NC STATE UNIVERSITY

SUSTAINABLE FLEET TECHNOLOGY

VIRTUAL CONFERENCE 2020

Session #14: Potential Impacts of Connected/Automation Technology in Transportation

November 18, 2020

NC CLEAN ENERGY TECHNOLOGY CENTER

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

SUSTAINABLE FLEET TECHNOLOGY

VIRTUAL CONFERENCE 2020

https://www.sustainablefleetexpo.com/

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SUSTAINABLE FLEET TECHNOLOGY
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Next Series Dates & Topics:

November 10: Sustainable Fleet Analytical Tools & Information

November 18: Potential Impacts of Connectivity/Automation Technology

December 02: Idle Reduction an Easy Win

December 09: The Green Garage Winners 2020

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Format

- Q&A at the end
- Submit questions and comments to “Panelists”
- Scheduled for 2:00p-3:30p
- Handout
- Recording

- Clean Transportation Program Director NC Clean Energy Technology Center at NC State University
- 8 years with NC State
- 30+ years experience including General Motors, Draper Lab and Great Lakes Pulp & Fibre in both engineering and business management roles

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Potential Impacts of Connected/Automation Technology in Transportation
November 18, 2020

2:00-2:05 **Rick Sapienza, NCCETC**--Welcome & Introduction
2:05-2:25 **Dr. Josh Siegel, Michigan State University**—Overview of CA & Applications
2:25-2:30 **Sunjay Dodani, Revvo**—Tire Safety Technology
2:30-2:35 **Jonathan Ford, City of Orlando**—Revvo Deployment Story
2:35-2:47 **Andrew Wolpert, Smart Columbus**—Autonomous Shuttle Service Deployment
2:47-2:55 **Sass Peress, iSun**—Solar Charging Solution
3:55-3:10 **Derrick Redding, Automotive Technology Consulting**—Connected/Automation Technology Safety & Solutions in Transportation
3:10-3:30 **Q&A**

(Applications of) Connected and Automated Vehicles

Josh Siegel, Ph.D.

I run MSU's "DeepTech" Lab and work with AI and IoT

Josh Siegel

Assistant Professor, Michigan State CSE

Courtesy appointment, ECE

- Research:
  - **Ubiquitous Connectivity** – secure, efficient, and scalable IoT using contextual AI
  - **Pervasive Sensing** and **Universal Diagnostics** – making actionable "data exhaust" across transportation, manufacturing, appliances, utilities, and health
  - **Enhanced Automation** – defensive and resilient self-driving algorithms
- Teaching:
  - **Advanced Topics in Automated Vehicles**
  - **Entrepreneurship and the Internet of Things**

Lead Instructor, MIT "DeepTech" and "IoT" Bootcamps

Short-Term Lecturer, MIT Sloan "Implementing Industry 4.0"

Former Research Scientist, MIT

- S.B., S.M., Ph.D. from MIT Mechanical Engineering

This talk introduces connectivity and automation in vehicles

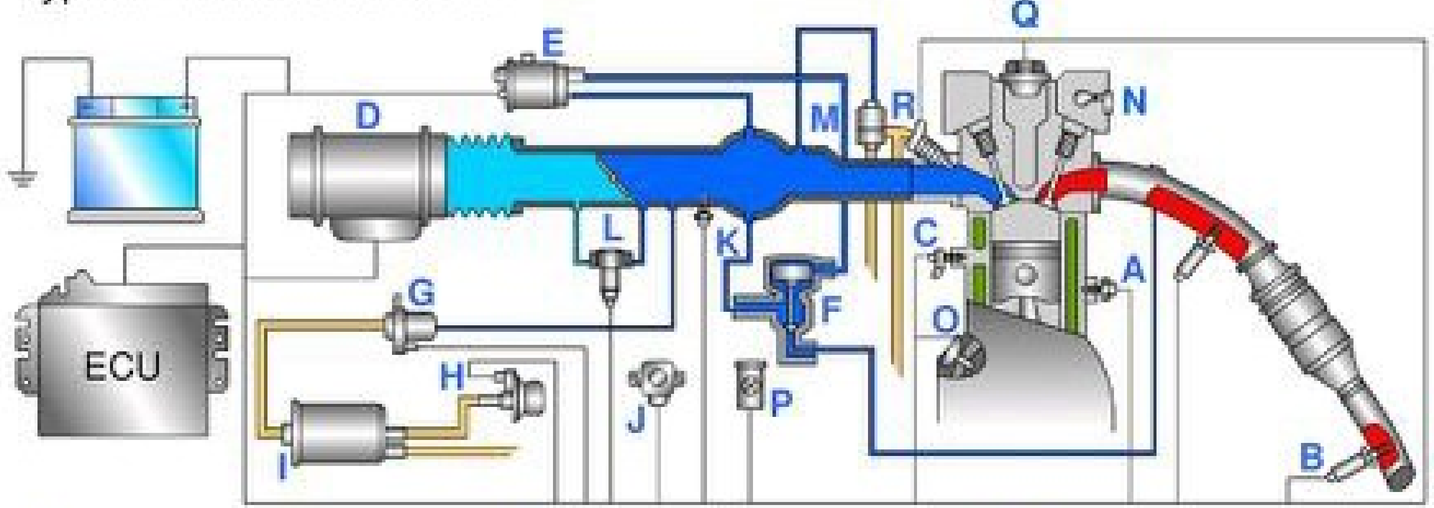
- Cars as computers
- Connectivity to generate data – and optimize – at scale
- Applications for connectivity
- Introduction to automated vehicles and degrees of autonomy
- Applications for automation in fleets today and tomorrow
- Challenges in technology implementation

Modern vehicles are computers on wheels

Sensors inform task-specific **electronic control units** (ECUs)

Simplified ECU Control System

Typical ECU and controls:



A. Engine temp sensor
B. Oxygen sensor
C. Knock sensor

D. Mass airflow sensor
E. Vacuum controller
F. EGR valve

G. Canister purge valve
H. Canister air valve
I. Charcoal canister

J. TPS
K. Air temp sensor
L. Idle actuator

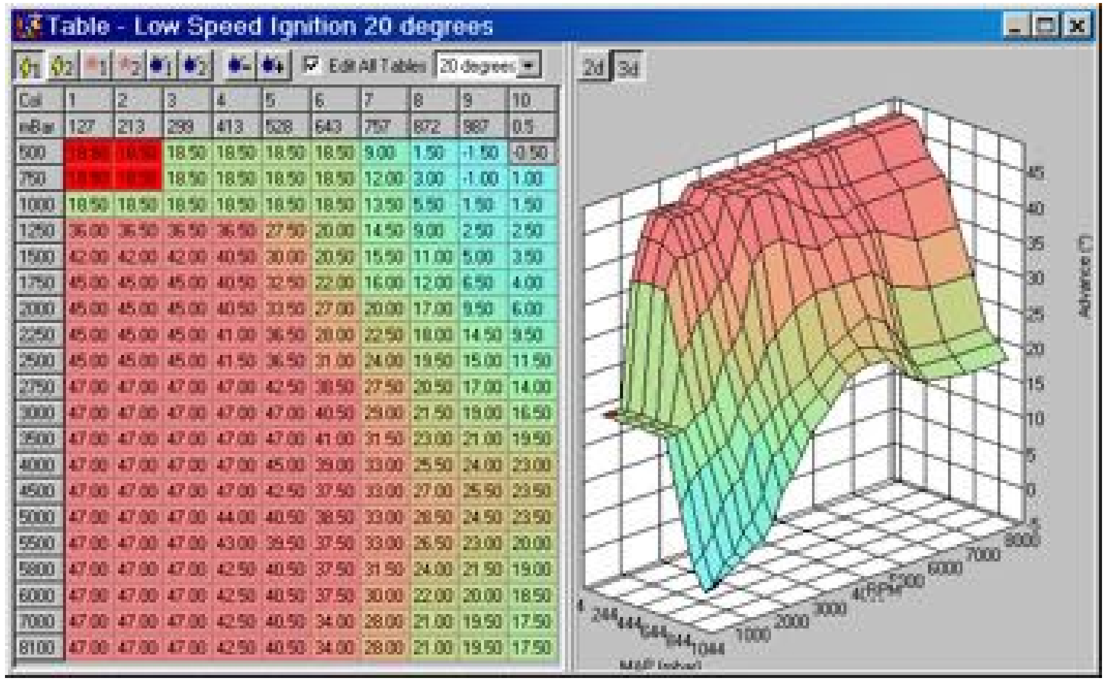
M. Fuel pressure regulator
N. Camshaft sensor
O. Crankshaft sensor

P. Diagnosis lamp
Q. Ignition coil
R. Injector

The purpose of **ECUs** is to **capture, filter,** and **act upon signals**

- ECUs **capture data**, **condition and filter signals**, and **transform information into insight** to respond appropriately to changing conditions or environments

- Example: Engine Control Unit A/F Map
  - These systems match operating conditions with air/fuel ratio tables to ensure safe, efficient, reliable and high-performance operation



