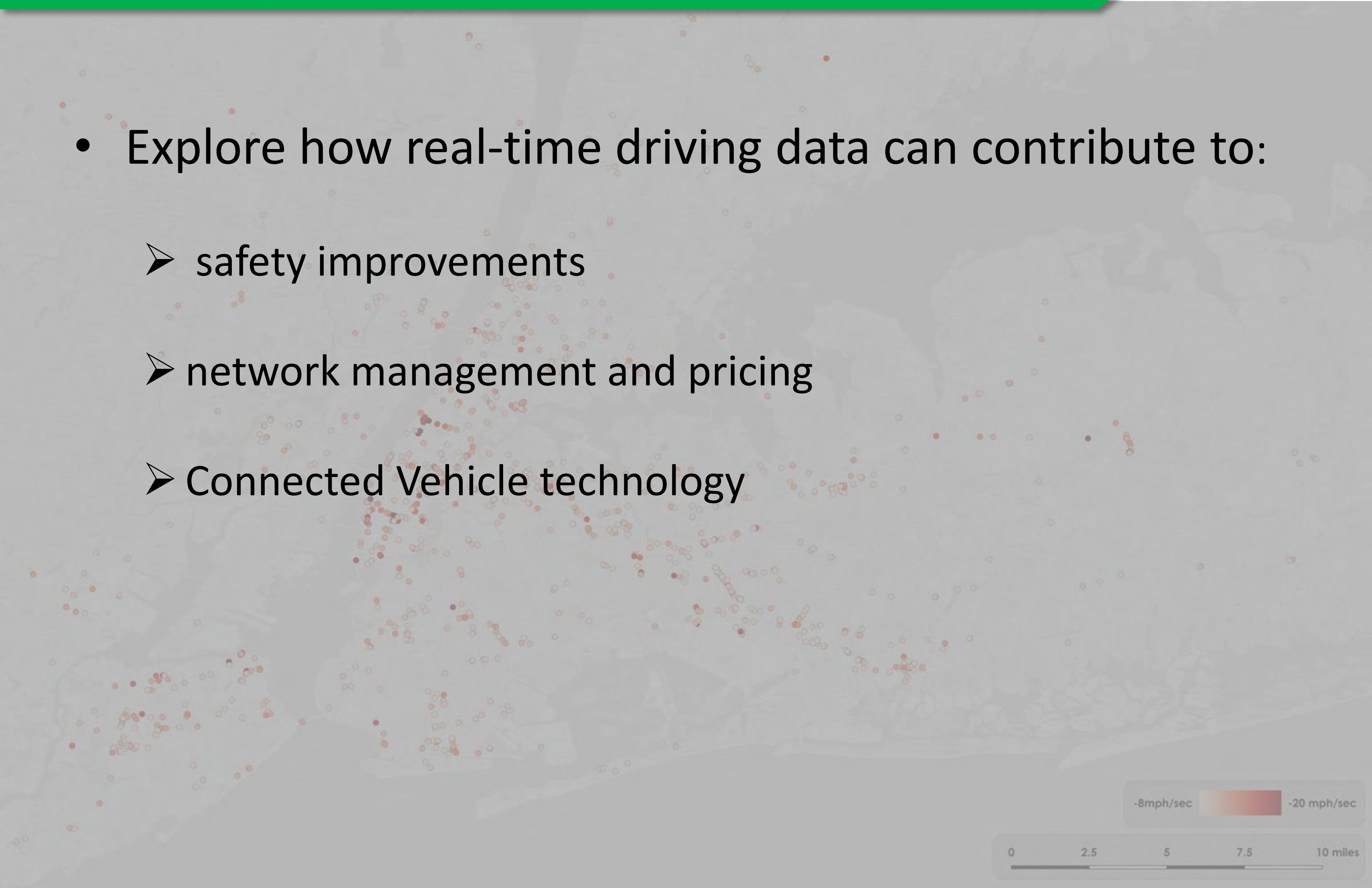


DOT Analysis & Evaluation



Next Steps

- Explore how real-time driving data can contribute to:
  - safety improvements
  - network management and pricing
  - Connected Vehicle technology



Questions

Alexander Keating
akeating@dot.nyc.gov
212.839.4389
www.DriveSmartNyc.com

NEW YORK CITY DOT

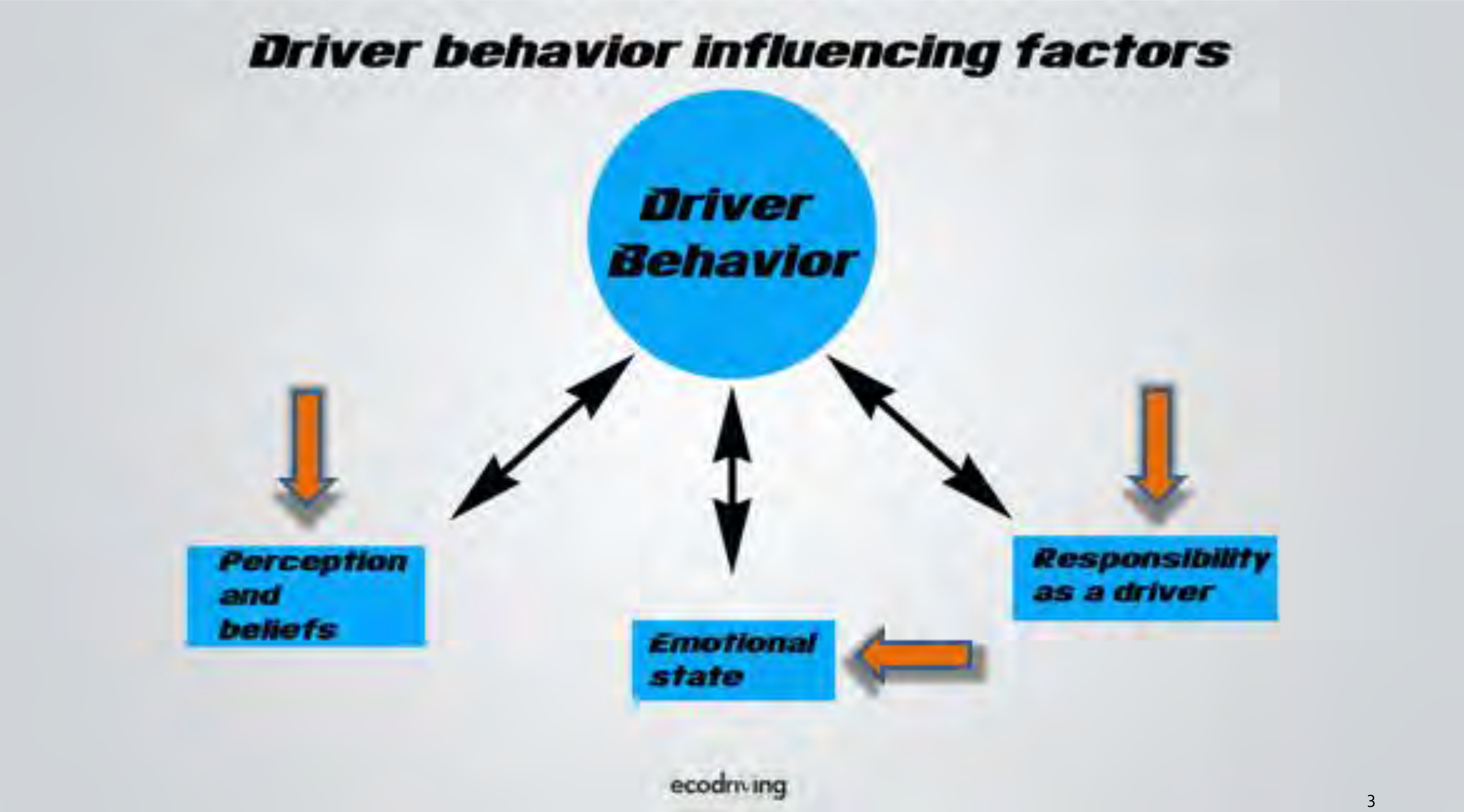
City of Yonkers Ecodriving Pilot

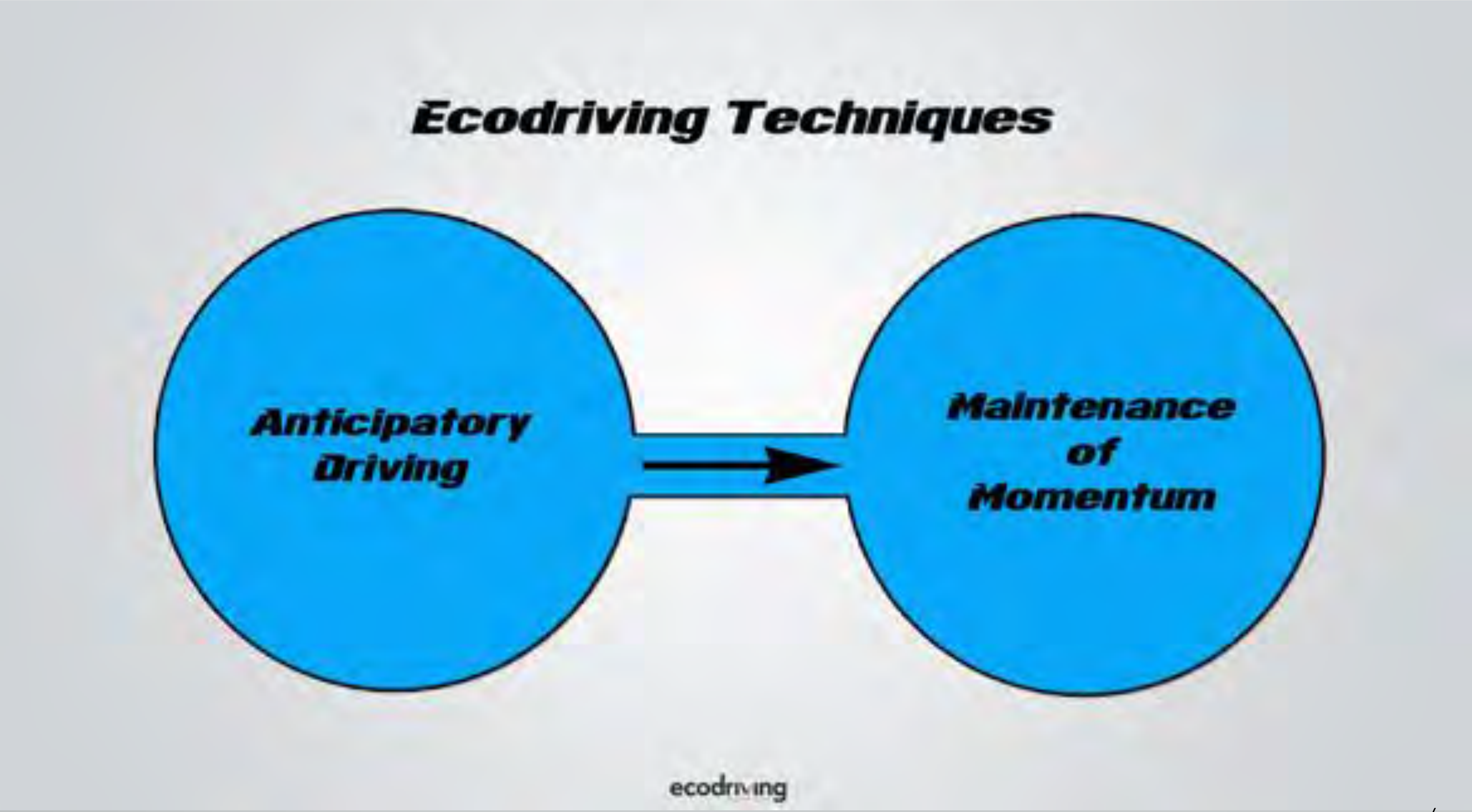
- ❖ MetroPool (511NY Rideshare)
- ❖ Ecodriving Solutions
- ❖ Pilot Parameters

John Lyons

April 7th, 2016


Ecodriving interelated and interdependent goals
Fuel and maintenance savings
increased safety
Reduced CO_2 emissions
EFT LANE
MUST
STOP
CENTER LANE
EXIT
YIELD
ecodriving

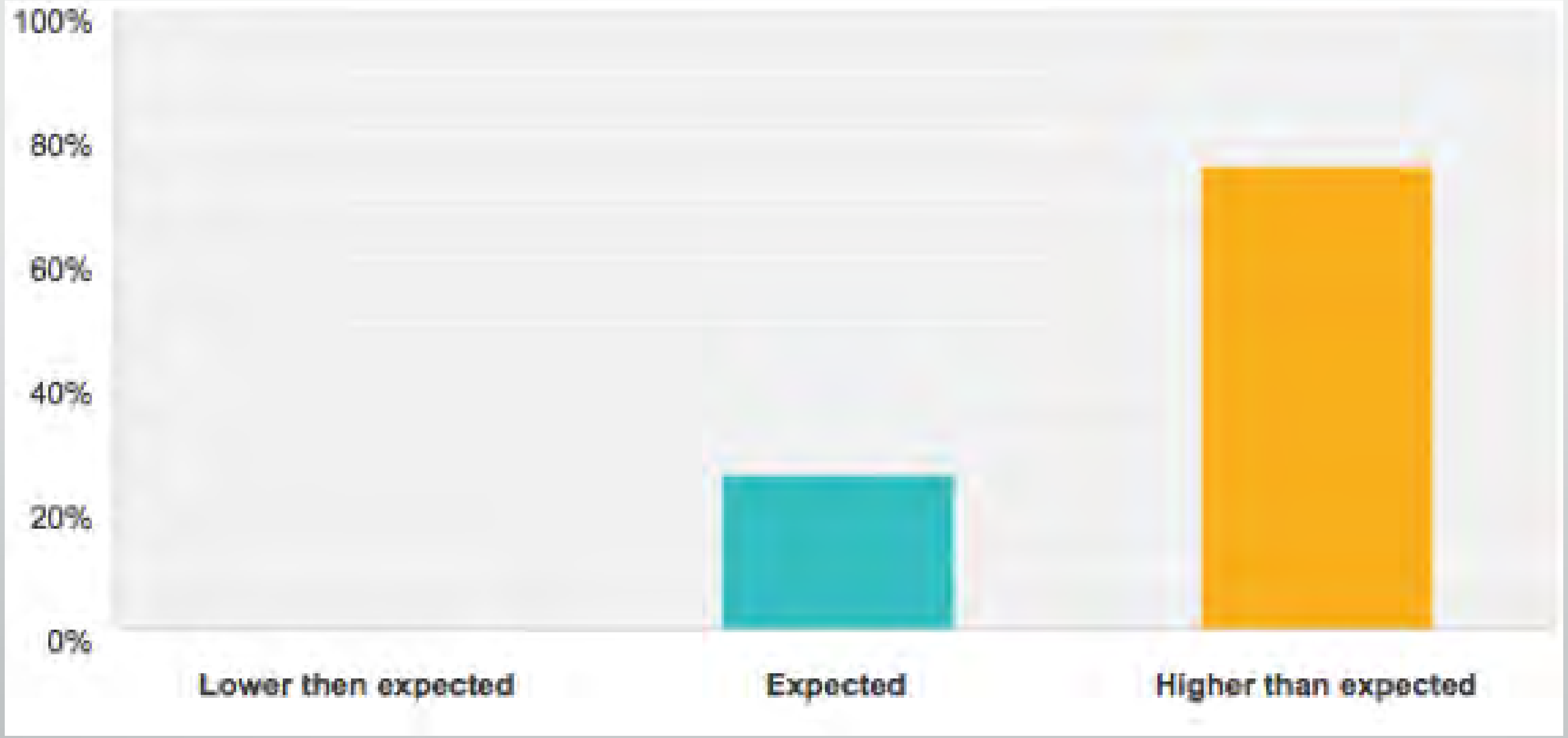

Driver behavior influencing factors
Driver Behavior
Perception and beliefs
Emotional state
Responsibility as a driver
ecodriving



http://view.earthchannel.com/PlayerController.aspx?PGD=ynkny&eID=242

Q: Based on your experienced today, how would you rate the following

Q: How did the ecodriving results match up with your expectations?



Q: Would you recommend an Ecodriving Solutions training for your department?

Results

- 3.5 Hour training
- 3 Trips Behind the Wheel
- Average improvement= 20.5%

  High= 47%

  Low =1.6%

Cost Calculation – Impact of fuel costs

- 2014 gas cost $3.25/gallon, Annual fuel cost=$2M

  7% Improved efficiency=$140,000 savings
- 2016 gas cost $2.10/gallon, Annual fuel cost=$1.3M

  7% Improved Efficiency= $90,461 savings

- $$ versus Environmental & Safety Impact

Training

- Behind the Wheel= $300/person
- Webinar= $30/person
- Combination
- Executive Buy-in
- Promotion & Reminders

Conclusions

- Ability to 'Sell' Concept
- Changing Attitudes about Behavior Change
- Multiple strategies for success

Thank you!

Questions?