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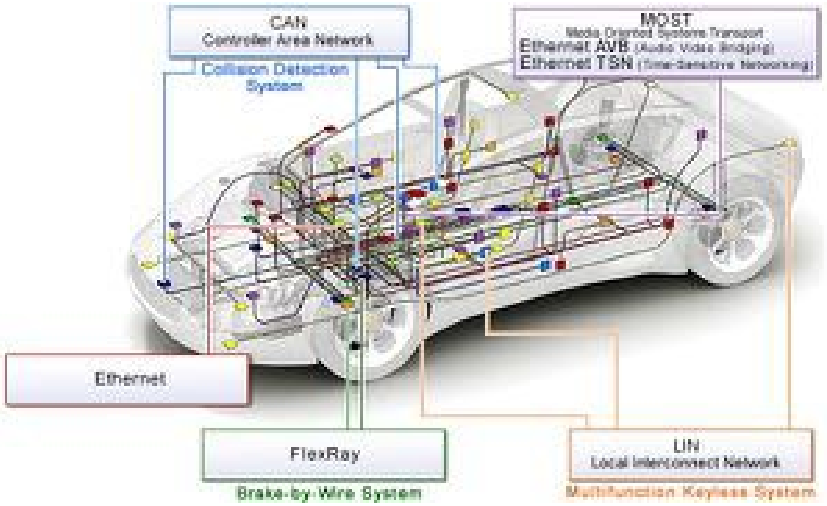
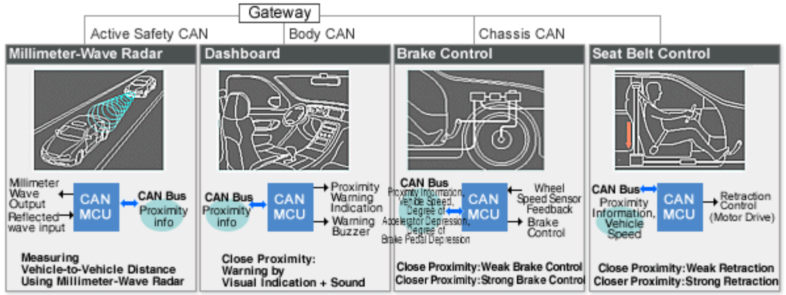
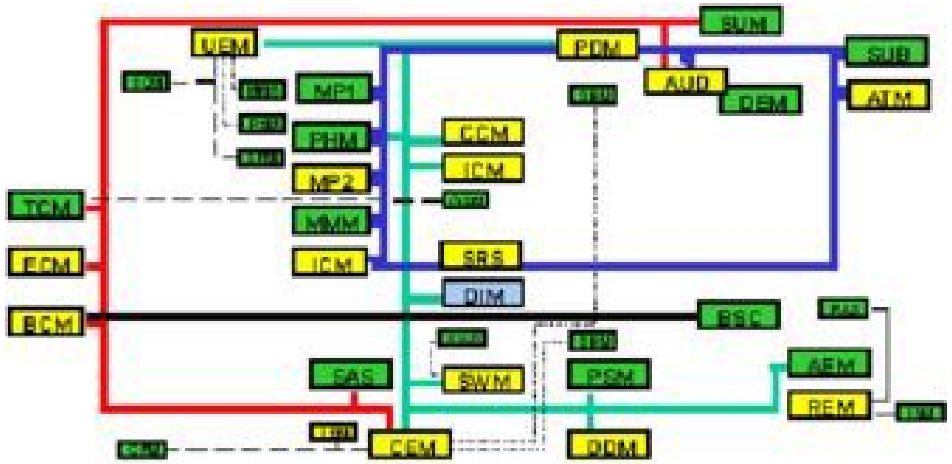
mBar	127	213	299	413	528	643	757	872	987	0.5
500	18.50	18.50	18.50	18.50	18.50	18.50	9.00	1.50	-1.50	-0.50
750	18.50	18.50	18.50	18.50	18.50	18.50	12.00	3.00	-1.00	1.00
1000	18.50	18.50	18.50	18.50	18.50	18.50	13.50	5.50	1.50	1.50
1250	36.00	36.50	36.50	36.50	27.50	20.00	14.50	9.00	2.50	2.50
1500	42.00	42.00	42.00	40.50	30.00	20.50	15.50	11.00	5.00	3.50
1750	45.00	45.00	45.00	40.50	32.50	22.00	16.00	12.00	6.50	4.00
2000	45.00	45.00	45.00	40.50	33.50	27.00	20.00	17.00	9.50	6.00
2250	45.00	45.00	45.00	41.00	36.50	28.00	22.50	18.00	14.50	9.50
2500	45.00	45.00	45.00	41.50	36.50	31.00	24.00	19.50	15.00	11.50
2750	47.00	47.00	47.00	47.00	42.50	38.50	27.50	20.50	17.00	14.00
3000	47.00	47.00	47.00	47.00	47.00	40.50	29.00	21.50	19.00	16.50
3500	47.00	47.00	47.00	47.00	47.00	41.00	31.50	23.00	21.00	19.50
4000	47.00	47.00	47.00	47.00	45.00	39.00	33.00	25.50	24.00	23.00
4500	47.00	47.00	47.00	47.00	42.50	37.50	33.00	27.00	25.50	23.50
5000	47.00	47.00	47.00	44.00	40.50	38.50	33.00	28.50	24.50	23.50
5500	47.00	47.00	47.00	43.00	39.50	37.50	33.00	26.50	23.00	20.00
5800	47.00	47.00	47.00	42.50	40.50	37.50	31.50	24.00	21.50	19.00
6000	47.00	47.00	47.00	42.50	40.50	37.50	30.00	22.00	20.00	18.50
7000	47.00	47.00	47.00	42.50	40.50	34.00	28.00	21.00	19.50	17.50
8100	47.00	47.00	47.00	42.50	40.50	34.00	28.00	21.00	19.50	17.50

ECUs may be self-contained computing elements controlling one subsystem,
but **typically share raw or aggregate data** for vehicle-wide diagnostics and optimization

ECU networks **generate 25GB/hour or more**







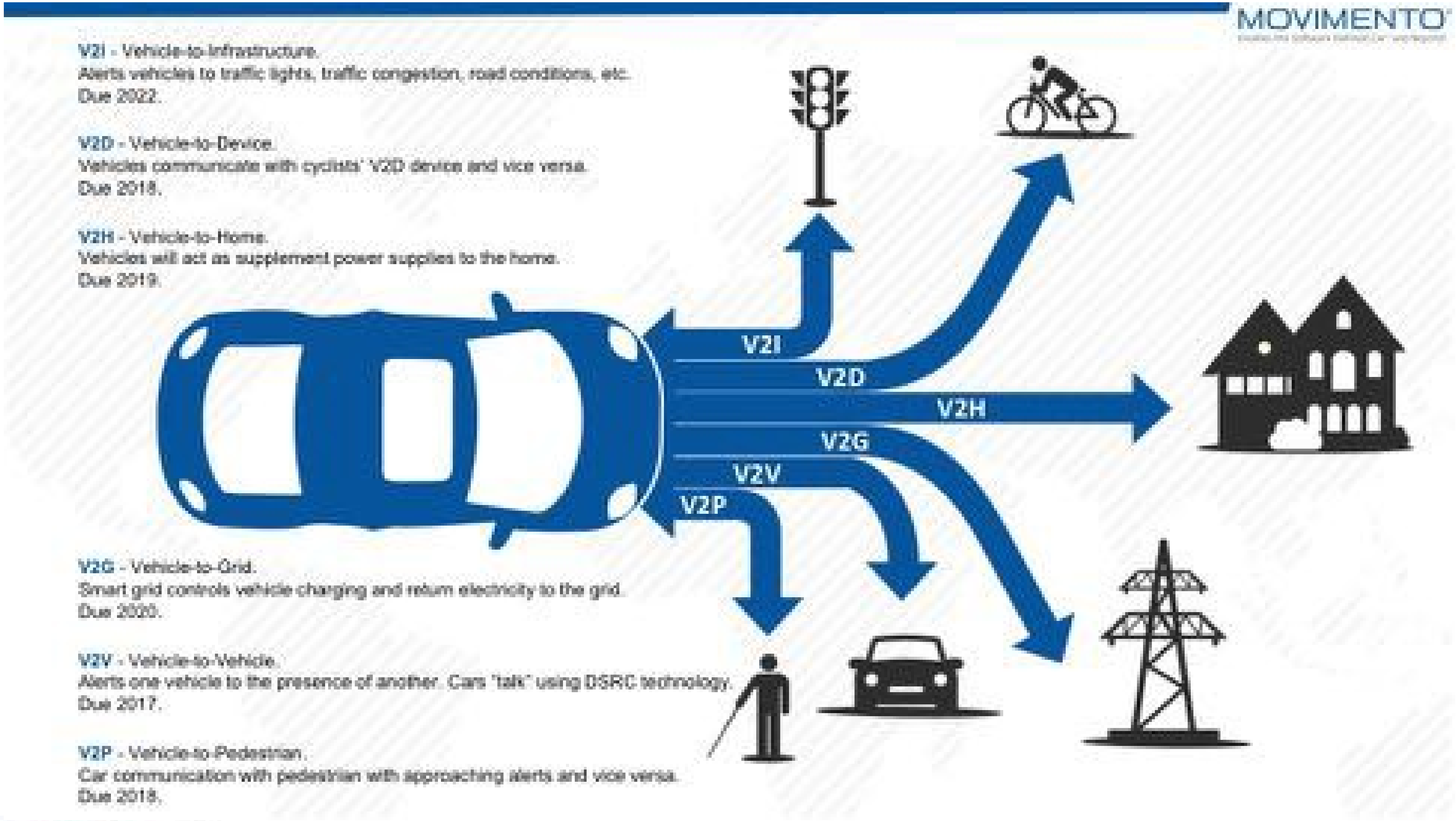
Networks develop as a means of sharing critical information across diverse systems; some may be intentionally divided to ensure security, protect bandwidth from saturating, and to meet hard real-time (deterministic processing) constraints

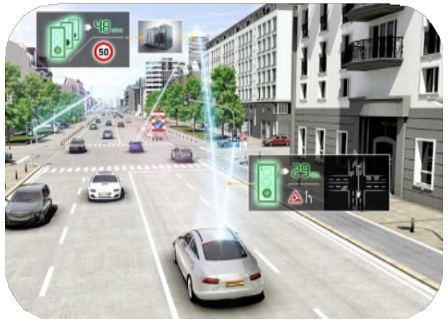
To share data, **vehicles increasingly form large networks**

Transportation is evolving and **vehicles are just another element of the Internet of Things**