John Lyons
President

Direct: 914.893.5700
Mobile: 203.249.8705

MetroPool
SUSTAINABLE MOBILITY

TRANSPORTATION TRANSFORMED

ADVANCING ECO-FRIENDLY MOBILITY

8:45am to 5:00pm | Thursday, April 7, 2016

2:45 PM - 3:30 PM / **Session 4** – Goods Movement and Eco-Driving

MODERATOR

Alison Conway, Ph.D.
Assistant Professor,
The City College of
New York

Kanok Borboonsomsin, Ph.D., UC Riverside: *Reducing the Carbon Footprint of Goods Movement through Eco-Driving*

Edward McCarthy, Vice President of Operations and Customer Success, Vnomics Corporation: *Driver Coaching and Fuel Optimization Solution*

Brian Brundige, Operations/Safety Manager, Terpening Trucking Company

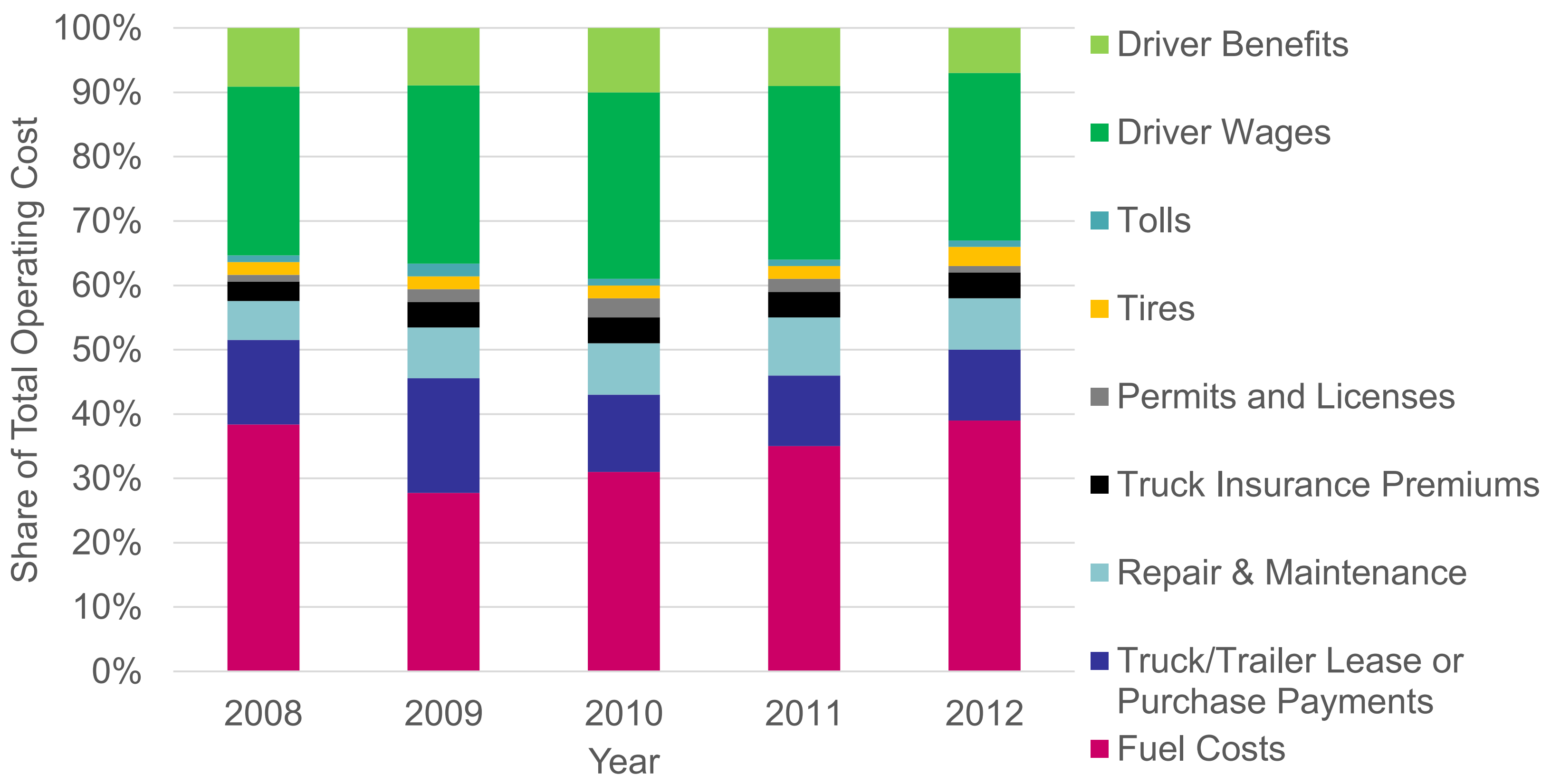
WIFI NYIT_Theater / Password: CobaltBlue77

Reducing the Carbon Footprint of Goods Movement through Eco-Driving

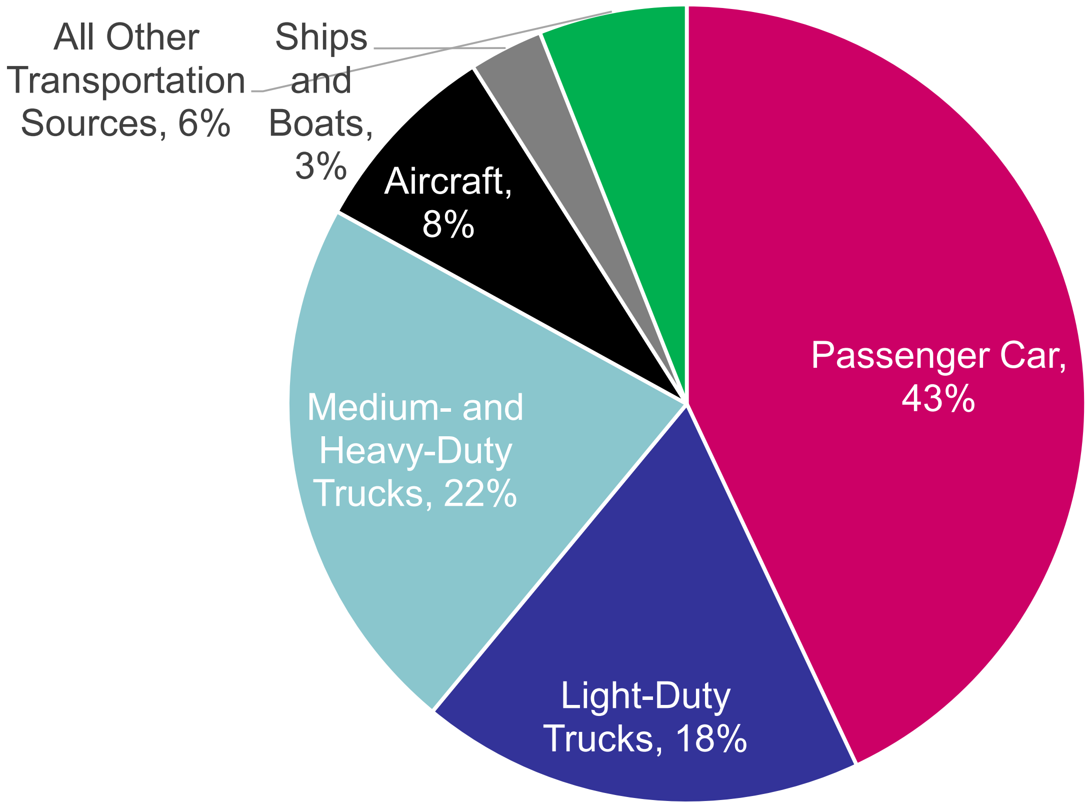
Kanok Boriboonsomsin
University of California at Riverside

Transportation Transformed: Advancing Eco-Friendly Mobility
Manhattan, NY
April 7, 2016

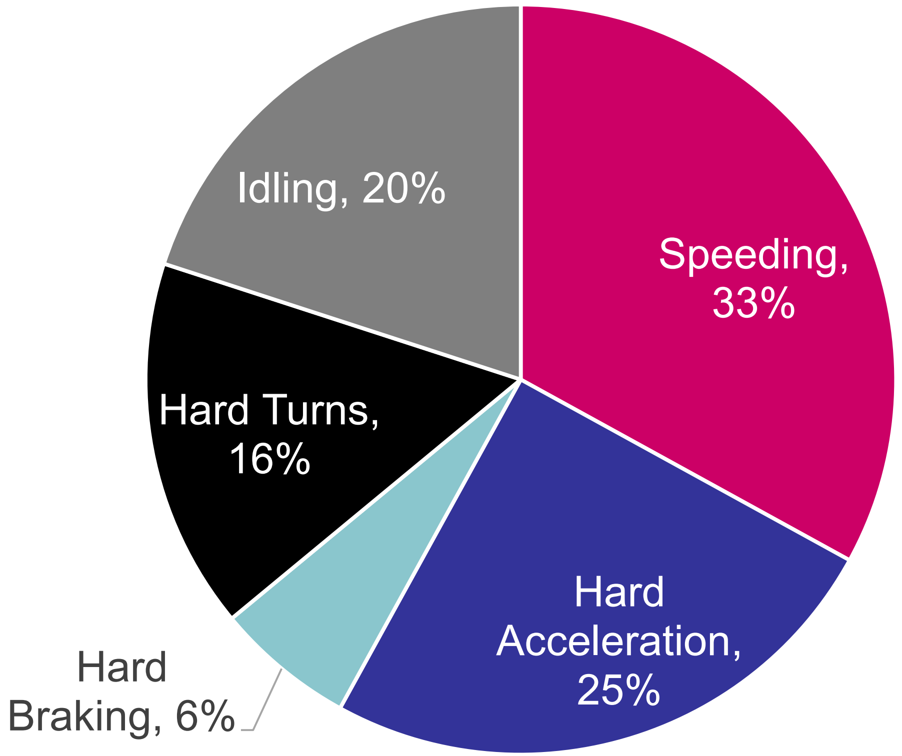
Operating Costs of Commercial Trucking in the U.S.



U.S. Greenhouse Gas Emissions 1990-2011 by Transportation Sources

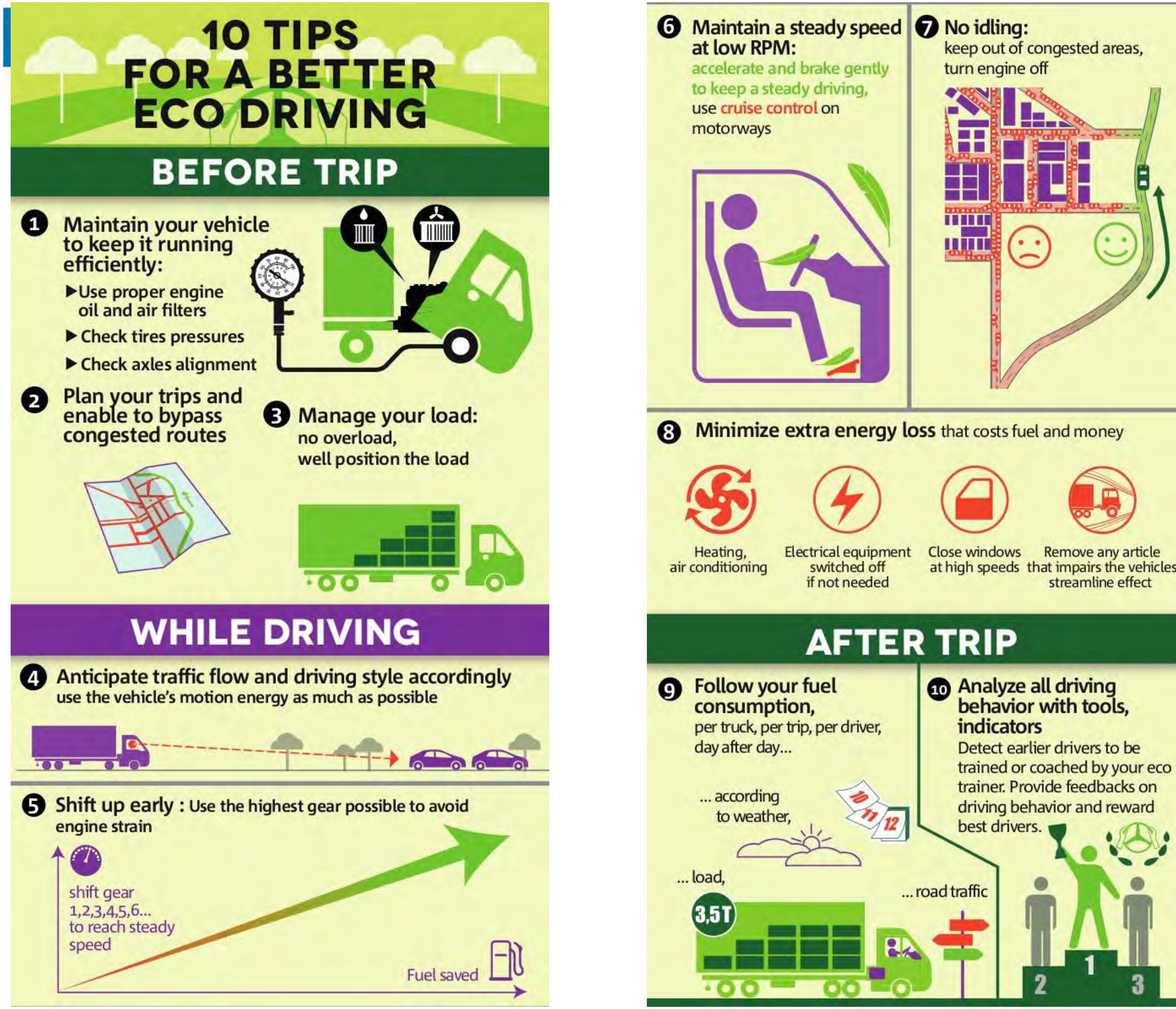


Reasons for Fuel Waste for a Typical Freight Truck



Eco-Driving

- "*The practice of driving in such a way as to minimize fuel consumption and the emission of carbon dioxide*" — Oxford Dictionaries
  - while not compromising the safety of oneself and other road users
- In a broader sense, may also include non-driving activities:
  - Pre-trip planning (of route and schedule)
  - Vehicle maintenance
- Core principles are similar across different vehicle types.
  - Some are specific to heavy-duty trucks due to certain unique aspects of truck engine's operation.



Credit: www.michelin-solutions.com

Effectiveness of Truck Eco-Driving Programs

- A limited number of studies have been conducted in Europe, Asia, Australia, and North America.
- Reported improvements in fuel economy vary greatly.
  - 5% to 40% for all studies reviewed
  - 5% to 15% for large-scale studies (> 300 drivers)
- Results depend on a number of factors such as:
  - Number of truck driver samples
  - Baseline driving performance
  - Method of eco-driving intervention
  - Setting for evaluating fuel economy improvement
  - Provision of incentives

Examples of Truck Eco-Driving Evaluation Studies

Year	Country	Training Method	Evaluation Setting	No. of Drivers	Fuel Economy Improvement
2005	U.K.	Driving simulator	Driving simulator	>600	3.5% immediately after training
2007	U.S.	Class	Closed driving course	36	33.6% to 40.5% immediately after training
2009	Australia	Class	Prescribed real-world route	12	27.3% immediately after training; 26.9% after 3 months
2010	European countries	Class followed by monthly feedback and regular refreshing class	Actual real-world routes	322	9.4% over an unknown period
2011	U.S.	Individualized coaching and in-vehicle real-time feedback system	Actual real-world routes	695	13.7% after 2 months
2013	Japan	Class	No information available	~3,000	8.7% immediately after training
2014	U.S.	Individualized coaching and in-vehicle real-time feedback system (plus financial incentives)	Actual real-world routes	46	2.6% (5.4% with financial incentives) for sleeper cabs and 5.2% (9.9% with financial incentives) for day cabs after 2 months

Truck Eco-Driving Program Elements (1)

- Driver education and training
  - Education
    - Awareness campaign
    - Course or seminar format
    - Classroom or online setting
  - Training
    - On-road or with driving simulator

Photo credits:
https://www.youtube.com/watch?v=7R-81ucUdDw
http://overall-economy.trucks-mercedes-benz.com/en_BE/Consumption/details.html
https://www.iru.org/en_policy_co2_response_ecodriving
http://corporate.renault-trucks.com/en/press-releases/2012_10_22_an-application-for-learning-how-to-eco-drive-a-truck.html

UCR | College of Engineering- Center for Environmental Research & Technology

Truck Eco-Driving Program Elements (2)

- Vehicle maintenance and technology support
  - Government
    - Provide free access to air pumps for tire inflation at rest areas
    - Accelerate the availability, adoption, and market penetration of fuel saving technologies
  - Fleet
    - Streamline preventive maintenance routines
    - Invest in fuel saving technologies

Credit: http://www.truckinginfo.com/article/story/2014/11/q-a-al-cohn-on-fuel-efficient-tires-footprints-and-inflation.aspx

Credit: http://www.comfleet.com/pages/APU/WillisAPU.html

Truck Eco-Driving Program Elements (3)

- Policy support
  - Government
    - Promote eco-driving through awareness campaigns
    - Include eco-driving as part of commercial driver licensing process
    - Provide financial subsidies for retrofitting existing trucks with fuel saving technologies
    - Encourage or mandate eco-driving technologies in new trucks
  - Fleet
    - Build culture of fuel-efficient driving
    - Include eco-driving metrics in driver performance review
    - Recognize or reward truck drivers for embracing eco-driving

Photo credit: http://blog.gordontrucking.com/bid/85580/Being-a-Professional-Truck-Driver

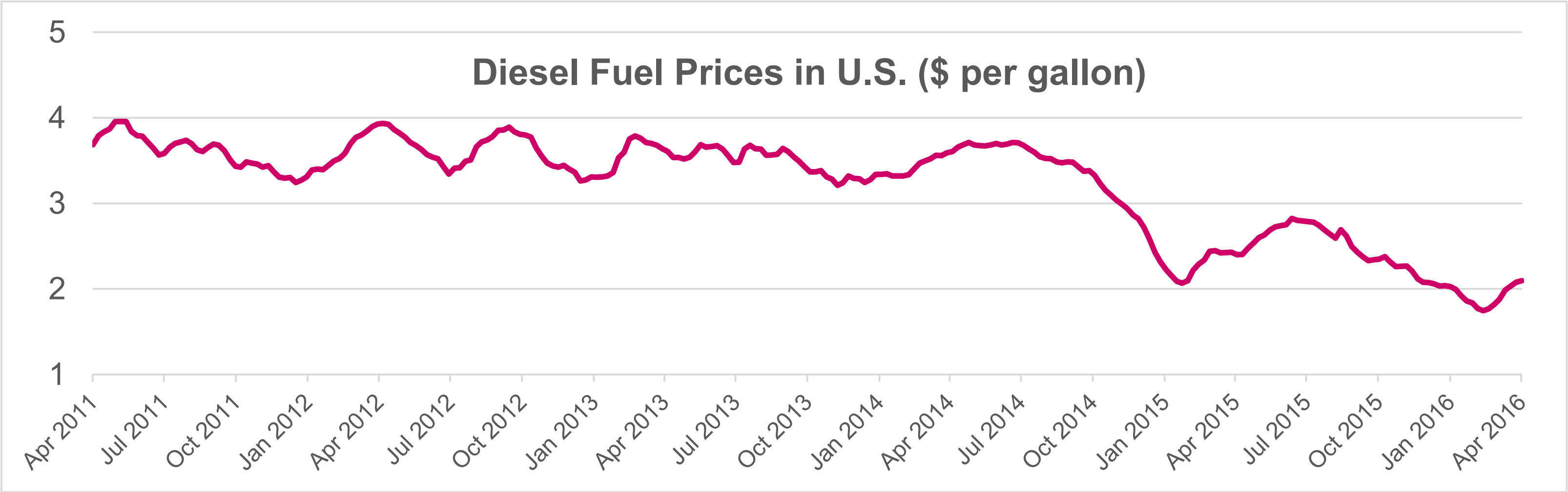
Challenges and Barriers (1)

- Driver
  - Habits are hard to break.
  - Eco-driving performance may fade over time without proper incentive or reinforcement mechanisms, e.g.,
    - Financial reward schemes based on driving performance or fuel saved
    - On-board driving feedback and telematics systems

Credits: http://cdllife.com/2013/video/video-homer-simpson-truck-driver-stereotypes/

Challenges and Barriers (2)

- Industry
  - High turnover rates of truck drivers make trucking companies reluctant to invest in eco-driving training and technology.
  - Trucking companies need to balance fuel efficiency with other goals such as productivity and safety.
  - Fuel prices dictate internal rate of return on eco-driving programs.



Challenges and Barriers (3)

- Government
  - Incorporating eco-driving training or exam as part of commercial driver licensing process would involve substantial institutional change by government agencies.
  - Mandating inclusion of eco-driving technologies in new model year trucks would require working closely with truck manufacturers and other stakeholders.
  - Funding
    - Educational eco-driving campaigns
    - Financial subsidies for the truck retrofits

Research Needs

- Co-benefits of truck eco-driving
  - Emissions (of criteria pollutants, especially NO_x and PM)
    - How much criteria pollutant emissions can be reduced?
  - Safety-related implications
    - Is there positive correlation between eco-driving and safe driving?
    - Any potential for driver distraction?
- Truck eco-driving technologies
  - On-board instrument
    - Customized feedback
    - Seamless integration
  - Connected Vehicles
    - New applications enabled by vehicle-to-vehicle and vehicle-to-infrastructure communications

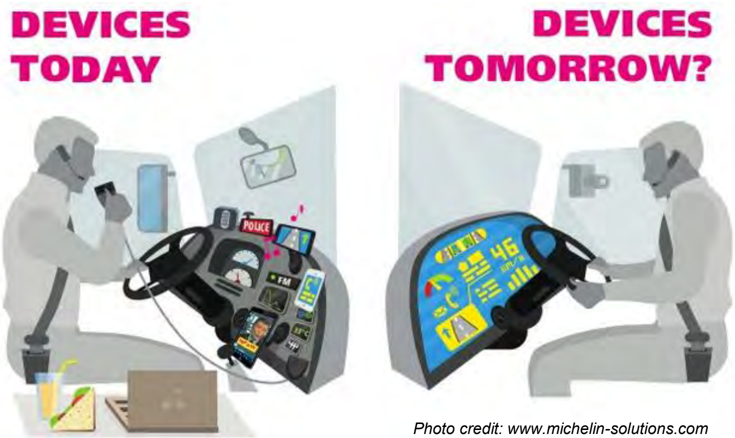
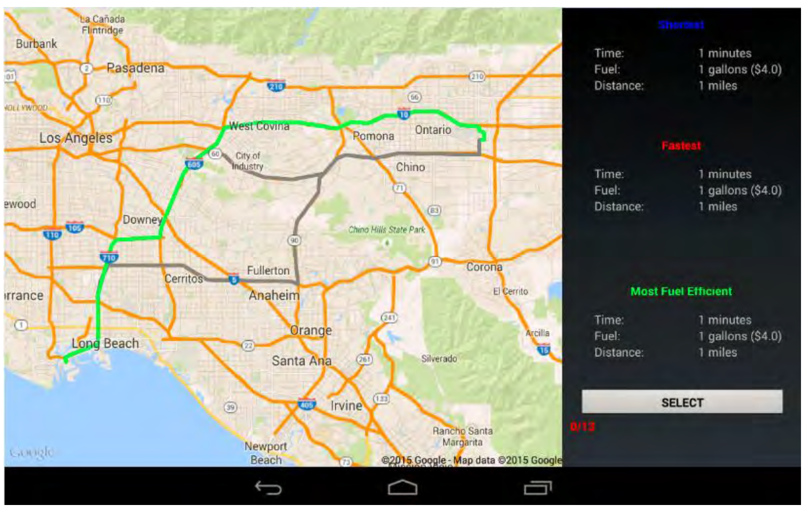
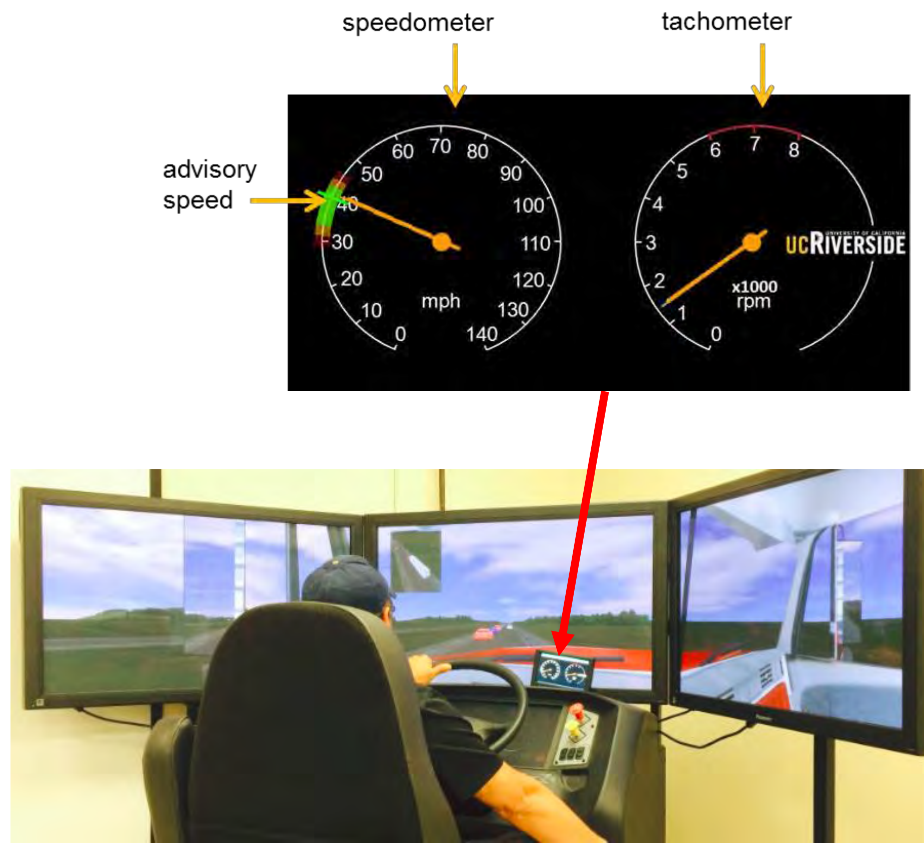


Photo credit: www.michelin-solutions.com

Examples of ongoing research

- Truck eco-routing
- Real-time speed advice
- Connected eco-driving



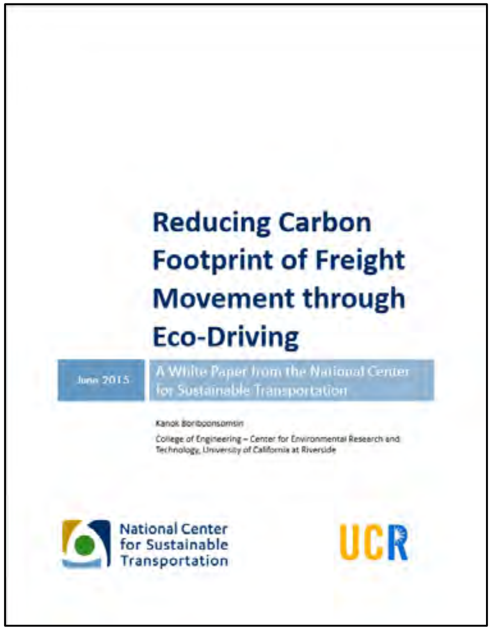


Summary

- Truck eco-driving is a win-win-win strategy for driver, industry, and government.
- Successful truck eco-driving programs consist of three elements:
  - Driver education and training
  - Vehicle maintenance and technology support
  - Policy support
- Large-scale studies show that truck eco-driving can save fuel in the range of 5% to 15%.
- More research is needed to:
  - Better understand the impacts of truck eco-driving programs
  - Further advance truck eco-driving technologies

Closure

- Acknowledgements
  - National Center for Sustainable Transportation
  - US Department of Transportation
  - Xuewei Qi of UC Riverside
  - Reviewers of draft whitepaper
    - California Air Resources Board
    - US Environmental Protection Agency
    - Federal Highway Administration
    - National Renewable Energy Laboratory


Reducing Carbon Footprint of Freight Movement through Eco-Driving

June 2015

A White Paper from the National Center for Sustainable Transportation

Kanok Boriboonsomsin

College of Engineering – Center for Environmental Research and Technology, University of California at Riverside

National Center for Sustainable Transportation

UCR

- For more info:
  - Kanok Boriboonsomsin (kanok@cert.ucr.edu)
  - *http://ncst.ucdavis.edu/research/white-papers/*

True Fuel™

Driver Coaching & Analytics

FUEL ACCOUNTS FOR MORE THAN 25% OF A FLEET'S COST PER MILE (CPM)

A TYPICIAL FLEET SPENDS MORE THAN $25,000 PER TRUCK / PER YEAR
FOR FUEL

POOR DRIVING HABITS COST FLEETS THOUSANDS OF DOLLARS IN FUEL WASTE AND UNNECESSARILY INFLATE COST PER MILE

BY OPTIMIZING DRIVING BEHAVIORS VNOMICS' CUSTOMERS HAVE TYPICALLY IMPROVED FUEL EFFICIENCY BY 3-10% FLEET-WIDE BY:

vnomics
DRIVING PERFORMANCE

TRUE FUEL™

Dash or under dash mounting in less than 15 minutes

Independent of any other on-board technologies

Matched to each vehicle's unique specifications and continuously learns the maximum achievable potential MPG

Real-time on vehicle processing vs. after the fact reporting

Vnomics DRIVING PERFORMANCE

TRUE FUEL APPROACH

Precisely monitors each vehicle's fuel use in real-time

Continually calculates actual mpg and maximum achievable mpg

Coaches drivers in real-time when change matters most

Fuel waste is eliminated and reduced CPM

True Fuel fairly measures each fuel use factor separately and precisely, exclusive of conditions outside of a drivers' control

vnomics
DRIVING PERFORMANCE

ECM MPG CAN BE OFF UP TO 4 PERCENT

"Fuel consumption data in an ECM is derived from an algorithm and not from actual fuel flow, and does not account for fuel energy content, density or temperature, there is an inherent error with those calculations."

Yves Provencher, PITT GROUP

http://fleetowner.com/maintenance/certifying-fuel-savings

OPTIMZATION & ANALYTICS

- Non-distracting tones alert drivers when change is needed
- If no change is needed we continue to monitor for efficiency
- End of trip audible shift score measuring performance efficiency on shifting/throttle control, idle and speeding

- Comprehensive analytics on fuel use and waste
- Rock-solid basis to assess best and worst performance on a per driver and truck view
- Normalized and balanced performance score on based on elements within the drivers control

vnomics DRIVING PERFORMANCE

COACHING IN REAL TIME AND MEASURING <u>DRIVERS'</u> PERFORMANCE IS MOST EFFECTIVE

<u>ACTUAL MPG:</u>
Accurate measurement of truck MPG. ECM reported actual MPG includes factors drivers can't control

<u>POTENTIAL MPG:</u>
Maximum achievable MPG based only on factors drivers can control (Shifting, Throttle Control, Speeding and Idling)

Drivers Control

Shifting

Idling

Throttle

Speeding

Drivers Do Not Control

Terrain

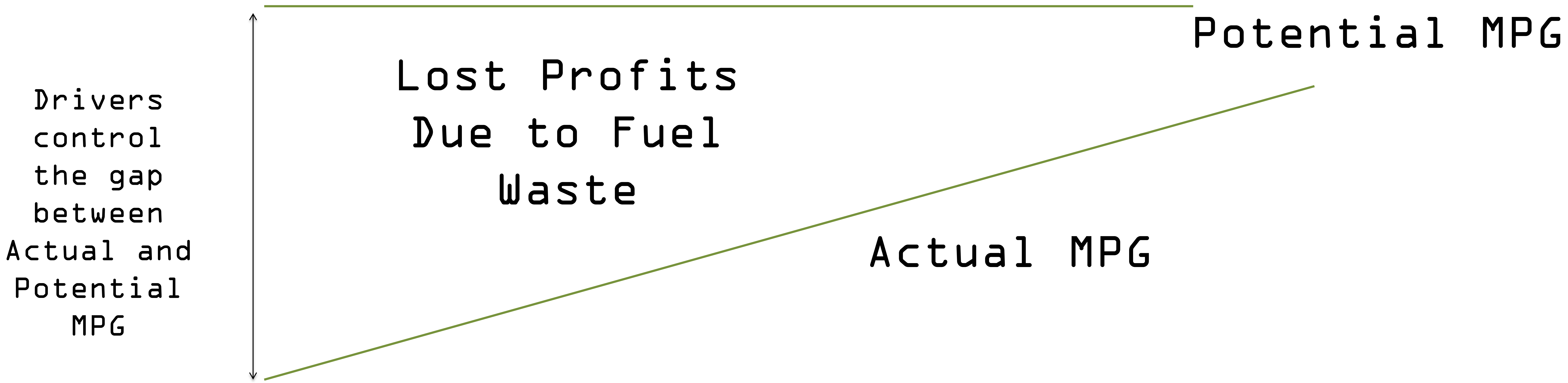
Environment

Load

Vehicle

vnomics
DRIVING PERFORMANCE

VNOMICS MEASURES DRIVER'S PERFORMANCE



Driver Results are Normalized - Drivers are assessed and ranked on how close the Actual MPG is to Potential MPG which is expressed in % Potential