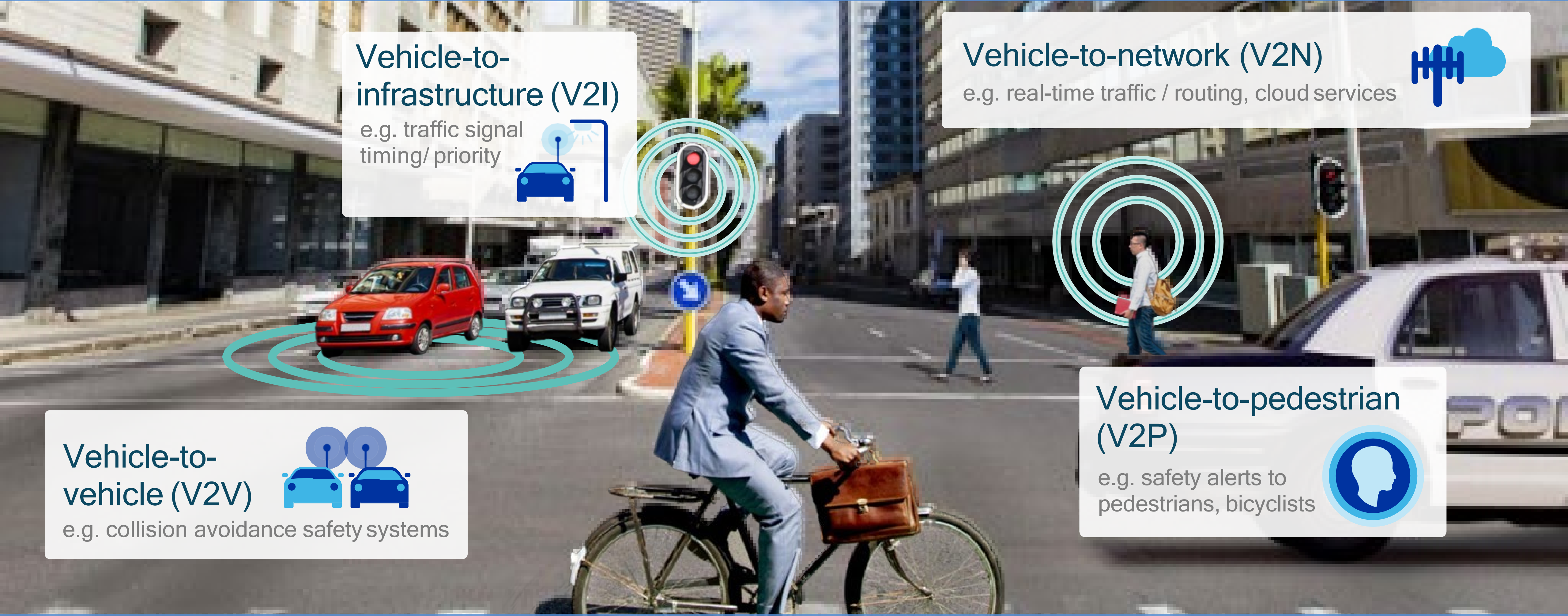
Extravehicular connectivity generates massive-scale data

Wide-area networks enable diverse communication modalities





External networks support **multiple communication topologies** termed "vehicle to X," or "V2X"



Slide from Junyi Li, "IoT: a 5G perspective," LIDS Smart Urban Infrastructures Workshop

There are **three primary extra-vehicular networks**

- **Cellular** (almost every car sold now has a SIM)
  - 3G, 4G, 5G
  - **2G sunset in the US and Europe** but pervasive in developing world
- **Bluetooth**
  - Pairs to mobile device to share media, but also to “piggyback” on existing, consumer-paid data connection
- **Dedicated Short Range Communication** (DSRC)
  - Designed specifically for transportation
  - Includes cars, infrastructure

Each **cell generation** supports different capabilities

1G	2G	3G	4G	5G
Voice	10~300kbps	300k~50Mbps Delay: 1.5s	50M~1Gbps Delay: 50ms	1~10Gbps Delay: 1ms

Sunset in US

Today's technology

Autonomy becomes feasible

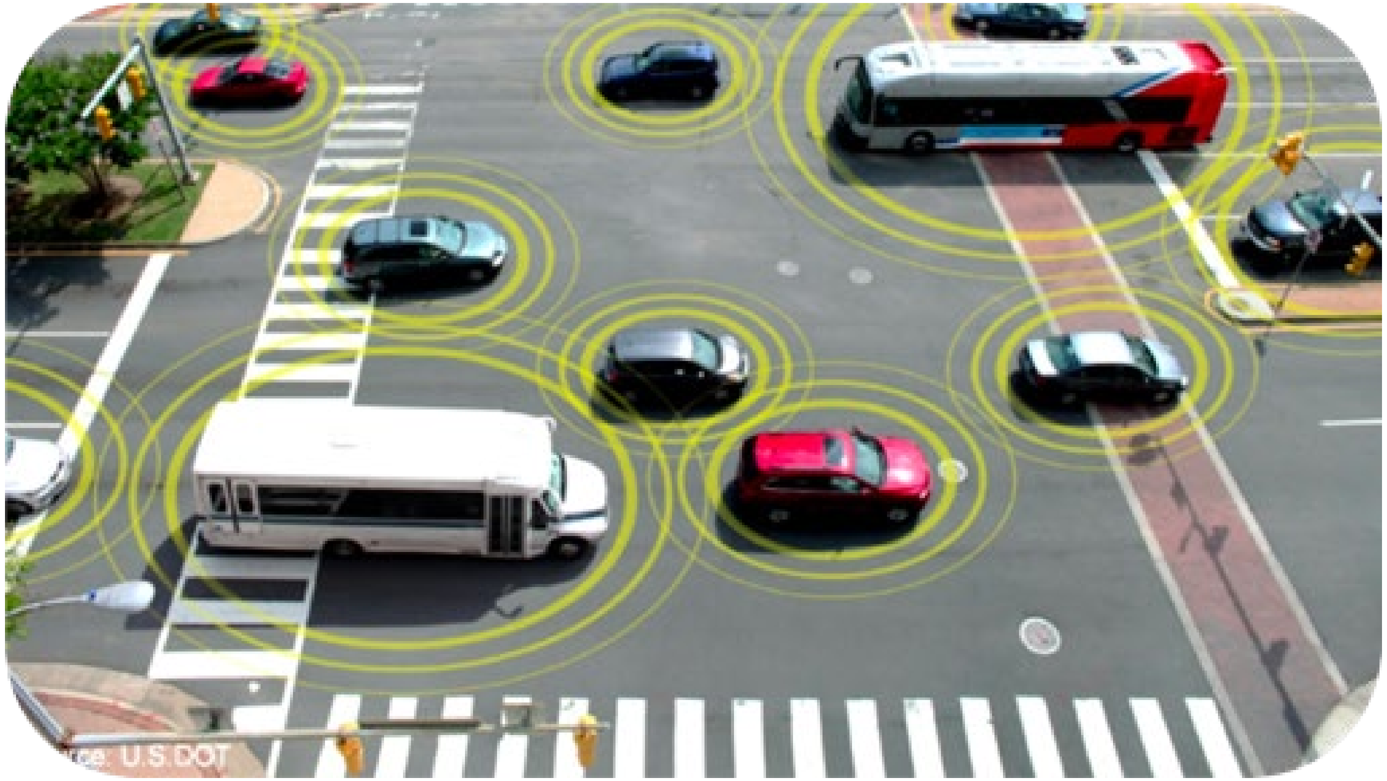
Bluetooth is commonly-used for short-range communication

Problems with Bluetooth include difficulty to **pairing**, **forgotten mobile devices**, and dead **batteries**

But, some manufacturers use the drivers' phone to bring Bluetooth data to the Cloud (for free!)

DSRC is designed to meet transportation's needs for flexible, fast networking

- **Short range** (< 300m)
- **Low latency** (10Hz, ~10ms delay)
- **Subscriptionless** (free, no SIM)
- **Standardized for vehicles and infrastructure**



Vehicle data today are used in a variety of applications

Connected vehicles generally use data three ways

Data-informed **diagnostics,** prognostics and maintenance needs

Data-informed **operations**, improving efficiency and performance in real-time

Reactive
(data for analytics)

Responsive
(data as a service)

Readied
(data as a design tool)

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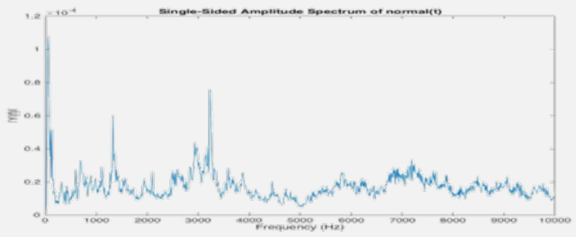
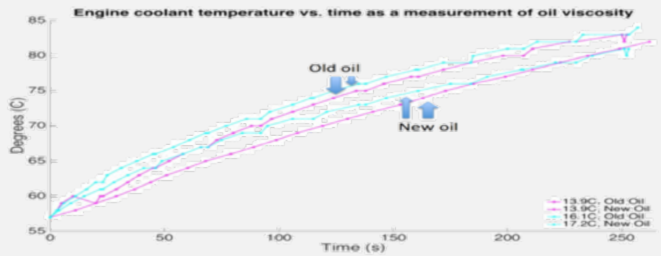
My own work uses connectivity to diagnose **common, costly failures using low-cost sensors**

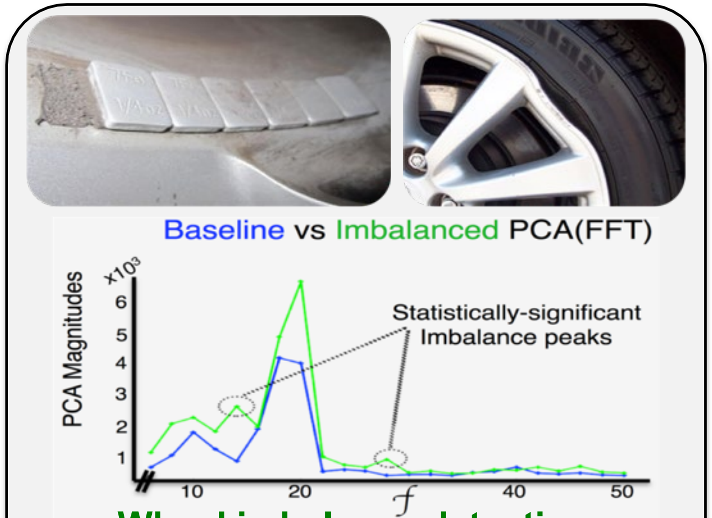


Misfire detection

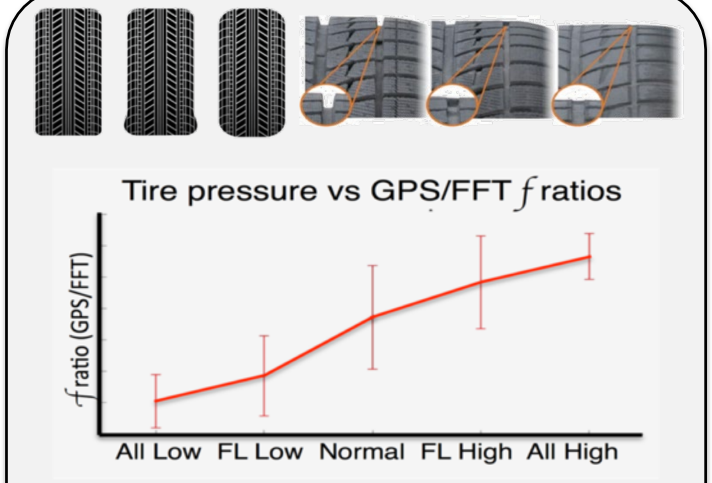


Oil monitoring

Air filter monitoring



Wheel imbalance detection



Tire pressure and tread supervision

Tire dry-rot detection

[In ECML-PKDD 2016, IEEE Sensors 2014, EAAI Journal, ASME DSCC 2016, SAI IntelliSys 2016 and AIMS 2018]