CREDIBLE, REAL-TIME & FAIR

Jeff

Actual fuel use: 7.2 MPG
Potential fuel use: 7.5 MPG

within 4% of Potential

Dave

Actual fuel use: 6.5 MPG
Potential fuel use: 7.2 MPG

within 9.7% of Potential

Sue

Actual fuel use: 6.1MPG
Potential fuel use: 6.2 MPG

within 1.6% of Potential

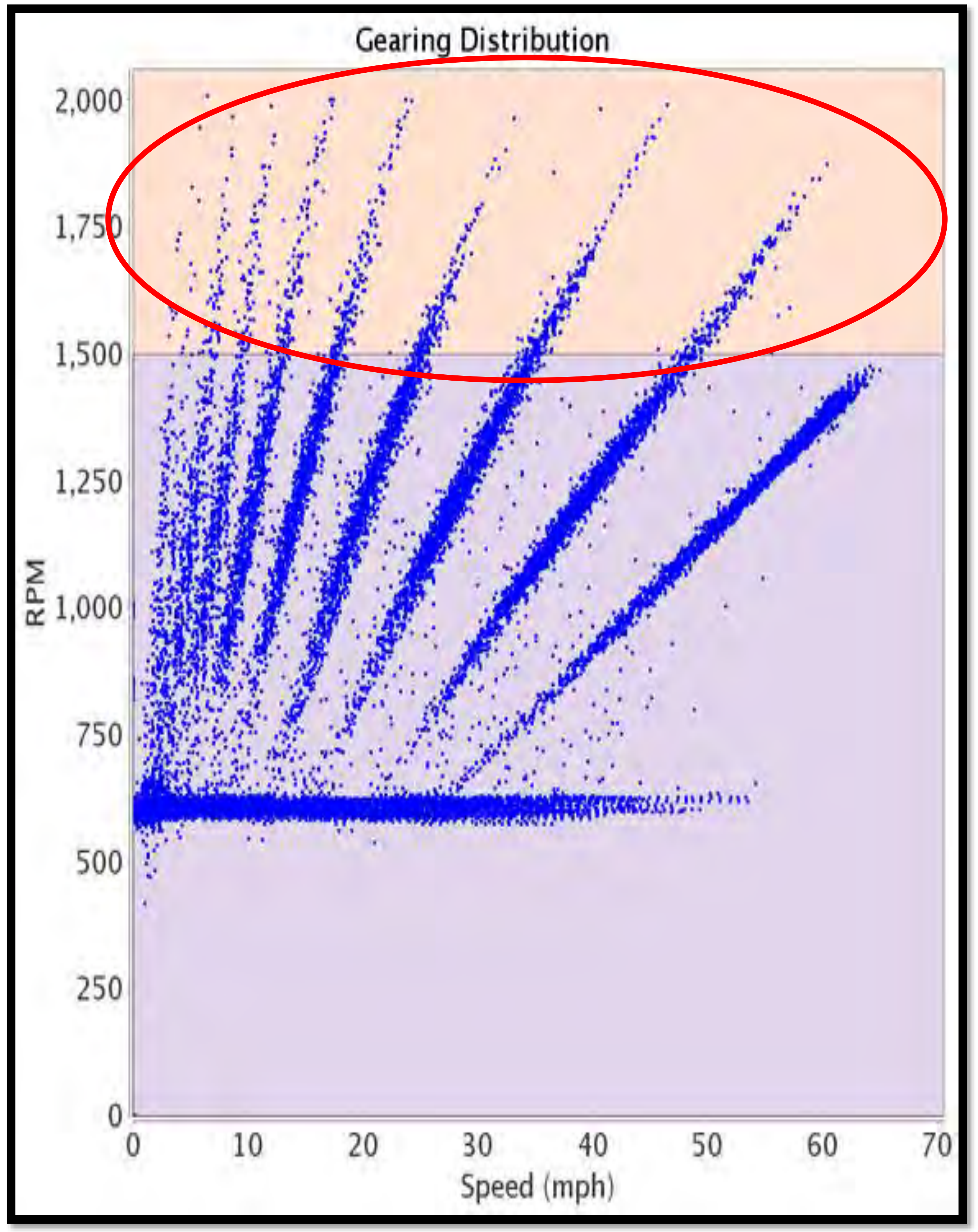
MPG is a poor metric of fuel efficiency especially when measuring driver performance. Fair and accurate measurement normalizes what was achieved and what was possible. Context matters!

vnomics
DRIVING PERFORMANCE

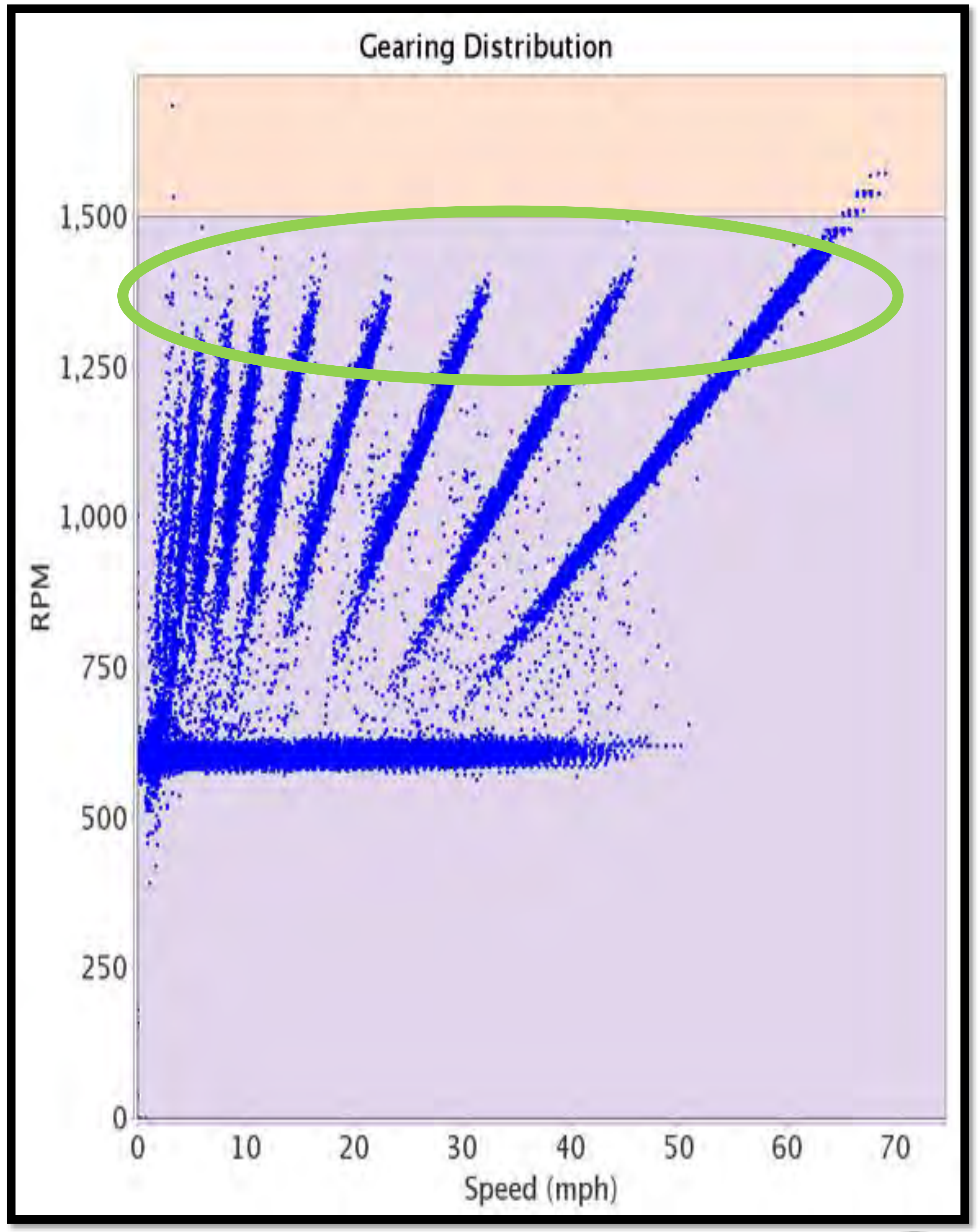
DRIVER SUCCESS

- Improved Shift score from 81% to 100%
- Reduces carbon footprint
- Reduces wear and tear on the engine and transmission
  - –Reduce downtime
  - –Lengthen engine and transmission life
- Improves fleet MPG
- Creates conscientious and responsible drivers

Benchmark: No Coaching



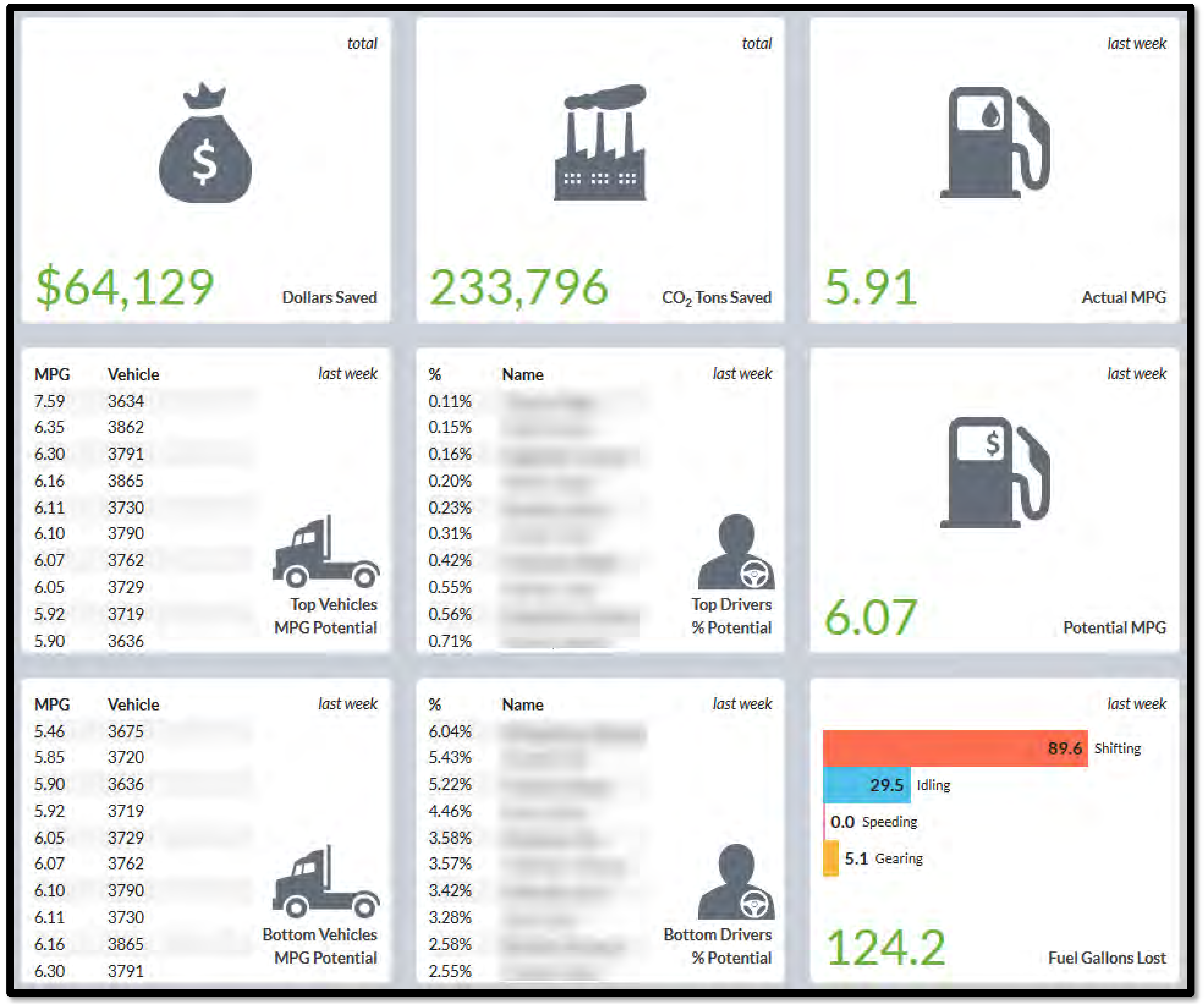
Results: With Coaching



vnomics DRIVING PERFORMANCE

Actionable Analytics

Fleet-wide Dashboards



Driver-specific Reports

- Precisely measure Fuel/Time impact of 62 vs 65 MPH governing
- Determining high-cost routes and adjusting accordingly
- Quickly, fairly and cost-effectively testing fuel improvement technologies (trailer skirts, wheel covers, aero packages, etc.)

Return on Investment

- **843,550 Gallons Annually**
- **Diesel: $2.15 per Gallon**
- **76 Trucks**
- **10% MPG Improvement**

- **843 Tons – Annual Reduction in CO^2**
- **84,355 Gallons – Annual Fuel Savings**

vnomics
DRIVING PERFORMANCE

Vnomics
DRIVING PERFORMANCE

Edward C McCarthy
Vice President of Operations and Customer Success
585.377.9700
www.vnomicscorp.com

Terpening
Trucking Co. Inc.

Brian Brundige
Operations Manager / Safety Department Manager
315.451.8661
www.terpeningtrucking.com

TRANSPORTATION TRANSFORMED

ADVANCING ECO-FRIENDLY MOBILITY

8:45am to 5:00pm | Thursday, April 7, 2016

3:45PM - 4:45 PM / Session 5 – Policy Session Panel

Round-table with questions to policy makers

MODERATOR

Matthew Daus
Distinguished Lecturer, UTRC, CCNY

Stacey Hodge, Director, Office of Freight Mobility, NYCDOT

Maureen Koetz, Koetz and Duncan LLC

Alec Slatky, AAA Northeast Government Affairs

WIFI NYIT_Theater / Password: CobaltBlue77

NYC Urban Freight

Transportation Transformed

Advancing Eco-Friendly Mobility

April 7, 2016

Stacey D. Hodge
Director Office of Freight Mobility
New York City Department of Transportation

NEW YORK CITY DOT

New York City

- Area 302 square miles
- NYC has 5 Boroughs
- **Population 8.4 Million in NYC**
- New York metro area has almost 20 million residents
- **An additional 1.7 million by 2040**

NEW YORK CITY DOT

OneNYC & Vision Zero

New York City's transportation network will be ***reliable, safe, sustainable, and accessible***, meeting the needs of all New Yorkers and ***supporting the city's growing economy***

NEW YORK CITY DOT

Policy Framework

Prioritizing ***low carbon modes, i***ncluding public transport, walking, and cycling in the City's transit rich areas

Policy Framework

Enhancing DOT's capabilities for ***effective operations, network management, enforcement***, and planning through wider use of sensors and data analytics and better interagency cooperation

NEW YORK CITY DOT


ONE WAY
Broadway
NO STANDING ANYTIME
fresh
CLARKE'S STANDARD
870
Burgers
Dr. Martens


BAG MAN
BAG MAN
FRiDAYS
FRiDAYS
FRiDAYS
GIFTS, CAMERAS
LUGGAGE
COFFEE
NEW YORKER
M34 SELECT BUS SERVICE
5859
GUILTY
WEEKDAYS

Street Seats

Benefits, Street Seats

Economic

Sales up 10-15%

Public life benefits

- More active street life
- 116% more people sitting outside on Pearl Street at lunchtime
- Space of one parked car utilized by 100 people in a day
- Provides greenery and seating; **opens views across street**

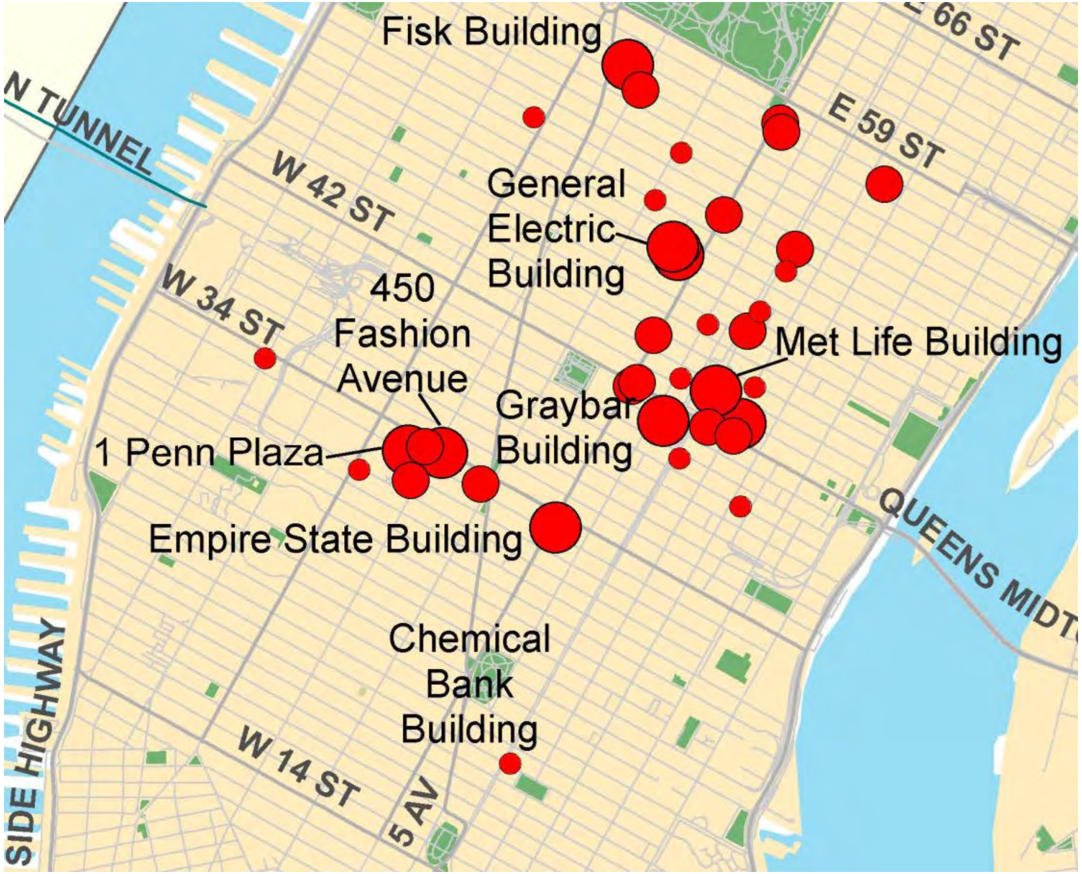
Our Challenge

In order to design our streets to accommodate deliveries, provide bike lanes, bus lanes, and plaza spaces, while also increasing safety for users and supporting the economy, we need to better understand the activity and constraints of all modes.

Truck Trips Demand

Commercial Building in Midtown Manhattan
That dominate delivery traffic

1. Empire State Building
2. Lincoln Building
3. 1 Penn Plaza
4. Graybar Building
5. 450 Fashion Avenue
6. General Electric Building
7. Met Life Building
8. Fisk Building



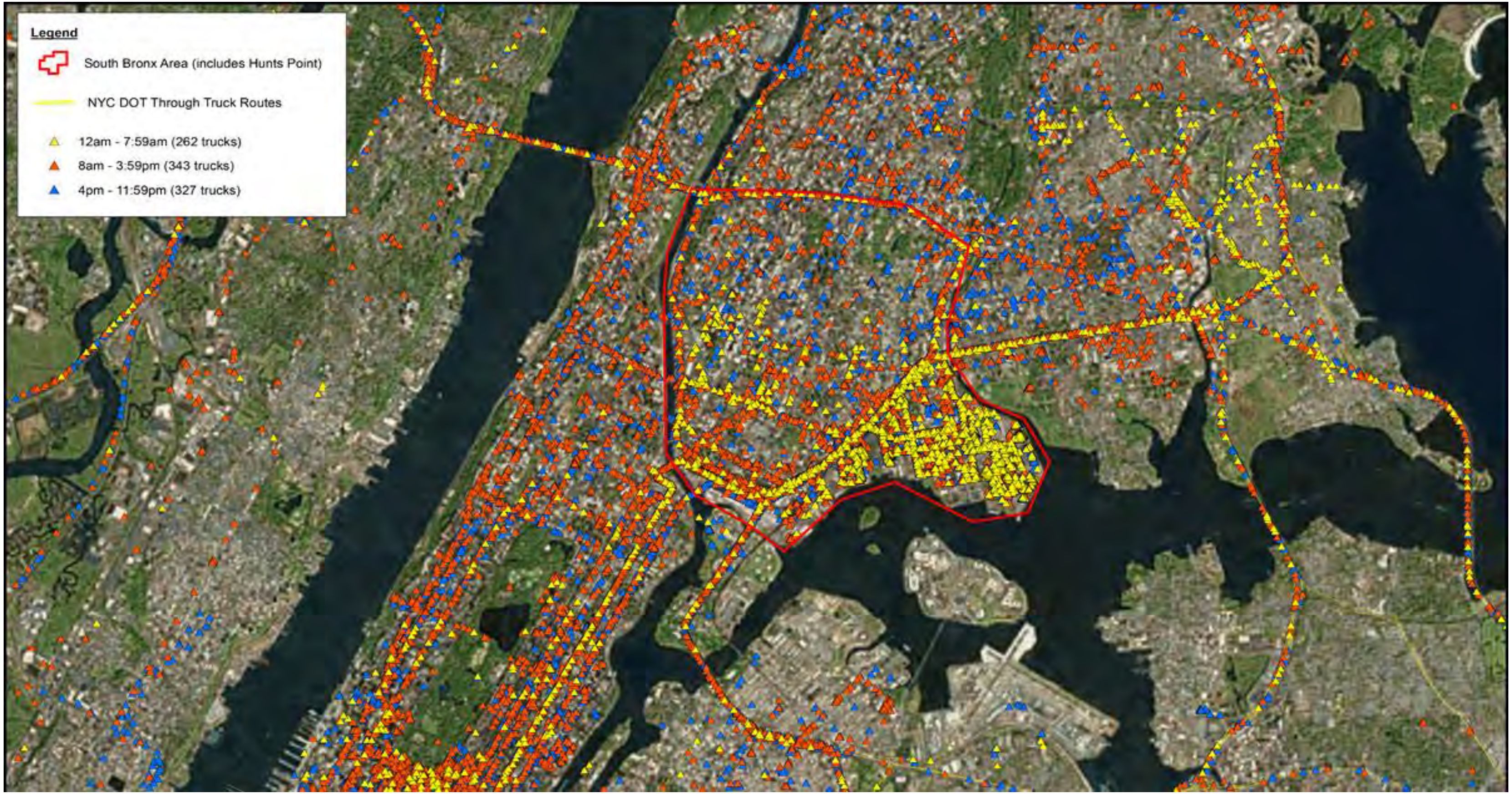
Greening Fleets
NYC DOT Alternative Fuels

Reducing CO_2 Emissions

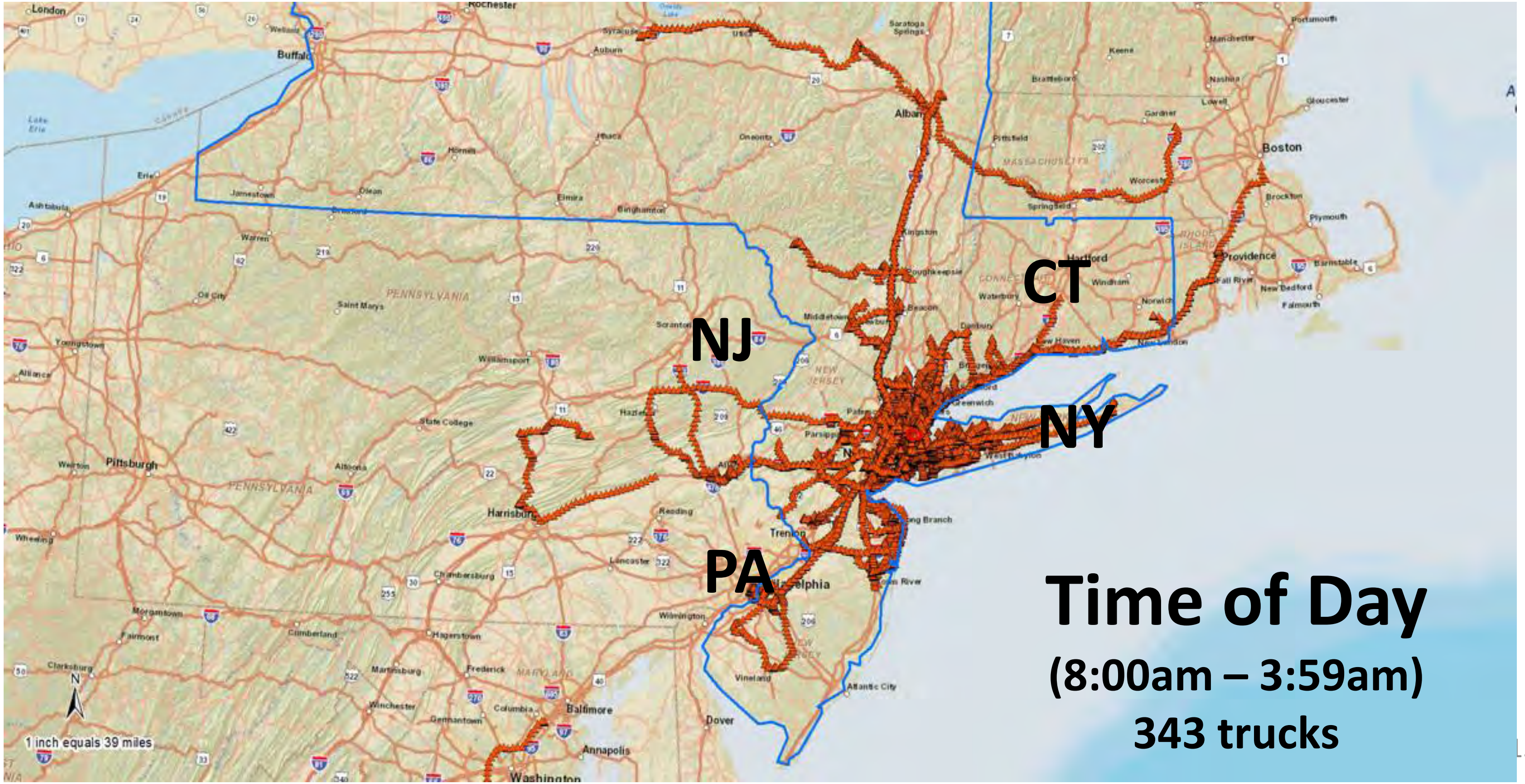
CO_2 reduced by 4643.4 short tons/year

Greening Fleets

NYC DOT Alternative Fuels



Greening Fleets
NYC DOT Alternative Fuels



Greening Fleets
NYC DOT Alternative Fuels

Tetra Tech provided:

- Program design and implementation support;
- Acted as direct interface with applicants;
- Issued the financial rebates;
- Assists DOT in responding to enforcement and compliance issues.

Winter 2015 FHWA Peter Osborne Congratulates NYCDOT and Key Program Participants

NEW YORK CITY DOT

Greening Fleets
NYC DOT Alternative Fuels

- Commitment is 5 years;
- **Prove 70% VMT in tri-state area;** Prove 2x average trips per week using clean truck in the South Bronx.
- Outreach and qualifying truck engine destruction inspection was done by subs Gladstein, Neandross and Assoc. and ISR (DBE contract component) , respectively.

NEW YORK CITY DOT

100% Electric Fleet

London, UK

100% Electric Fleet

London, UK

"How people want to be served in the area where they live will determine if we deliver in a cargo cycle or truck" (UK Panel Discussion June 2015)

London: DHL – Safe, Quiet Demonstration Truck

"Lead by example" DHL custom built this truck to educate and inspire others.

Consolidate Comm. By Products

Consolidate Commercial Waste

Consolidate Commercial Waste

CCTV Monitoring Pilot

Manage curb access, identify violations

Camera allowed staff to see that vans exceeded the one hour loading Limit at this location a taxi was parked in truck loading zone. Coordinated with NYPD to TOW vehicles

Delivery Windows

CCTV Truck Monitoring

CCTV Mobile Units

Units will be used for truckers outreach and to monitor truck route compliance citywide for Local Law 057

Reduce Conflicts
Grand Central Partnership Area

- More than 16,000 pedestrians per hour on average at a single point weekday peak time
- Approximately 900 retail stores and boutiques
- More than 30 luxury hotels
- Approximately 150 full-service restaurants

Source: Grand Central Partnership, Annual Report 2011

Day Time Hours

Four Points by Sheraton 326 W. 40th St.
Between 8th and 9th Avenues Manhattan

Off Hours

Four Points by Sheraton 326 W. 40th St.
Between 8th and 9th Avenues Manhattan

Off Hour Deliveries

- When expanded more broadly, off hour deliveries will result in less truck interactions with pedestrian and cyclists
- There are 9,178 restaurants and drinking places in Manhattan, they generate more truck traffic than the Port Authority of New York and New Jersey
- NYC has adopted off-hour deliveries as part of its sustainability strategy.

Partners: Rensselaer Polytechnic Institute, NYSDOT NYSERDA, NYC DEP

Truck Routes, Land Use & Freight Conflicts

Large Trucks on Local Streets

Thank You

To Contact us:

Office of Freight Mobility

Stacey D. Hodge
shodge@dot.nyc.gov
212-839-6670

nyc.gov/trucks
trucknyc.info

Truck Permits Unit

(212) 839-6341

Over dimensional Truck Permits

Alternative Fuels Program

Mark Simon

msimon@dot.nyc.gov

Public Space Unit

Shari R Glickman

SGlickman@dot.nyc.gov

NEW YORK CITY DOT

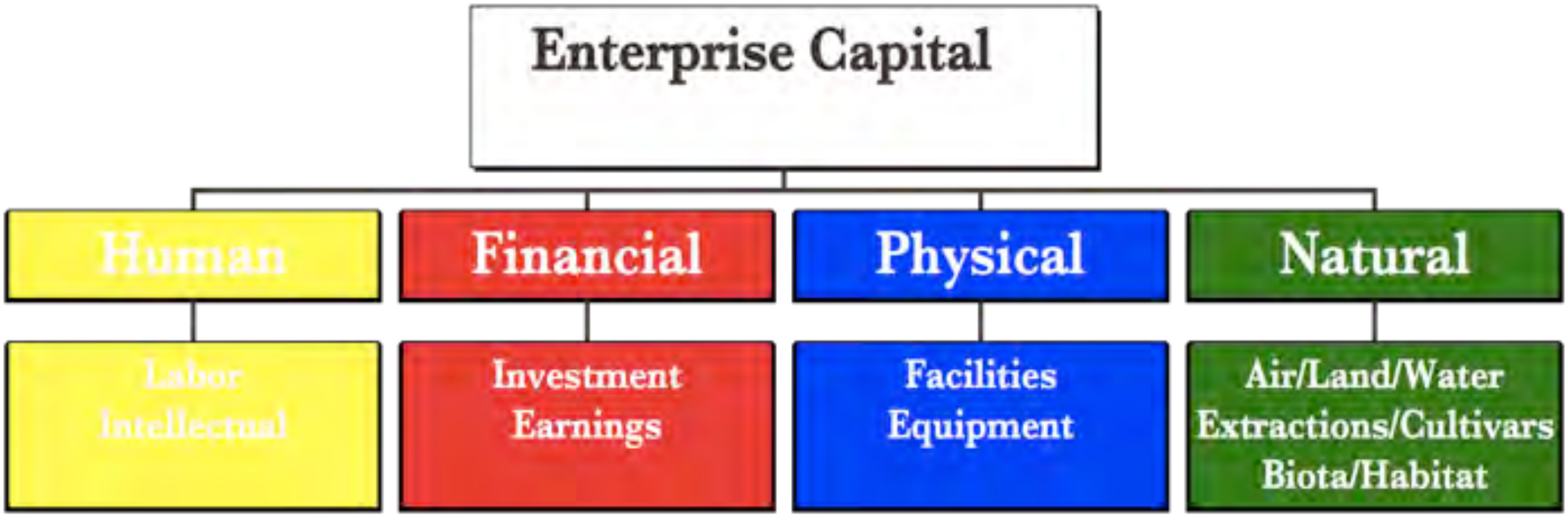
Strategic *Design and Management* *for* *Eco-Mobility*

US DOT Region 2
UTRC Eco-Mobility Conference

Maureen T. Koetz, Esq.

April 7, 2016

Why <u>Sustainable</u> Transport?



- Use Today, but Leave for Tomorrow
- Natural Capital Capacity Supply Static/Shrinking
- Natural Capital Capacity Demand Increasing
- Natural Capital the Basis for Transport System Design

What is Sustainable Transport?

- **Movement of persons/information/goods optimized for smallest volume of natural capital consumption per unit of performance**
- **Optimization possible in supply, build, and operational process phases**
- **Requires quantitative not qualitative metrics**

Implementing Sustainable Transport

1. Recognize inherent technology features and relationships
   - Scale
   - Design
   - Psychology/Behaviors
2. Inventory used and available Natural Capital Capacity Supply (NCCS)
   - Air, land, and water components
3. Align NCCS to Performance Requirements (big data)
4. Manage gaps
   - Design Basis alterations
   - O&M Improvements
   - Directed Investment
   - Credit accrual
5. Market Green to Green Market

After all, sustainability means running the global environment - Earth Inc. - like a corporation: with depreciation, amortization and maintenance accounts. In other words, keeping the asset whole, rather than undermining your natural capital.

Maurice Strong

A man is rich in proportion to the number of things he can afford to leave alone.