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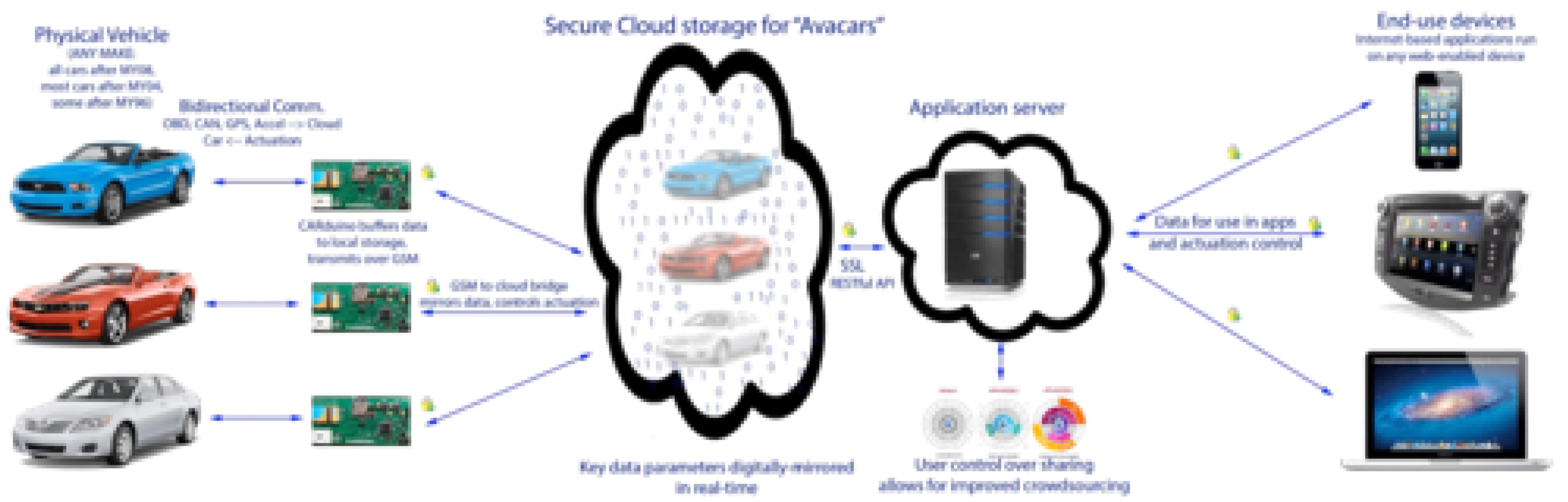
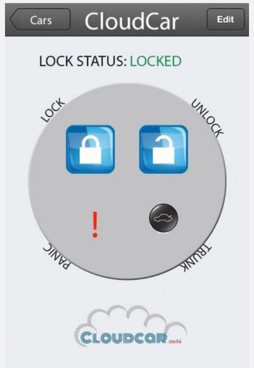
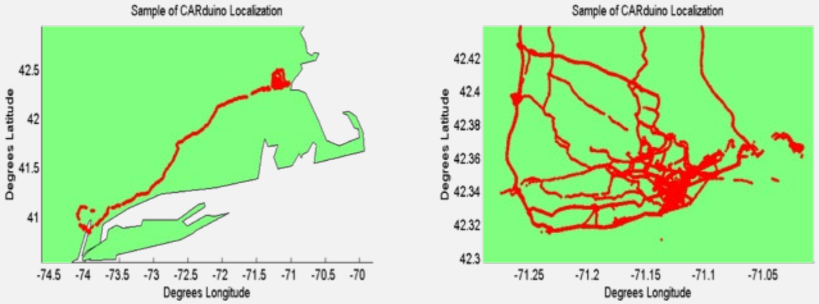
Application platforms may enable **networked features**



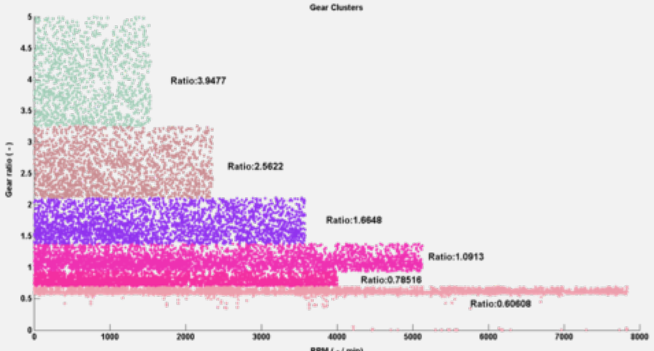
Connectivity supports remote **access** and **vehicle control**



Remote locking

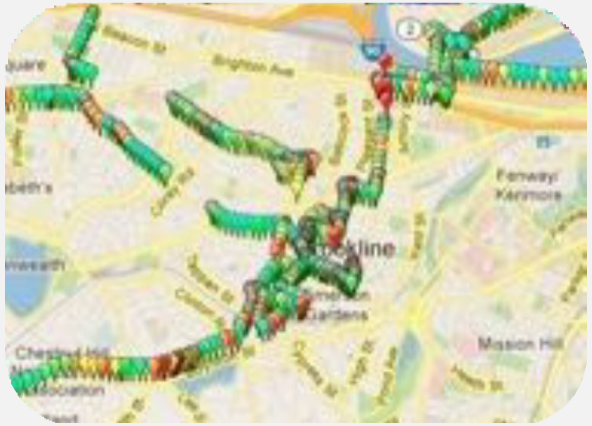


Route histories

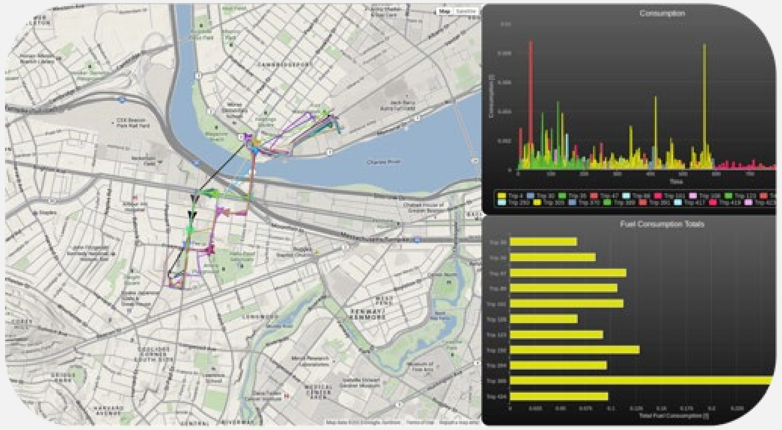


Vehicle health monitoring

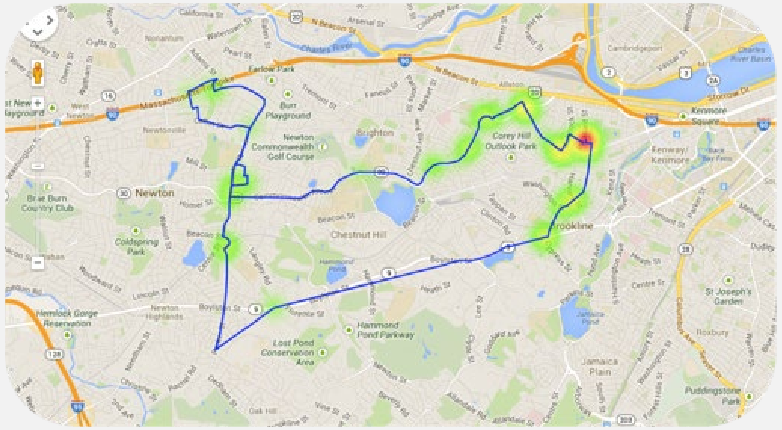
Driver tracking



Fuel economy over time



Idling & Emissions mapping



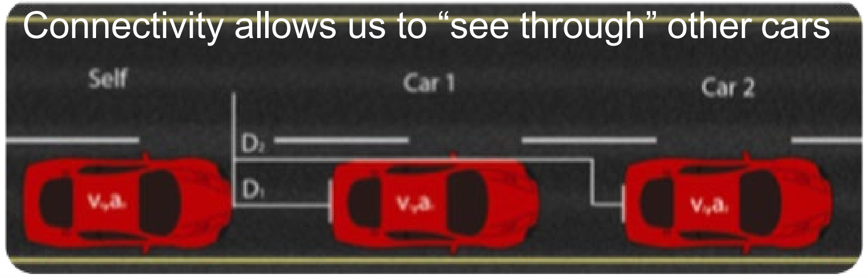
Connected data illuminate the road ahead

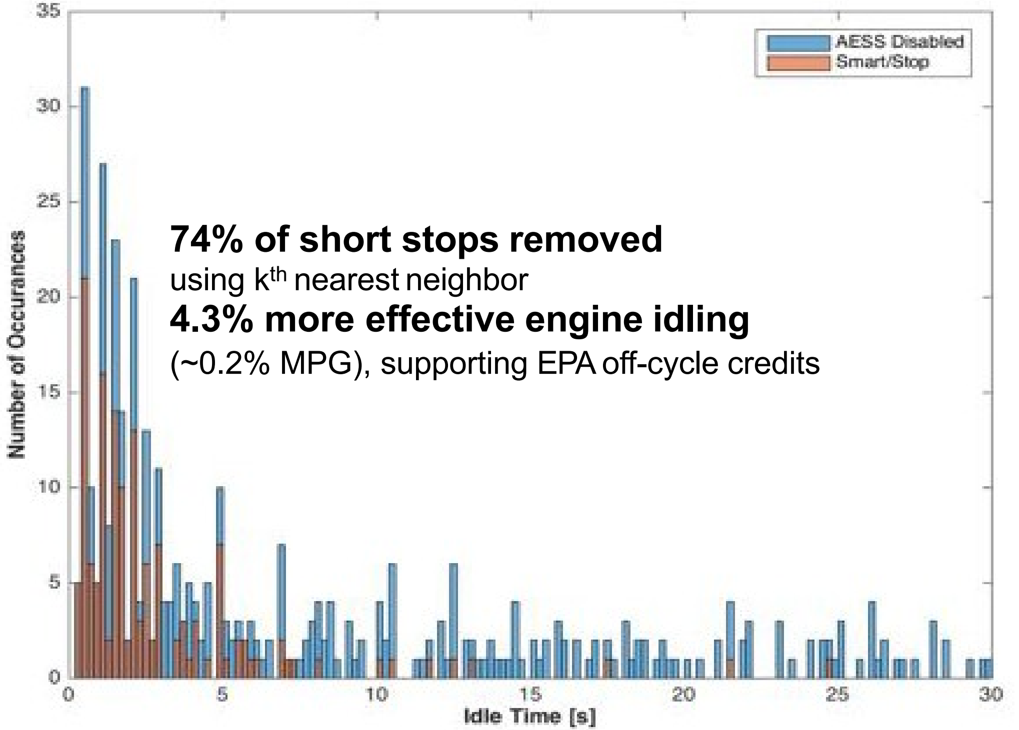
[https://jalopnik.com/the-mclaren-gts-suspension-predicts-the-future-to-give-1838107298]
[https://arstechnica.com/cars/2019/07/the-lincoln-aviator-uses-cameras-to-read-the-road-smooth-out-big-potholes/]
[https://www.repairerdrivennews.com/2015/06/11/jaguar-land-rover-testing-out-pothole-detecting-camera-sensor-tech/]