Henry David Thoreau

AAA & Eco-Friendly Mobility

UTRC Region 2
April 7, 2016
NYIT

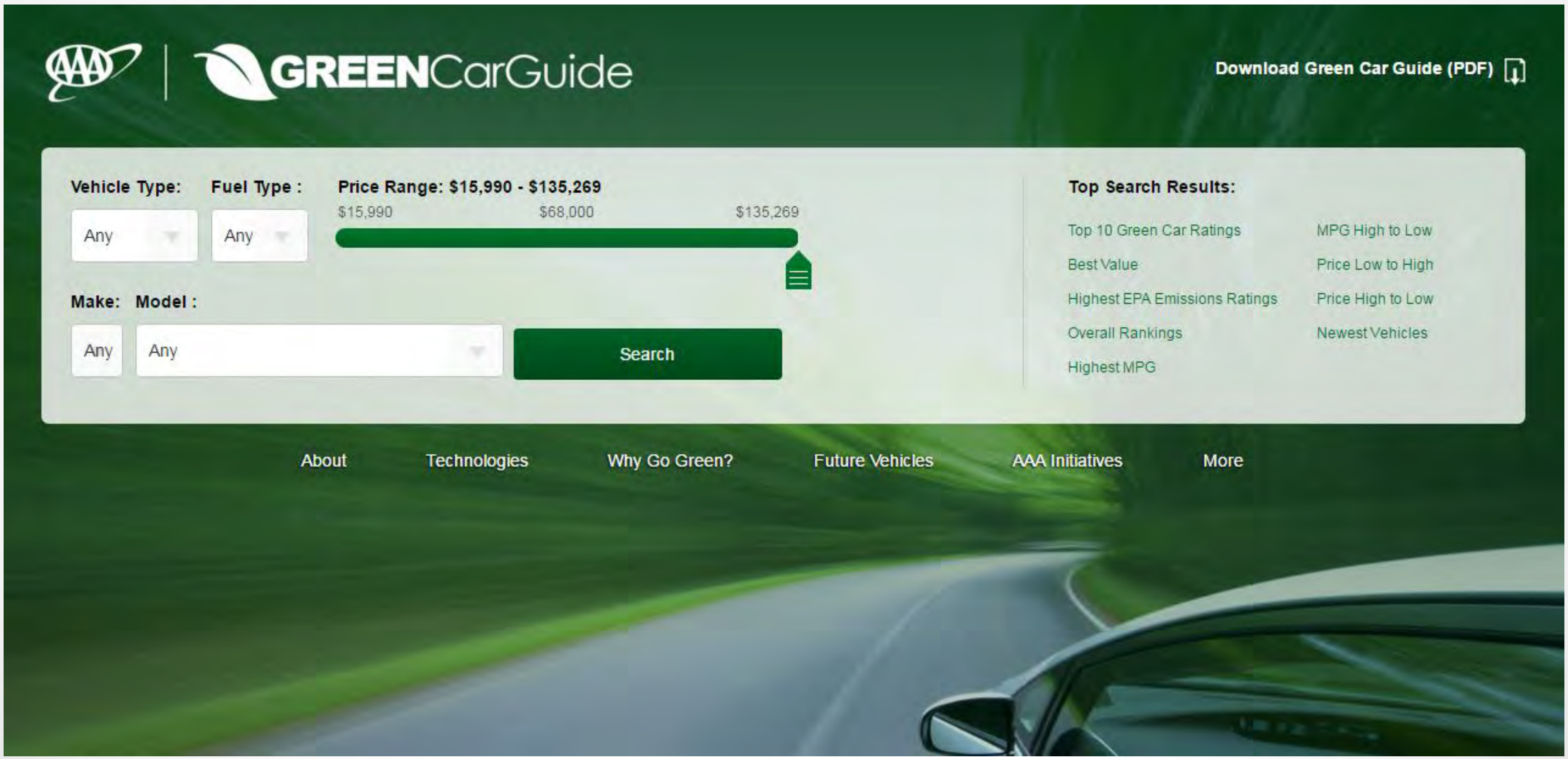
AAA by the Numbers

- New York City: 570,000 members
- New York State: 2.7 million members
- United States: 54 million members

AAA & the Environment

- Education
  - Green Car Guide
  - Electric Vehicle Guide

AAA & the Environment



AAA & the Environment

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- Education
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  - Electric Vehicle Guide
- Research
  - Automatic stop-start systems
  - EV battery testing

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- Operations
  - Roadside assistance for EVs (NOT IN NY REGION)
  - Roadside assistance for bicycles

AAA & the Environment

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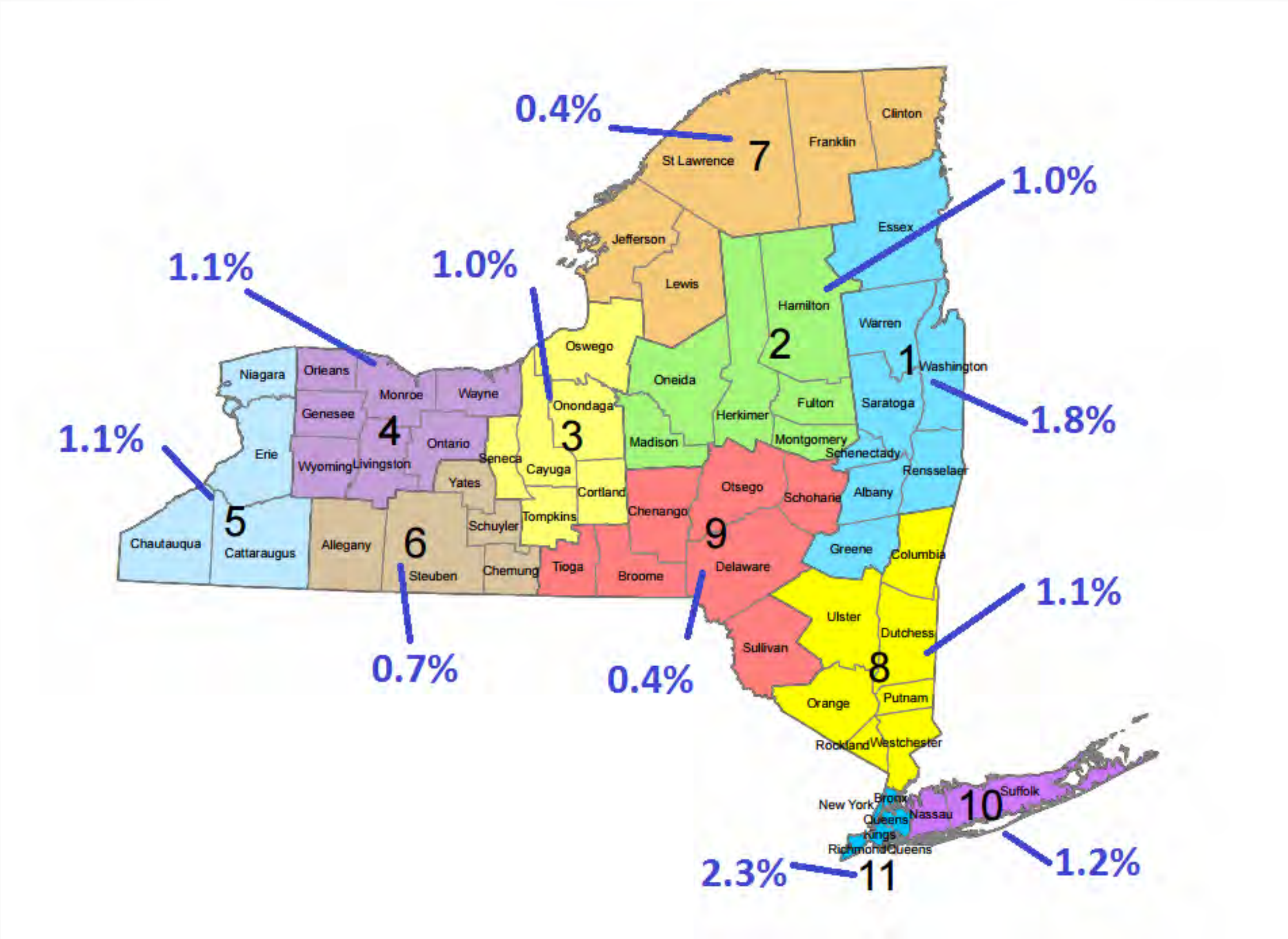
  - EV battery testing
- Operations
  - Roadside assistance for EVs (NOT IN NY REGION)
  - Roadside assistance for bicycles
- Policies
  - HOV lanes
  - Federal gas tax

Automotive Trends

- NYS passenger vehicle registrations increased:
  - 3.9% from 2010-15
  - 1.4% from 2014-15

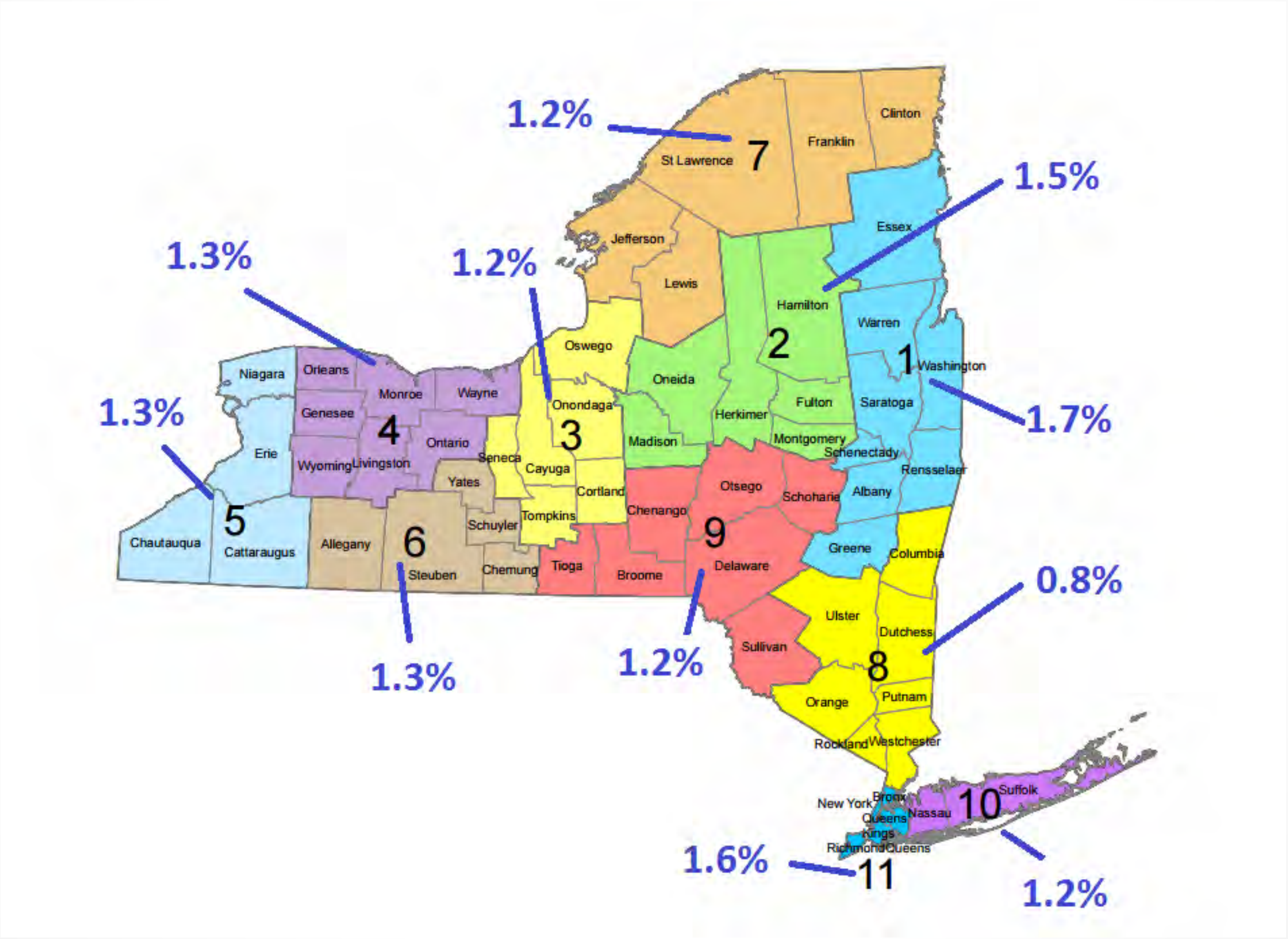
Automotive Trends



Automotive Trends

- NYS passenger vehicle registrations increased:
  - 3.9% from 2010-15
  - 1.4% from 2014-15
- NYS per-capita passenger vehicle registrations increased:
  - 1.8% from 2010-15
  - 1.1% from 2014-15

Automotive Trends



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  - 1.1% from 2014-15
- NYS VMT increased:
  - 0.4% from 2010-15
  - 3.1% from 2014-15

Automotive Trends

NEW YORK THRUWAY

⇧ 1.9%

MTA Bridges and Tunnels

⇧ 4.0%

THE PORT AUTHORITY OF NY & NJ

⇧ 1.7%

NEW YORK STATE BRIDGE AUTHORITY

⇧ 2.7%

Automotive Trends

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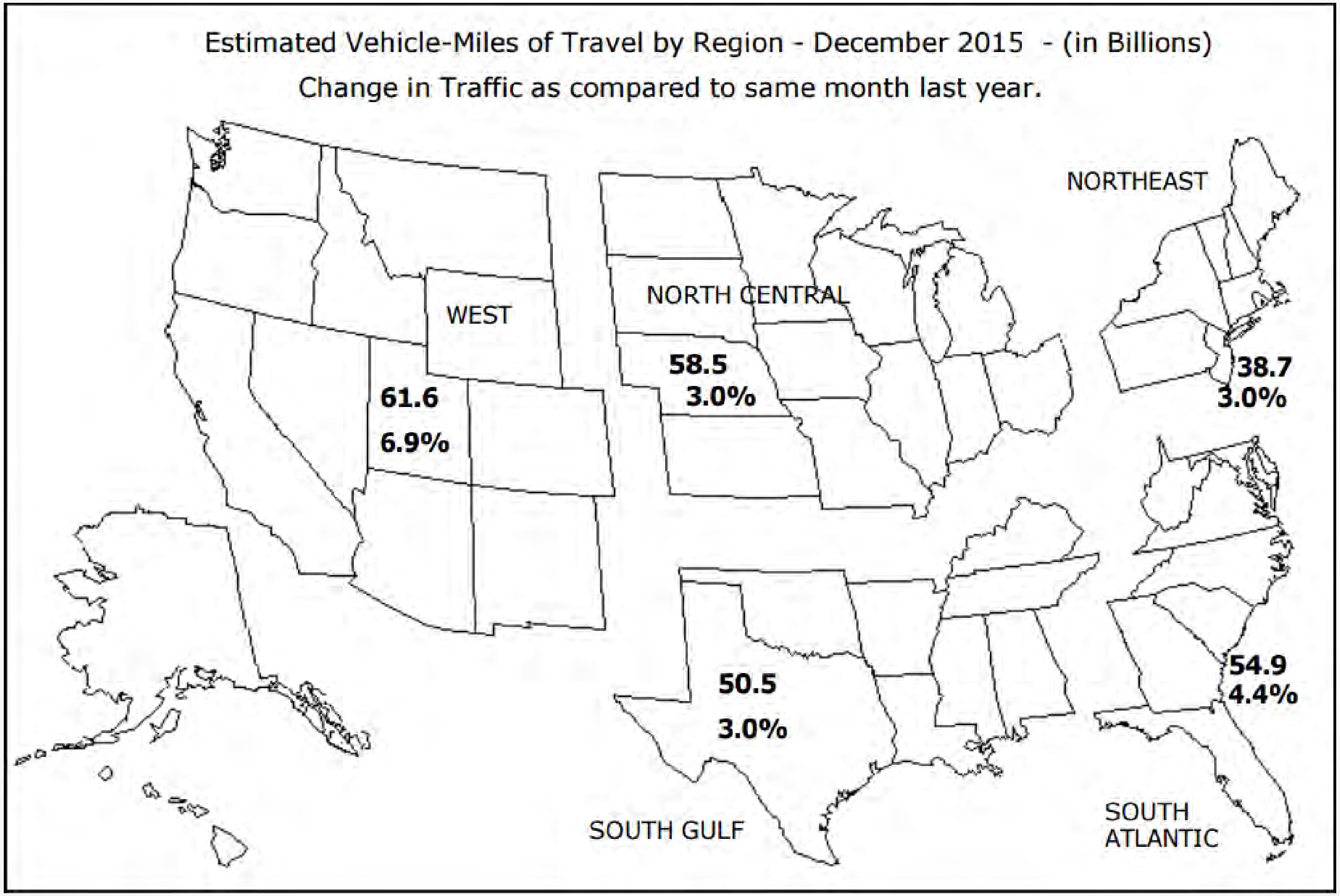
- NYS per-capita passenger vehicle registrations increased:
  - 1.8% from 2010-15
  - 1.1% from 2014-15
- NYS VMT increased:
  - 0.4% from 2010-15
  - 3.1% from 2014-15
- USA VMT increased:
  - 5.0% from 2010-15
  - 3.6% from 2014-15