V2V can even **reduce idle fuel consumption**

- Connectivity allows vehicles to **observe and adapt to their environments** in **realtime**
  - While in traffic, you look at truck a few cars ahead to anticipate when you'll move
  - Connectivity provides cars similar **context data** on which to act

- We **trained cars to "look ahead,"** and **eliminated 74%** of annoying and wasteful **short idle events**



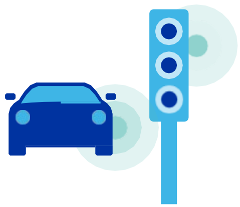


74% of short stops removed
using k[th] nearest neighbor
4.3% more effective engine idling
(~0.2% MPG), supporting EPA off-cycle credits

1. Erb, Dylan Charles. *Optimizing hybrid vehicles: battery pack design, energy management, and collaborative learning*. Diss. Massachusetts Institute of Technology, 2016.
2. J. Siegel, D. Erb, S. Sarma, "Automotive Application Locality: The 'When' and 'Where' of Connected Vehicle Applications, as Applied to Idle Time Prediction." To appear in IEEE Transactions on Intelligent Transportation Systems Magazine.

Connected applications save money and fuel by improving routing efficiency, traffic density, and signal timing

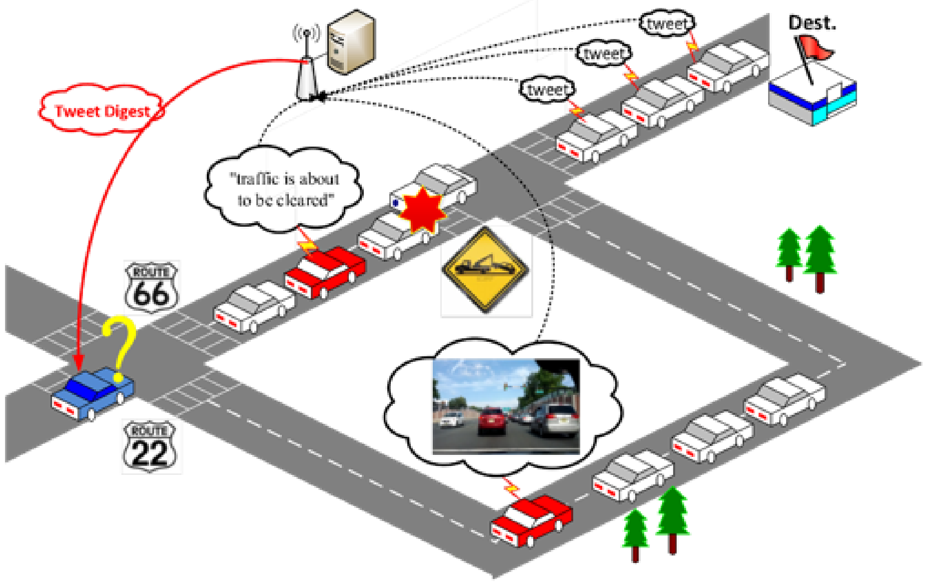
Cooperative adaptive cruise control & platooning



Traffic signal priority and optimal speed advisory

Road-trains and platooning

Collaborative traffic reporting and routing



Vehicles may work together to lighten road-load

Improved routing and **shared mobility** reduce energy

10-40% fuel savings from improved routing and traffic shaping alone [McKinsey, 2015]

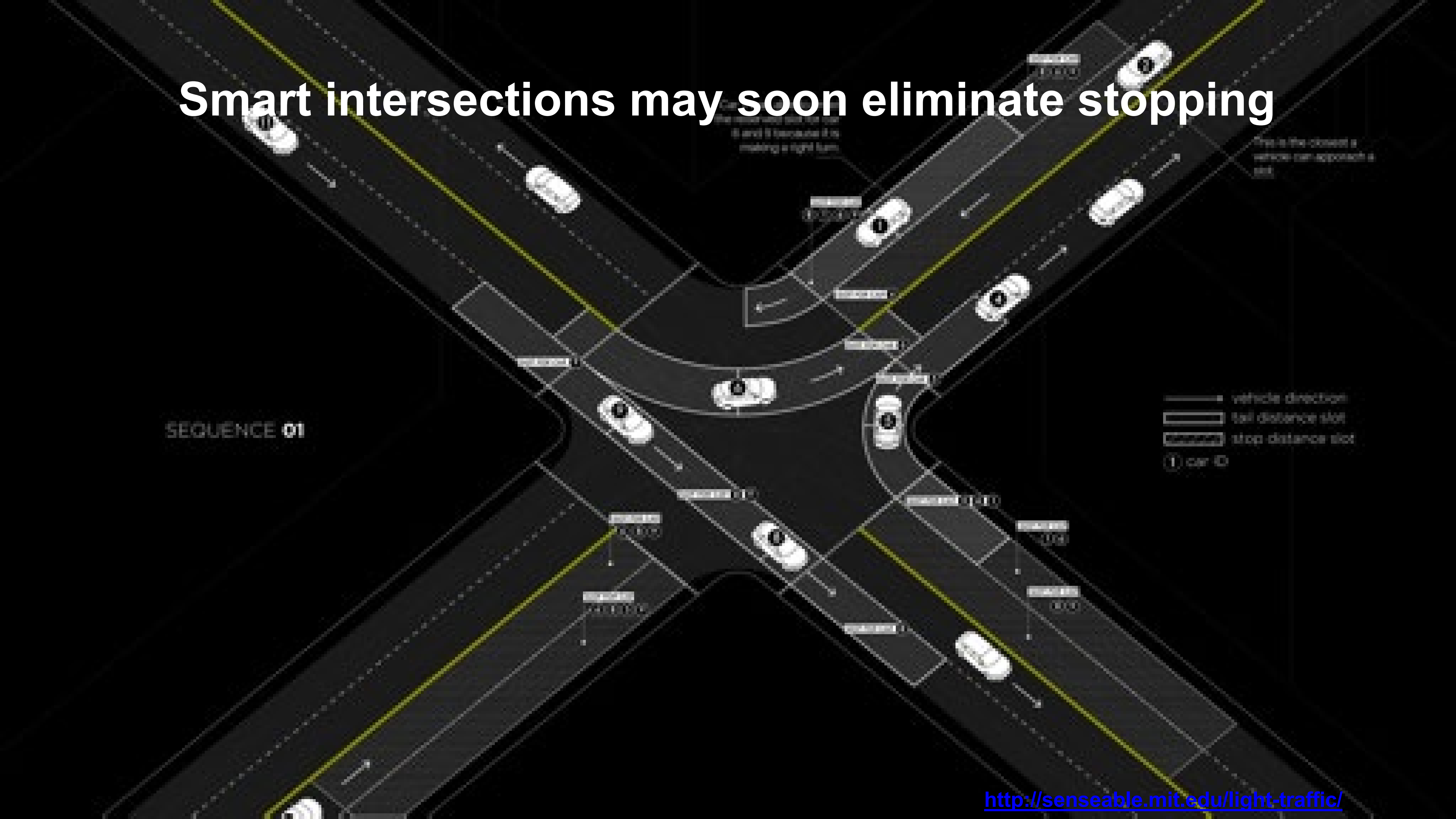
Figure [Höegh Autoliners]

Large-scale **routing reduces wait times** and **shockwave traffic**

Minimizing speed changes
can significantly reduce traffic

Tomorrow, data will enable new applications

Smart intersections may soon eliminate stopping



http://senseable.mit.edu/light-traffic/

Car-to-car networks may be used for **content distribution**

- Car-to-car media streaming
- Over-the-horizon vision

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5G may soon enable **high bandwidth, low latency telepresence**

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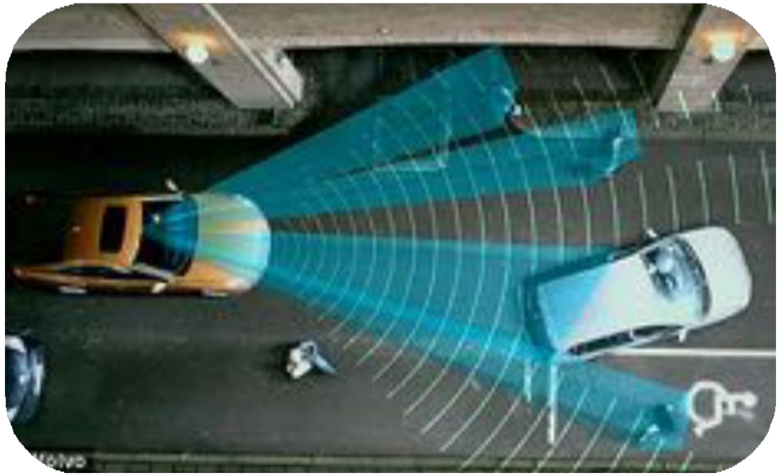
Automation is taking hold in parallel to the connectivity revolution

Automation can **improve transportation safety** and **efficiency**

- **Handle complex tasks** (like parallel parking)
- **Warn drivers of potential issues** (traffic stopped up ahead)
- **Augment driver control** (lane keeping)
- **Intervene under special circumstances** (automated braking)
- **Control vehicle motion** (adaptive cruise control)



- These are primarily “**advanced driver assistance systems**” (ADAS)

There are “degrees of automation” in self-driving

Level 0 has **no automation**

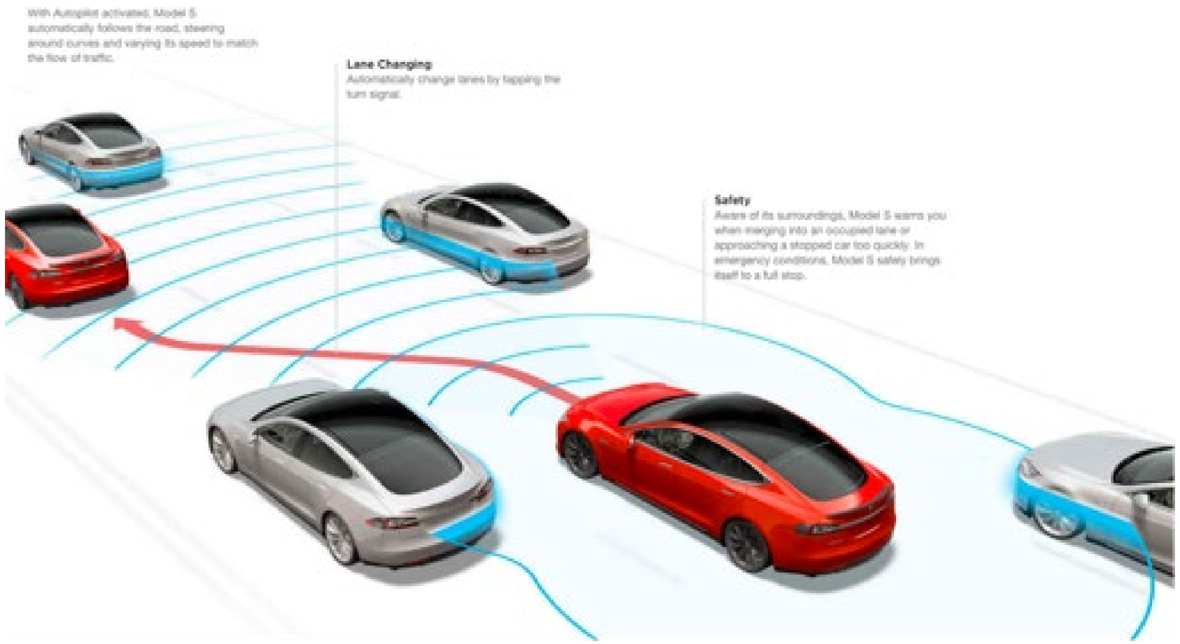
- The driver completely controls brakes, steering, and throttle at all times
- Fun! But also (comparatively) unsafe

Level 1 supports **supervised steering** *or* **velocity assistance**

- One function, like cruise control, lane keeping, or parking may be automated
- Drivers are fully engaged and responsible for direct physical control (hands on steering and feet on pedals at all times)
- **Function-specific automation** more than true automation

Level 2 supports **supervised steering** *and* **velocity assistance**

- **Combined function automation,** e.g. multiple simultaneous control functions, like speed and lane keeping
- Drivers monitor the roadway and are prepared to take control at all times
- **System may self-disengage if driver becomes distracted**



Level 3 drives itself, but **may know to ask for a human handoff**

- Drivers rely on vehicle for safety-critical functions
- Vehicle monitors for conditions that will require human-handoff and notify the driver
- Drivers may reduce active roadway monitoring, but must be ready to take control within 2-3 seconds
  (*is that really feasible?)*
- **This is the state-of-the-art today**

L1-3 is **shared control** – like a human riding a horse, the human has control but the horse wont jump off any cliffs it knows about

Level 4 drives itself without supervision under set conditions

- Vehicles may **operate fully without occupants** (e.g. for package delivery)
- **May be limited** by area (geographic region), intersection type (roundabouts), or certain weather patterns
- **This is the lowest-level truly-driverless car**, capable of stopping itself safely in unknown situations **without human intervention**

Level 5 drives itself without supervision in all circumstances

- **We're a long way away** due to:
  - Human interactions (unpredictable drivers, pedestrians, cyclists)
  - Existing infrastructure (non-connected intersections)
  - Incomplete mapping
  - Other deeply-entrenched patterns

- **The last 10% of automation is 90% of the effort**
  - The biggest challenge may be working with roads and traffic "as-is"

The concept is not new, but technology is maturing

We are following a **winding, 90-year path to AV's**

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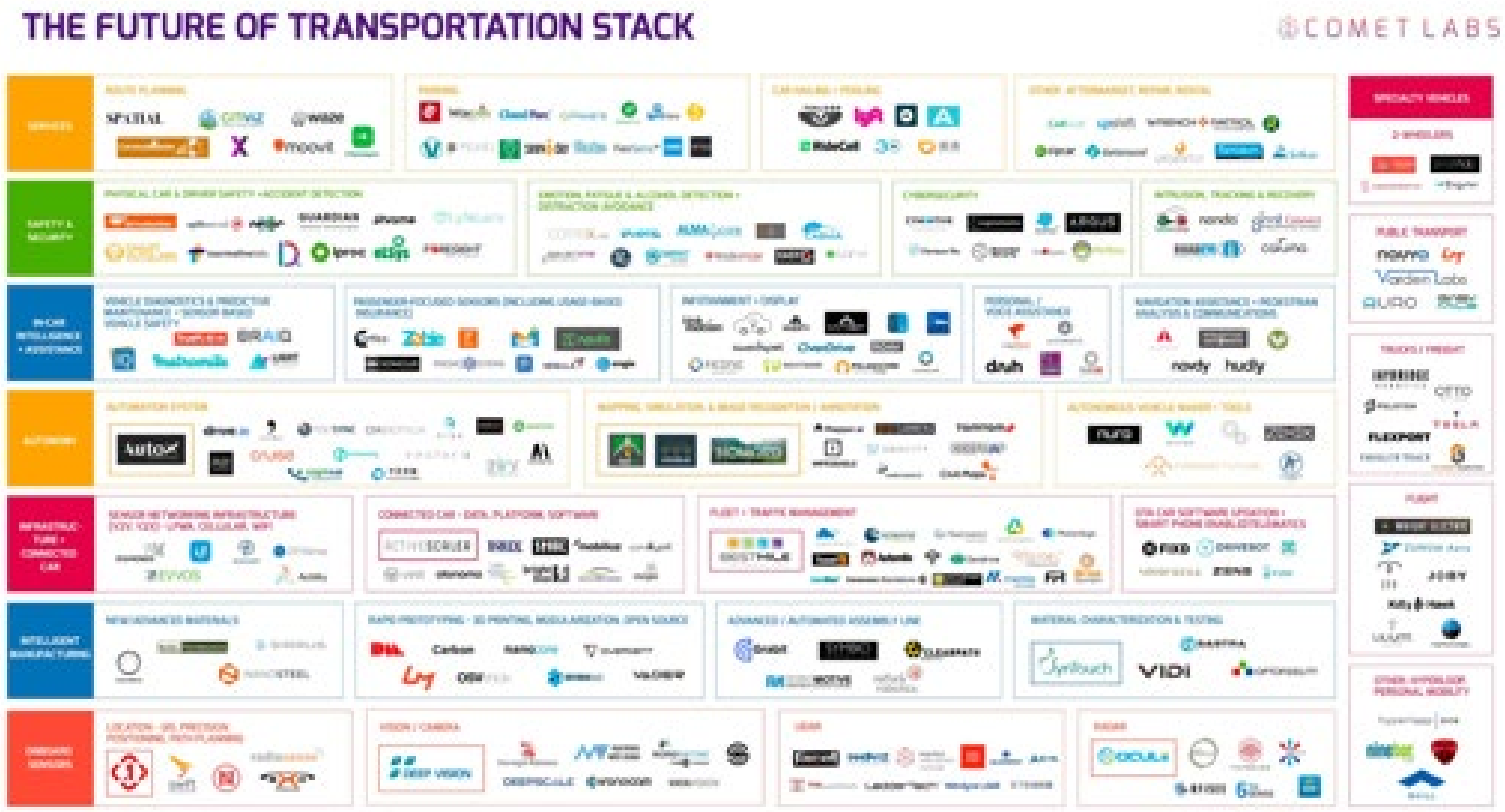
[BMW]

Beyond actors like Google, Tesla, Uber, Ford, and GM, there are **260+ *supporting* companies**



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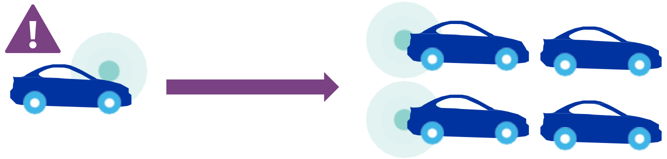
Cutting-edge CAVs already transform fleet operations

Some applications are **safety-related**

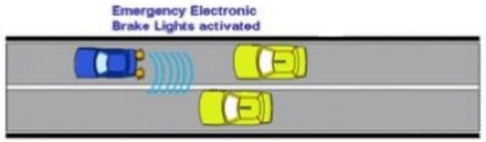
Forward collision warning



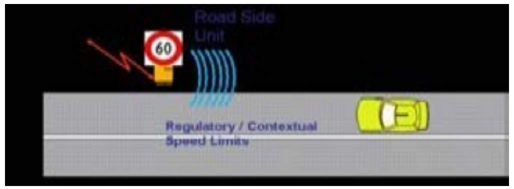
Queue warning

Vulnerable Road User alerts

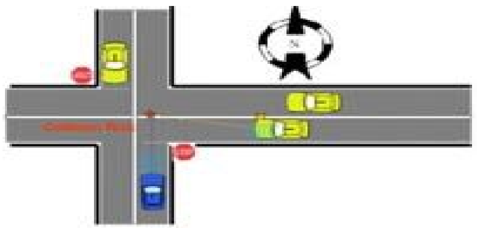
Blind intersection reporting



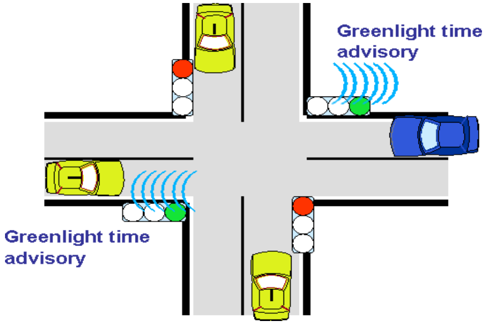
Over-the-hill emergency braking



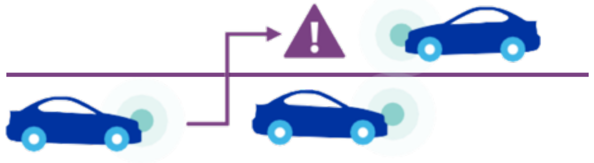
Speed limit warning and adaptation



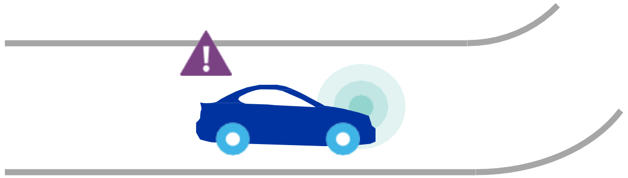
Collision warning



Traffic light redundancy and enforcement



Do Not Pass Warning (DNPW)