Automotive Trends



Differing Perspectives

- Automobile Club of New York v. Koch (1981)
  - Defeated a proposed ban on single-occupant vehicles on the East River Bridges

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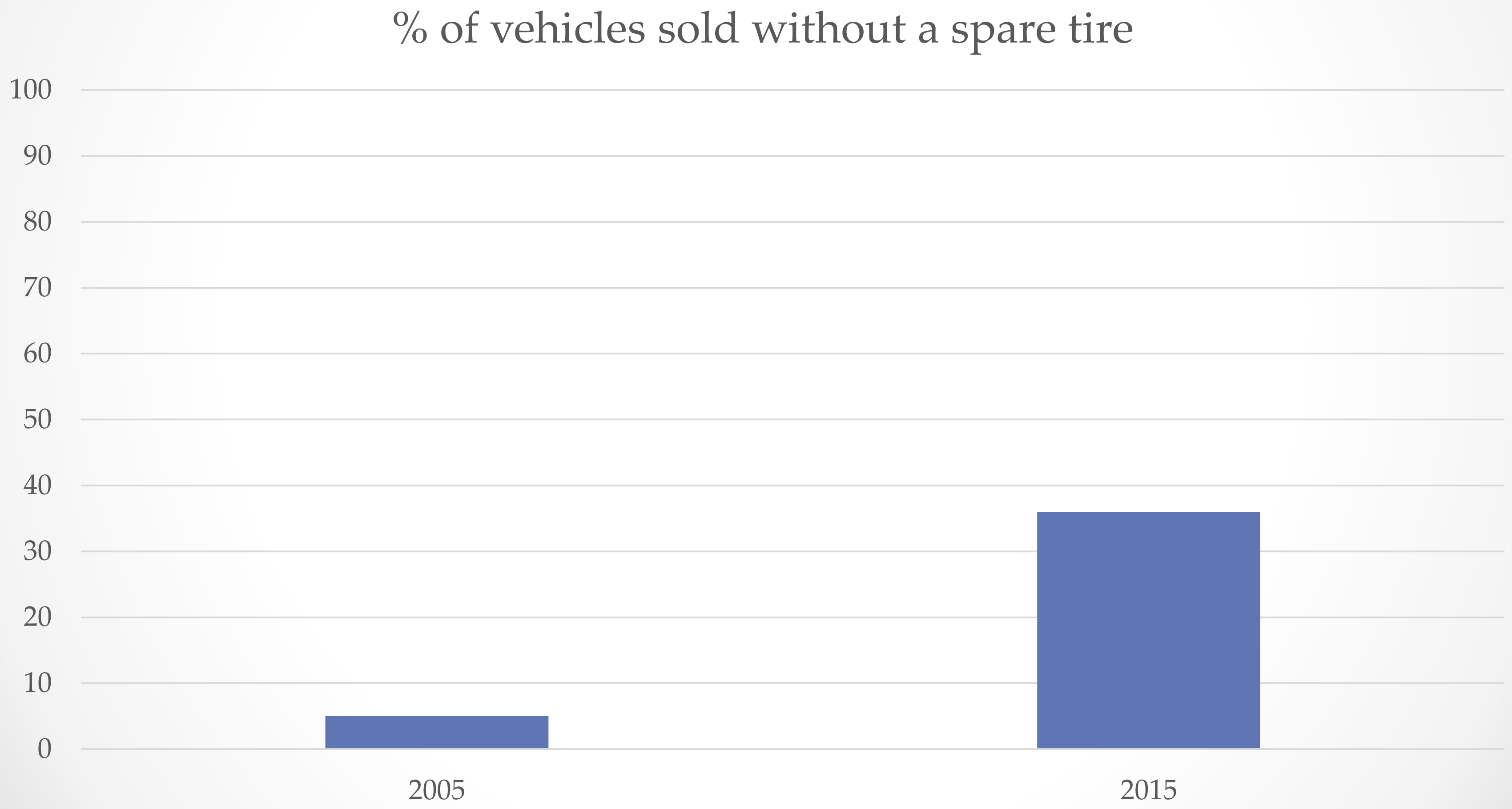
- Renewable Fuels Standard – E15
  - Warned consumers that warranties could be voided

Differing Perspectives

Differing Perspectives

- Automobile Club of New York v. Koch (1981)
  - Defeated a proposed ban on single-occupant vehicles on the East River Bridges
- Renewable Fuels Standard
  - Warned consumers that E15 could void warranties
- CAFE standards
  - Educated consumers about the “disappearing spare tire”

Differing Perspectives



Shared Goals

- Safety
- Mobility
- Efficiency
- Affordability

Thanks!

- Alec Slatky
- Email: aslatky@aaanortheast.com
- Tel: (516) 873-2266

Appendix 2

Agenda and Conference Program Brochure

TRANSPORTATION TRANSFORMED

ADVANCING ECO-FRIENDLY MOBILITY

University Transportation Research Center

NEW YORK STATE OF OPPORTUNITY. | NYSERDA | Department of Transportation

New York Institute of Technology

TODAY'S SCHEDULE 04/07

8:45 AM - 9:30 AM / Registration/Continental Breakfast

9:30 AM - 10:30 AM / Welcome & Keynote Speakers

Welcoming Remarks

Camille Kamga Ph.D.,
Director, UTRC

Mr. Jamil Ahmad, Deputy Director, United Nations, Environment Programme (UNEP):
Global Warming, Climate Change, COP21

Gabriel Pacyniak, Adjunct Professor, Mitigation Program Manager, Georgetown Climate Center:
Transportation and Climate Initiative

10:30 AM - 11:15 AM / Session 1 – Technology for Eco-Mobility

MODERATOR

Joseph Tario
Senior Project Manager
NYSERDA

Stanley Young Ph.D., National Renewable Energy Lab/ or
Vassilis Papayannoulis, Ph.D., Metropia: TRANSNET *(Traveler Response Architecture Using Novel Signaling for Network Efficiency in Transportation)*

Jamyn Edis Ph.D. Adjunct Professor at NYU & CEO /Co-founder @ Dash:
"DASH Smart Driving App"

Alain Kornhauser Ph.D., Princeton University: *Shared Autonomous Taxis for Eco-Mobility*

11:15 AM - 11:30 AM / Break

11:30 AM - 12:30 PM / Session 2 – Academic Research

MODERATOR

Elisabeth Lennon
NYSDOT

Angela Sanguinetti, Ph.D., Institute of Transportation Studies, U. California, Davis:
A Behavioral Review of Eco-driving

Kanok Boriboonsomsin, Ph.D., College of Engineering, Center for Environmental Research and Technology, UC Riverside: *Evaluating Real World Impacts of Eco-driving*

Rae Zimmerman, Ph.D., NYU Wagner Graduate School of Public Service:
Issues of Intermodal Connectivity and Eco-mobility

12:30 PM - 1:30 PM / Lunch

Walk to 16 West 61st St., 11th Floor Auditorium

1:30 PM - 2:00 PM / Afternoon Keynote

Administrator/Chairman **Raymond P. Martinez,** New Jersey Motor Vehicle Commission

2:00 PM - 2:45 PM / Session 3 – Government Programs (City & State)

MODERATOR

Frank Mongioi
ICF International

Brenda Dix, ICF International:
Metropolitan Transportation Commission/San Francisco Bay Area Sustainability Programs

Alex Keating, NYCDOT: *Drive Smart Program*

John Lyons, Metropool (or Brad Tito, former Sustainability Director, City of Yonkers) :
Eco-driving Training of Municipal Fleet Drivers

2:45 PM - 3:30 PM / Session 4 – Goods Movement and Eco-Driving

MODERATOR

Alison Conway, Ph.D.
The City College of New York

Edward McCarthy, Vice President of Operations and Customer Success, Vnomics Corporation:
Driver Coaching and Fuel Optimization Solution

Brian Brundige, Operations/Safety Manager, Terpening Trucking Company

Kanok Borboonsomsin, Ph.D., UC Riverside: *Reducing the Carbon Footprint of Heavy Duty Trucks*

3:30 PM - 3:45 PM / Break

3:45PM - 4:35 PM / Session 5 – Policy Session Panel

Round-table with questions to policy makers

MODERATOR

Matthew Daus

Stacey Hodge, Director, Office of Freight Mobility, NYCDOT

Maureen Koetz, Koetz and Duncan LLC

Alec Slatky, AAA Northeast Government Affairs

4:35 PM - 5:00 PM / Closing Remarks

1:30 PM - 2:00 PM / Afternoon Keynote

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KEYNOTE SPEAKERS

Mr. Jamil Ahmad
Deputy Director, United Nations Environment Programme

Mr. Jamil Ahmad was appointed to his current position in 2014 where, besides other matters, he leads coordination of UNEP's engagement in intergovernmental processes and negotiations on the environment and sustainable development.

Earlier, he was the Secretary for the Governing Bodies of UNEP, based in Nairobi, Kenya (2008-14). He directed, managed and coordinated the work of the Governing Bodies, led the organization of the sessions of the Governing Council (renamed United Nations Environment Assembly) and was the focal point of UNEP's external relations.

As an advocate of sustainability, he regularly engages with stakeholders, speaks to civil society groups, students and others about environment, climate change and sustainable development.

A career diplomat, Mr. Jamil Ahmad joined the Foreign Service of Pakistan in 1986 and has worked in a number of different duty stations with rich experience of bilateral and multilateral affairs, including Acting Permanent Representative to the UN agencies in Rome and Deputy Permanent Representative to UNEP in Nairobi. He participated in numerous important UN and other intergovernmental meetings, including the World Summit on Sustainable Development (WSSD) in 2002, sessions of the UNGA, the Commission of Sustainable Development (CSD) and the Governing Councils of UNEP, UN-HABITAT and FAO. He was lead negotiator of the Group of 77 & China for Climate Change under Pakistan's chairmanship in 2007 culminating at COP13 to UNFCCC in Bali in 2007.

He joined UNEP in 2008.

Mr. Jamil Ahmad holds a Master's Degree in Political Science.

Gabriel Pacyniak
Adjunct Professor, Mitigation Program Manager, Georgetown Climate Center:
Transportation and Climate Initiative

Gabriel Pacyniak is the climate change mitigation program manager at the Georgetown Climate Center and adjunct professor at Georgetown Law. He works closely with Deputy Director Kate Zyla to oversee the Climate Center's work on reducing emissions from the electricity and transportation sectors. This includes the Climate Center's work on federal carbon pollution regulations for the power sector, focused on supporting state engagement with, and implementation of, the federal standards through facilitation, convening, and analysis. It also includes the facilitation of the Transportation and Climate Initiative, a collaboration among 11 northeast and mid-Atlantic states and the District of Columbia to reduce GHG emissions from the transportation sector. Along with Executive Director Vicki Arroyo, he co-teaches a yearly practicum course on the law and policy of climate change that provides students an opportunity to work on real-world legal and policy issues.

Raymond P. Martinez
Chairman and Chief Administrator, New Jersey Motor Vehicle Commission

Raymond P. Martinez was nominated by Governor Chris Christie on February 1, 2010 to become the Chairman and Chief Administrator of the New Jersey Motor Vehicle Commission (MVC). In this role, Mr. Martinez manages a state agency, which generates more than $1 billion annually and is charged with the licensing of nearly six million drivers and the titling, registration and inspection of more than 4.9 million vehicles. He is also the Chairman of the MVC Board, a policy-making body made up of government and public members. In 2014, Governor Christie also appointed Mr. Martinez as an Executive Branch Member of the State Planning Commission. In this role, he represents state government in the oversight of environmental protection issues, land use, development and redevelopment.

Mr. Martinez came to the MVC with a wealth of motor vehicle experience, having served from 2000 to 2005 as Commissioner for the New York State Department of Motor Vehicles under Governor George Pataki. There he oversaw an organization that served more than 20 million customers.

In his capacity as Commissioner, Mr. Martinez also held the position of Chairman of the Governor's Traffic Safety Committee, administering federal funding for state and local highway safety projects. During his tenure as Commissioner, Martinez was a member of the American Association of Motor Vehicle Administrators (AAMVA) and served as President of its Region I Board and as a member of its International Board in 2005.

Prior to his nomination by Governor Christie, Mr. Martinez was most recently the Deputy U.S. Chief of Protocol and Diplomatic Affairs for the U.S. Department of State and the White House where he was responsible for managing five operational divisions: Diplomatic Affairs, Foreign Visits, Ceremonial Events, Blair House, and Administration.

Mr. Martinez served on numerous White House advance teams for domestic and international trips of Presidents Ronald Reagan, George H.W. Bush and George W. Bush. During the Reagan Administration, he was Deputy Director for Scheduling and Advance at the White House for First Lady Nancy Reagan and also served as a Special Assistant at the New York Regional Office of the United States Department of Housing and Urban Development.

Additionally, Mr. Martinez served as Assistant General Counsel for the Long Island Power Authority, one of the largest public utilities in the nation, and as Deputy Chief of Staff and Special Counsel to the New York State Attorney General.

Mr. Martinez received his BA from Long Island University/C.W. Post College in Brookville, New York and is a graduate of St. John's University School of Law. He resides in Monmouth County, New Jersey.

SPEAKERS

Kanok Boriboonsomsin
Associate Research Engineer, College of Engineering Center for Environmental Research and Technology University of California at Riverside

Dr. Kanok Boriboonsomsin is an Associate Research Engineer with the College of Engineering – Center for Environmental Research and Technology, University of California at Riverside. His recent research has been in the areas of eco-friendly transportation technologies, eco-driving simulation and evaluation, connected and automated vehicle applications, and advanced traffic operations. Dr. Boriboonsomsin currently serves on the Transportation and Air Quality Standing Committee of the TRB, and as an Associate Editor of the IEEE Intelligent Transportation Systems Magazine.

Brian Brundige
Operations/Safety Manager, Terpening Trucking Company

Brian Brundige is currently employed at Terpening Trucking Company, Inc., which provides fuel delivery in New York, Pennsylvania, and surrounding locations. Brian is the Operations/Safety Manager, a position he has held since 2014. In this capacity, he oversees the Safety Department of three safety professionals and manages 100+ driver's and a 76 truck fleet. Trained in emergency responding, spill response, and accident recreation, he works extensively with the Safety Department in refining and developing better safety systems. In addition, Brian has also been responsible for implementing an improved tracking system in partnership with Vnomics Corporation in mid-2011 and in March 2012, leading Terpening in implementing Vnomics's fully electronic E-Log and Truck Tracking systems. This position represents Brian's second stint with Terpening; the first was from July 1994- October 1995 when he was a fuel hauler.

Since his graduation from high school in Cazenovia, New York in 1982, Brian has held several positions in warehousing management and distribution and the trucking industries, in addition to his time at Terpening. Some of these included a Class A driving position with a local frozen food distributor and subsequently holding a warehouse management position for this same company; serving as a driver with Armarada Hess Corporation and later becoming involved with terminal and pipeline operations at TED Park in Warners, New York for both the Hess and Exxon/Mobil corporations.

Believing that everyone should volunteer as part of their everyday life, Brian has volunteered as a Boy Scout leader since 2011 for Troop 80 in Baldwinsville, NY.

He has five children ranging from ages 16 to 33 and five grandchildren. He is extremely proud of them all.

Moderator

Alison Conway
Assistant Professor of Civil Engineering, The City College of New York
Associate Director for New Initiatives, University Transportation Research Center

Alison Conway is an Assistant Professor of Civil Engineering at the City College of New York and the Associate Director for New Initiatives at the Region 2 University Transportation Research Center. She is also an associated faculty member of METROFREIGHT, a Volvo Research and Education Foundation Center of Excellence in Urban Freight. At CCNY, Dr. Conway teaches courses in transportation engineering and planning and conducts research primarily in the areas of commercial freight policy and logistics, sustainable freight transportation, and multi-modal interactions in the urban environment. She currently chairs the TRB Young Members Council and the ASCE Transportation and Development Institute's Freight and Logistics Committee, and is a member of TRB's Freight Data, Truck Size and Weight, and Urban Freight Committees. Dr. Conway holds Ph. D. and Master's degrees in Civil Engineering from The University of Texas at Austin, and a Bachelor's of Civil Engineering from the University of Delaware.

Moderator

Matthew Daus, Esq.
Distinguished Lecturer, UTRC, CUNY

Matthew W. Daus, Esq. currently serves as a Distinguished Lecturer at the City University of New York's (CUNY) Transportation Research Center of The City College of New York. Professor Daus conducts research and is extensively published as an expert on ground transportation regulation and technology. He teaches courses on transportation history, policy, sustainability, for-hire regulation and technology. Mr. Daus also continues to serve as President of the International Association of Transportation Regulators (IATR), a non-profit educational and advocacy peer group of government transportation regulators from around the world promoting best regulatory practices. Mr. Daus is the longest serving Chairman of the New York City Taxi and Limousine Commission (TLC), serving for 8 ½ years. Prior to his tenure as Commissioner, Mr. Daus served in executive positions in NYC government for almost 16 years at several agencies including as General Counsel to the TLC and the NYC Community Development Agency, as Special Counsel to the TLC and NYC Trade Waste Commission, and as a NYC Human Rights Prosecutor. Mr. Daus is a partner and currently chairs the Transportation Practice Group at Windels Marx Lane & Mittendorf, LLP.