Curve speed warning

Emergency vehicle alert

Modified from Qualcomm, “Leading the world to 5G: Vehicle-to-Everything”

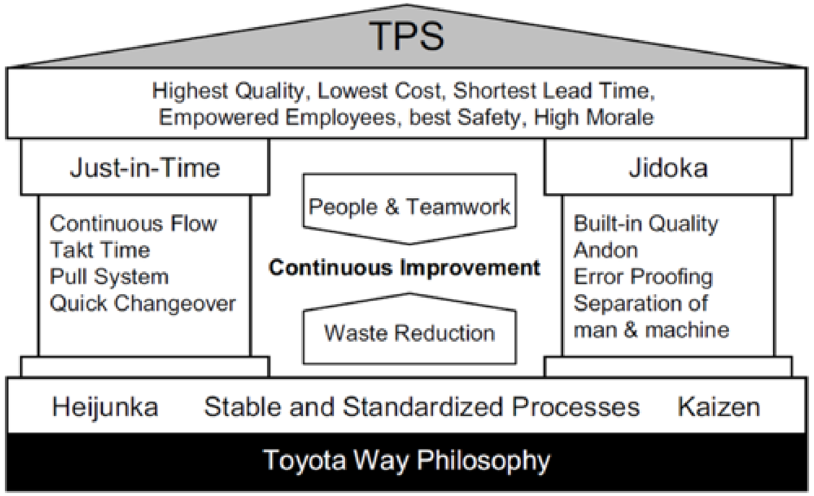
Platooning uses V2V to enable efficient **adaptive cruise control**

https://arstechnica.com/cars/2019/04/this-semi-autonomous-truck-tech-could-seriously-boost-fuel-efficiency/

There are great opportunities on the horizon for CAV’s

We are entering **the era of automotive mobility 3.0**

Automotive Mobility 1.0
Henry Ford
Moving Assembly Line
~1920



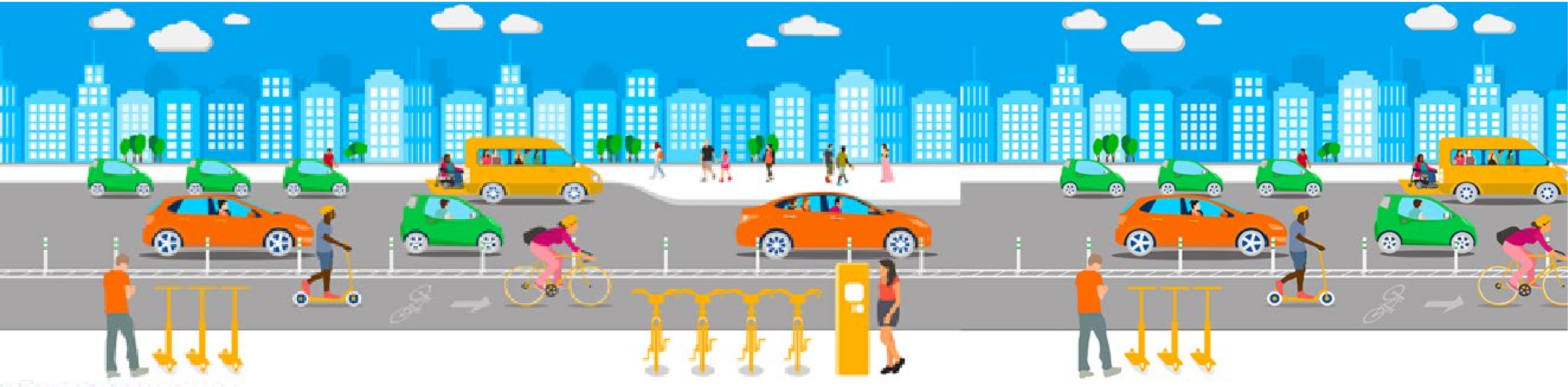
Automotive Mobility 2.0
Toyota Motor Company
Toyota Production System
~1980

Automotive Mobility 3.0
Waymo, Tesla, Cruze, Uber, …
High Automation
Today

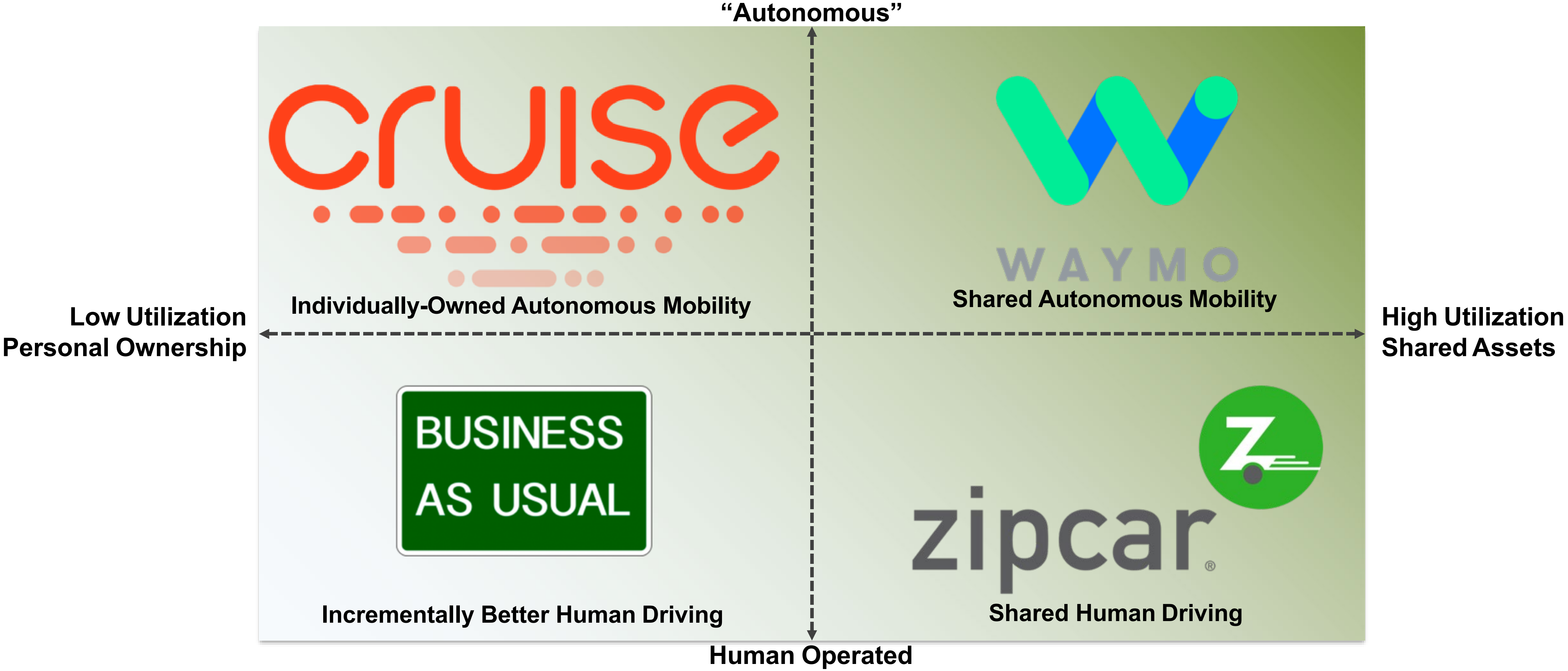
Technological innovations lead social revolutions (democratized vehicle ownership, high-reliability transportation, and ride-sharing)

Self-driving is expensive; **shared mobility** is a likely solution

- Capital **costs amortized by multiple drivers / types of cargo**
- **Higher utilization and uptime** than vehicles today
- **Different vehicles used for different purposes**
  (small pods for individual drivers, buses for large groups, cargo-carriers for packages)

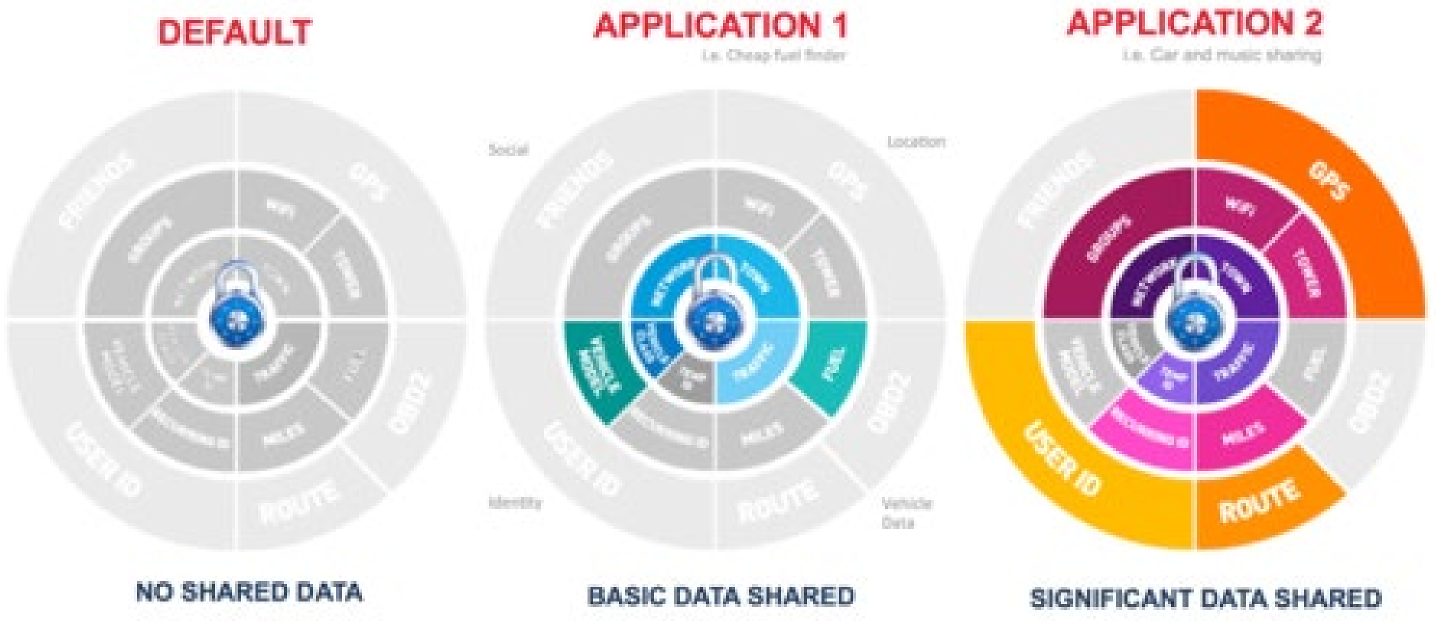


These services and existing business models reflect **four potential states of future mobility**