Brenda Dix

Senior Associate, Climate Change and Sustainability, ICF International

Brenda Dix is a Senior Associate at ICF International with over seven years of experience in transportation planning, policy development, and environmental analysis, covering air quality and climate change issues, in particular. Brenda currently focuses on climate change adaptation planning for transportation agencies including identifying climate sensitive decisions, conducting benefit-cost analyses to develop a financial case for adaptation, and developing innovative methods for integrating climate change into planning, asset management, engineering design, and operations. Prior to joining ICF, Brenda worked as a transportation planner at the Metropolitan Transportation Commission (MTC), the MPO for the San Francisco Bay Area. She has been able to continue her work with them at ICF where she manages their Smart Driving educational campaign and in-vehicle device promotion program, as well as the evaluation of several of their sustainability programs. Brenda has Master's and Bachelor's degrees in Civil and Environmental Engineering from the University of California at Berkeley.

Jamyn Edis

Founder and CEO, Dash

Jamyn Edis is the founder and CEO of Dash, a connected car platform (www.dashmobile.co).

Jamyn is also a mentor and investor in Techstars, the world's premier technology accelerator, as well as being a participant in the New York 2013 program.

He has over 20 years of experience in strategy, product development, partnerships, finance and marketing, primarily in the technology, media and telecoms industries.

As a VP at HBO, he led the Emerging Technology R&D Group. He also worked in the London and New York offices at Accenture's strategy consulting practice, which has an industry focus on technology, media and telecoms; his clients include Sprint, BT, Fox Interactive, MySpace, Rogers, Global Telematics, Trader.com, Sony PlayStation, World Rally Championships, Warner Music, EMI.

He is currently a Professor in New Media and Entrepreneur-in-Residence at NYU Stern School of Business. He holds an MBA from Harvard Business School and a BA/MA from Cambridge University.

Stacey Hodge

Director, Office of the Freight Mobility, New York City Department of Transportation

Ms. Hodge is the Director of the Office of Freight Mobility for the New York City Department (NYCDOT) of Transportation where she manages a multi-million dollar freight program with responsibility for managing the City truck routes, truck delivery programs and traffic rules and regulations governing truck movement. Ms. Hodge has over 20 years of transportation design and planning experience in the public and private sector.

Ms. Hodge coordinates with City, State and Federal agencies on transportation projects and policy. NYCDOT is a core city partner of the VREF Center of Excellence (CoE) for Sustainable Urban Freight Systems and Ms. Hodge serves as the point of contact at NYCDOT for the CoE.

In May 2013, Ms. Hodge was appointed by the United States Department of Transportation (USDOT) Secretary to serve on the National Freight Advisory Committee (NFAC). Ms. Hodge is a member of the Transportation Research Board's Urban Freight Transportation Committee. Ms. Hodge has B.S.C.E. from Florida Institute of Technology and an M.S.C.E. from Purdue University.

Welcoming Remarks

Camille Kamga
Director, UTRC

Dr. Camille Kamga is Director for the University Transportation Research Center, and an Assistant Professor of Civil Engineering at The City College of New York. The Region 2 University Transportation Research Center is one of ten original National Centers, established in 1987, in recognition that transportation plays a key role in the nation's economy and in the quality of people's lives. He serves as member of the Board of Directors of the Intelligent Transportation Society of NY – a professional group providing education and outreach to foster the understanding of ITS applications and technologies. He is also a member of the Education and Research Committee of the International Association of Transportation Regulators and a member of the Research and Outreach Committees of the Maritime Academic Council. He holds a Ph.D. in Civil Engineering from the Graduate Center of the City University of New York, specializing in Intelligent Transportation Systems (ITS). He is the 2006 recipient of the National Pikarsky Award for Outstanding Dissertation in Science and Technology from the Council of University Transportation Centers.

Alexander Keating
Senior Project Manager, Community Initiatives, New York City Department of Transportation

Alexander Keating is Director of the Special Projects Unit at New York City Department of Transportation, where he oversees a variety of technology demonstration projects, policy research, and planning initiatives. His current work includes the Drive Smart pilot program, which leverages data drawn from a vehicle's on-board diagnostic port (OBD-II) in order to help drivers save money, save time, and drive more safely. Prior to joining NYCDOT, he worked as Project Manager for Global Initiatives at the Penn Institute for Urban Research, where his work focused on city-to-city knowledge transfer and sustainable urban development. He received his Master's in City Planning from MIT's Department of Urban Studies and Planning (DUSP) in 2010 and his Master's in Politics from the University of Edinburgh (2007).

Maureen T. Koetz
Principal Partner, Koetz and Duncan LLC

Maureen T. Koetz is the Principal Partner in Koetz and Duncan LLC, a small, woman-owned consultancy to public and private enterprise on sustainability risk and value management. Applying operational analytics first developed for national security planning, Koetz and Duncan is an industry leader in quantification-based sustainability profiling using Natural Capital Asset Management™ to assess current and future enterprise capability. Clients and partners include Federal and municipal agencies, private equity, and international engineering firms.

Prior to forming Koetz and Duncan, Ms. Koetz served as a Presidential appointee and senior executive in the United States Air Force. In her capacity as Acting Assistant Secretary and Principal Deputy Assistant Secretary for Installations, Environment, and Logistics, she managed a 10-million acre/$250 billion asset portfolio in support of sustainable operations for the largest energy consumer in the federal government and one of the largest transport systems in the world. Serving in diverse capacities that included Natural Resource Trustee and Historic Preservation Officer, she oversaw ongoing base closures and disposition, streamlined department procedures, and reduced program spending while also developing the first Defense Department programs to sustain adequate natural capital capacity in response to increasing operational encroachment.

Ms. Koetz has also held positions as Counsel for the Senate Energy and Natural Resources Committee and Counsel to U.S. Senator Pete Domenici. As a Director for the Nuclear Energy Institute, she developed the first analytic models for "Emissions Avoidance," the results of which have remained a key operational and policy element supporting continued global nuclear expansion. She has represented the nuclear industry at the Kyoto Climate Change Conference and the United Nations Conference on Sustainable Development.

Ms. Koetz has been an Adjunct Professor of Environmental Finance at NYU-Poly, is a veteran of active duty service with the U.S. Navy, and has written on several areas related to sustainability. She holds a Juris Doctor from the Washington College of Law at American University, a Bachelor of Arts degree from the American University, and is a member of the Bar of the State of New York.

Moderator

Elisabeth Lennon
Sustainability Coordinator, New York State Department of Transportation

Elisabeth Lennon has 20 years of experience with the NYS Department of Transportation including environmental analysis work for construction, engineering and operations. She now serves as NYSDOT's Planning section lead on climate change issues and project manager for NYSDOT's Statewide Flooding Vulnerability Assessment. In her role, Ms. Lennon pursues multiple avenues and pathways to integrate climate change considerations into all levels of NYSDOT's decision-making. She serves as leader for NYSDOT's cross-divisional adaptation workgroup and as NYSDOT's lead project liaison for FHWA's Hurricane Sandy Follow-Up Vulnerability Assessment and Adaptation Analysis Pilot. Ms. Lennon has represented NYSDOT for numerous efforts including the NYS Climate Action Council and the NYS Interagency Adaptation Work Group.

John Lyons
President/CEO at MetroPool, Inc.

John Lyons has served as President and CEO of MetroPool, Inc. since 2001. Mr. Lyons provides leadership and management direction, while carrying out MetroPool's mission, objectives and strategic plans. As an innovator, collaborator and recognized expert in the Transportation Demand Management industry, he piloted many novel approaches and new TDM services. Lyons has extensive experience across the downstate area of New York as well as in 'Upstate' and in CT.

Mr. Lyons joined MetroPool in 1999 with extensive project management experience implementing publically funded programs in cooperation with the private sector aimed at changing behavior. Before MetroPool, Lyons worked for eight years assisting newly privatized businesses in the emerging market economies of Eastern Europe and Russia. Prior to working overseas, Lyons was a pioneer in promoting energy conserving building technologies focusing on solar energy and energy conservation through his business Sunspace Design.

Edward McCarthy
Vice President of Operations and Customer Success

Ed is a founding member of the Vnomics team, having joined from the Center for Integrated Manufacturing Studies at Rochester Institute of Technology (RIT) where the company was founded in 2008. Ed has over 10 years of experience with their fleet management technology starting as a Senior Program Manager responsible for developing and directing strategic initiatives for the Department of Defense research partnership that developed the Vnomics unique real-time onboard analytics engine. Ed subsequently introduced this technology to the military by co-leading a joint private/public effort to install it on both wheeled and tracked vehicles across the United States Marine Corps. After joining Vnomics as first Vice President of Engineering, he transitioned the technology from the university as he led all product development, engineering, customer support, and fielding activities for initial telematics offerings, fielding over 14 thousand systems in a little over four years. In this new role focused on customer success, Ed is responsible for the ensuring that all of Vnomics's customers, from installation to renewal, have a positive deployment of the Vnomics telematics, professional support from customer engagement team, and derive maximum value from their products to meet their business objectives.

Ed brings a unique background of leadership, technical acumen, problem solving, and credible communication to his role in Vnomics having previously served as a military officer with more than 20 years of active duty in heavy equipment combat units with the United States Marine Corps. As such Ed has held positons of increasing leadership responsibilities including introducing many new technologies to armor and logistics units he commanded both in the United States and overseas. His experience also includes being appointed Inspector Instructor with 8th Tank Battalion where he was instrumental in the training, equipping, and deployment of more than 800 hundred Marines for combat in Iraq.

Ed holds a Master of Science in Electrical Engineering from the Naval Postgraduate School with distinction, an MBA from the Simon Graduate School of Business, where he was recognized as a top graduate with nomination for membership in Beta Gamma Sigma, and a BS with Merit in Mathematics as an Arleigh Burke Scholar from the United States Naval Academy.

SPEAKERS

Moderator

Frank T. Mongioi, Jr.
Senior Manager, ICF International

Mr. Frank T. Mongioi, Jr. is a Senior Manager at ICF International and has more than 19 years of experience in Transportation Demand Management (TDM). He is currently the Immediate Past President of the Mid Atlantic Chapter of ACT, a director for the National Association for Commuter Transportation and a member of the Transportation Research Board's Committee on TDM. Prior to ICF International, he worked for Meadowlink, a progressive non-profit Transportation Management Association (TMA), managing a six county TDM program for the New Jersey Department of Transportation and NJ Transit. He is currently the Main Project Account Manager for the Integrated Regional and Statewide Travel Demand Management (TDM) Program Delivering Support of an Active and Transportation Demand Management (ATDM) program, a new contract with the New York State Department of Transportation (NYSDOT). Mr. Mongioi provides leadership to the entire contract team, including the Regional Project Account Managers, the core program staff, and the specialized technical experts. He is experienced in implementing TDM programs and successfully partnering with stakeholders to implement behavior-changing programs. He has supported NYSDOT for more than 9 years through 511NY Rideshare, Clean Air NY, 511NY, and the Statewide Strategic TDM Policy Framework. He has also served as a Senior TDM Advisor on the Atlanta Regional Commission's long range regional TDM plan and he currently serves as a Senior TDM Advisor for SANDAG's on-call TDM contract.

Mr. Mongioi has a B.S. in Management and Marketing, and an M.B.A. from Montclair State University in New Jersey. He is married with two children, Thomas (12) and Katie (9). Frank enjoys traveling with his family and in his spare time plays guitar with his son on the drums.

Vassilis Papayannoulis, Ph.D.
Metropia, Inc.

Dr. Papayannoulis leads Metropia's Urban Analytics Group (UAG) which leverages Metropia's Synergy patented technology and unique qualifications in advanced and emerging transportation areas to provide clients with creative and cutting-edge solutions. Dr. Papayannoulis' in-depth technical knowledge of transportation system operations has engaged him in pioneering projects at the local, regional, and national level. He has authored or co-authored a number of papers, participated in Peer Review Panels and served as the Project Manager or Principal-in-Charge for numerous multi-modal corridor, large-scale complex transportation network and advanced technical studies. In addition, Dr. Papayannoulis has taught transportation graduate courses as an Adjunct Professor and as an Instructor for an on-line course on Multi-Resolution Models sponsored by the NYU School of Engineering and Scientific American.

Angela Sanguinetti, Ph.D., BCBA
Behavioral Scientist, Consumer Energy Interfaces Lab Plug-in Hybrid & Electric Vehicle Research Center, University of California, Davis

Dr. Sanguinetti is a Board Certified Behavior Analyst and environmental psychologist. She is a postdoctoral researcher at University of California, Davis, where she directs Consumer Energy Interfaces (cenergi.ucdavis.edu), a lab investigating all forms of eco-feedback, including eco-driving feedback, from an interdisciplinary perspective that bridges design, technology, and behavior science in theoretical and applied research.

Alec Slatky
Legislative and Community Relations Representative, AAA Northeast

Alec Slatky is a Legislative and Community Relations Representative at AAA Northeast. He is responsible for AAA's advocacy efforts in Albany, New York City, and across the Empire State. In this capacity, Alec focuses on traffic safety issues, particularly automated enforcement, occupant protection, and distracted driving, as well as infrastructure issues such as Port Authority reform. Alec is AAA Northeast's resident data geek, and has prepared reports on topics ranging from red light cameras across the state to parking summonses in New York City.

Alec assists AAA members with questions or concerns related to the intersection of government and transportation, from moving violations to unsafe road conditions to intricacies of the state's Vehicle and Traffic Law. Alec also aids AAA Northeast's public relations efforts and has been quoted by media outlets across the state, from Newsday on Long Island to WBFO in Buffalo.

Alec splits his time between his residence on Long Island and his girlfriend's apartment in the Washington Heights neighborhood of Manhattan. Alec is a graduate of Princeton University with a degree in Politics.

Moderator

Joseph D. Tario, P.E.,
Senior Project Manager, New York State Energy Research and Development Authority

Joseph D. Tario is a Senior Project Manager with the New York State Energy Research and Development Authority (NYSERDA). Working in their Transportation Research Department, he primarily manages projects focused on transportation demand management and advanced transportation infrastructure.

In addition to his duties at NYSERDA, Mr. Tario also manages a collaborative research program with the New York State Department of Transportation and is a past president and a current director of the Intelligent Transportation Society of New York.

A graduate of Rensselaer Polytechnic Institute in Troy NY, he holds an M.E. in environmental engineering, a B.S. in civil engineering, and is a licensed professional engineer in the state of New York.

Stanley E. Young, Ph.D.
National Renewable Energy Lab (NREL)

Since May of 2015, Dr. Young has pursued research initiatives at the National Renewable Energy Laboratory in Golden, Colorado focused on connected and automated vehicle technology, and its impact on the nation's future energy budget and greenhouse gas emissions. From 2006 through 2015, he was on staff at the University of Maryland's Center for Advanced Transportation Technology and involved with the I-95 Vehicle Probe Project (VPP), arterial performance assessment, and Bluetooth re-identification traffic monitoring. In 2009 he co-founded Traffax Inc., a university start-up to accelerate the commercialization of Bluetooth re-identification technology. Prior to the University of Maryland, he worked at the Kansas Department of Transportation in various capacities. He is an alumnus of Kansas State University, and served in the United States Peace Corps in Cameroon, West Africa.

Rae Zimmerman
Professor of Planning and Public Administration
Director, Institute for Civil Infrastructure Systems (www.nyu.edu/icis)
NYU Wagner Graduate School of Public Service

Rae Zimmerman is Professor of Planning and Public Administration and Director of the Institute for Civil Infrastructure Systems at NYU's Wagner Graduate School of Public Service. She is an elected Fellow of the American Association for the Advancement of Science (AAAS), a Fellow past president of the Society for Risk Analysis, and currently holds appointments to the third NYC Panel on Climate Change, the National Academies Committee on Pathways to Urban Sustainability, and the Transportation Research Board Critical Transportation Infrastructure Protection committee. Her teaching and research are at the intersection of infrastructure, climate change and the environment, natural hazards, social equity, and security in the context of the quality of life in cities and the use of urban infrastructure innovations to adapt to extreme conditions. In addition to authoring or co-authoring numerous journal articles and book chapters in these fields, she is the author of the book, Transport, the Environment and Security: Making the Connection. She has participated in about four dozen grants, as Principal Investigator on about three dozen of these. She recently completed National Science Foundation funded research on electric power and transit recovery following Hurricane Sandy, and also completed a U.S. Department of Transportation Region 2 University Transportation Research Center funded project on multi-modal transportation use in emergencies and its relationship to poverty in New York City. She has a B.A. in Chemistry from the University of California (Berkeley), a Master of City Planning from the University of Pennsylvania, and a Ph.D. in planning from Columbia University. URL: http://wagner.nyu.edu/zimmerman

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