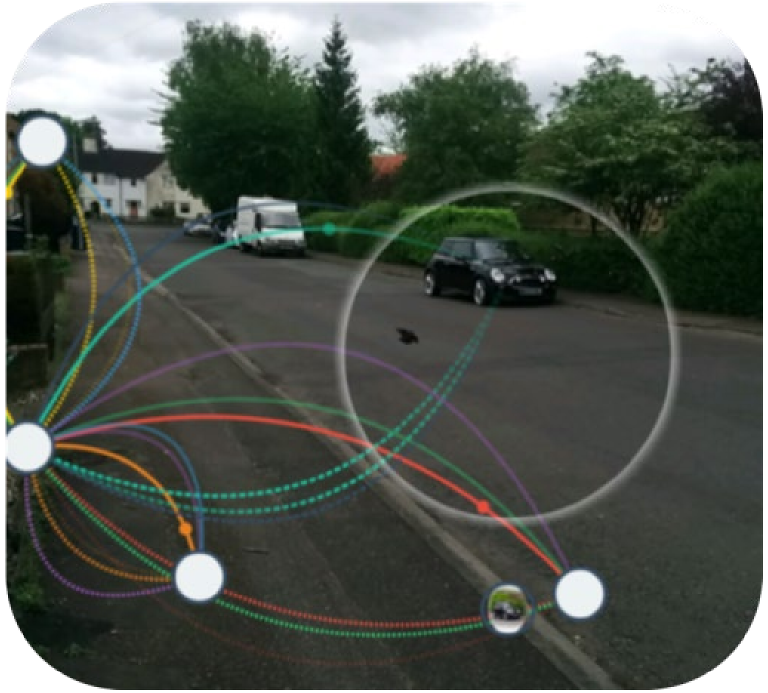


Technological revolution is not without challenges

Connectivity requires **thoughtful design to ensure privacy and security**



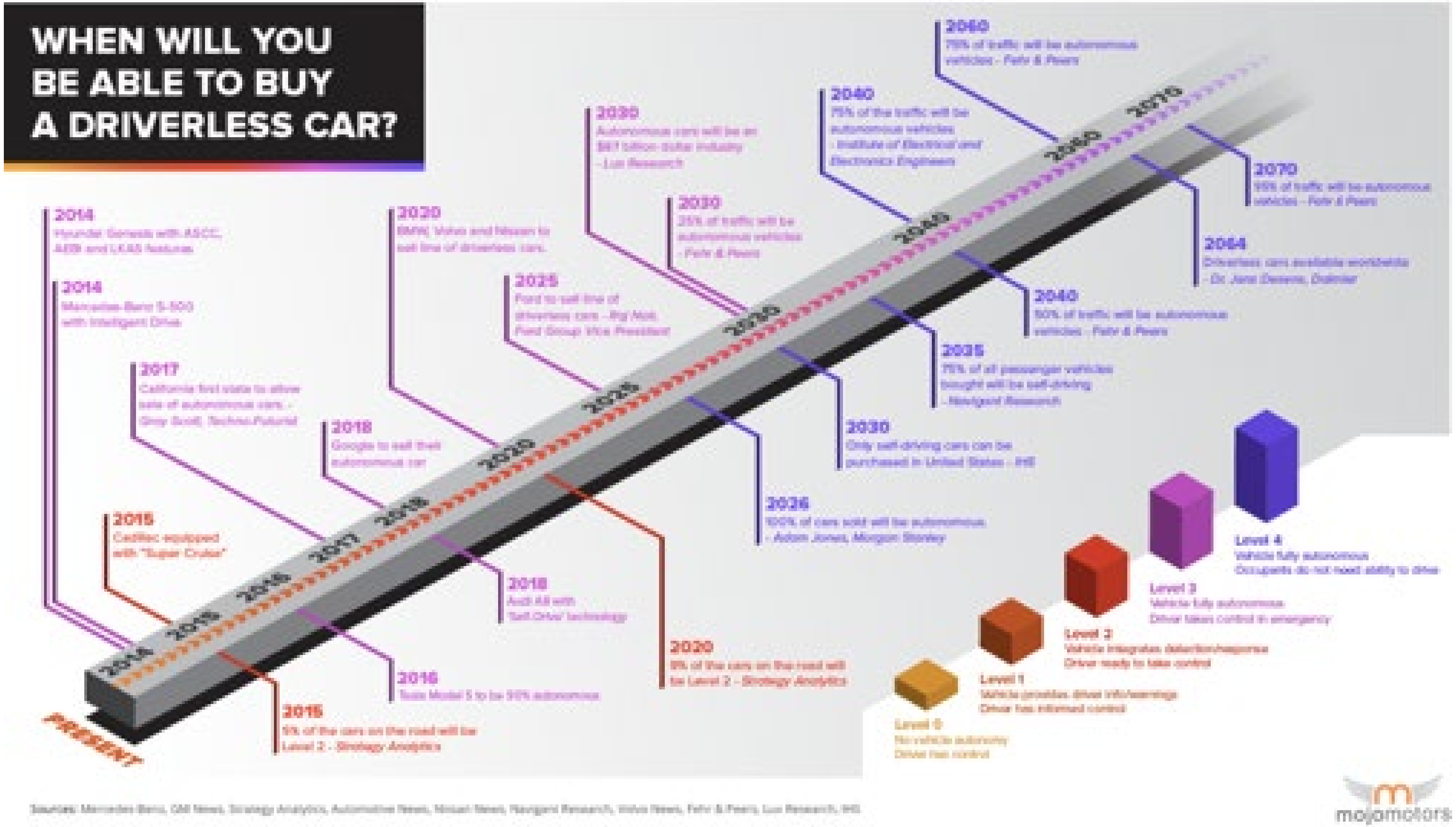
Privacy Radar for permission visualization



Magic Lens
Augmented Reality data interaction display

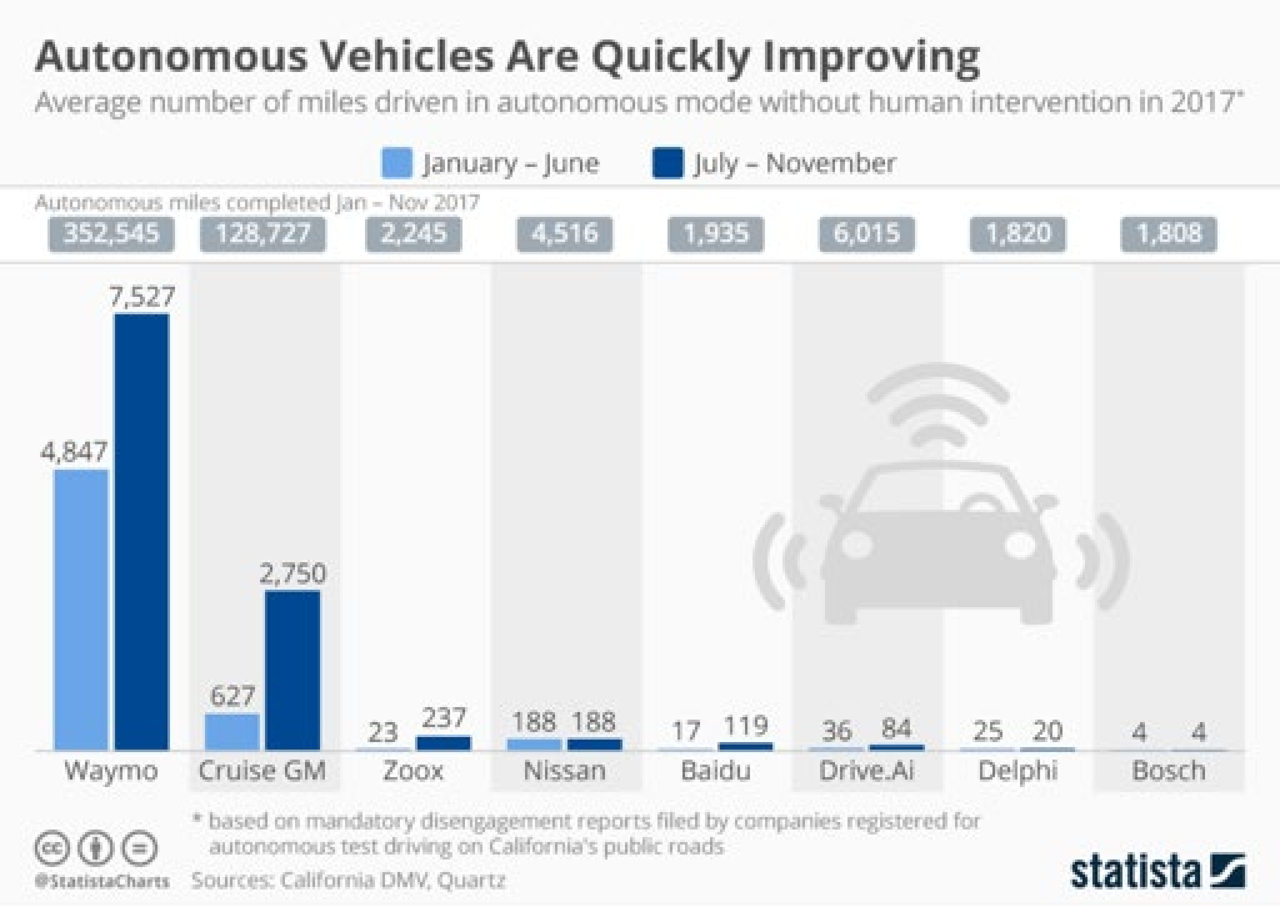
E. Wilhelm, J. Siegel et al. "CloudThink: a scalable secure platform for mirroring transportation systems in the cloud." Transport, Volume 30, 2015.
S. Mayer, J. Siegel. "Conversations with Connected Vehicles." IoT Conference, 2015.

Full automation may (not) be closer than we think



One possible pathway: Ultrasonic parking sensors → Radar crash avoidance → Radar cruise control → Blind spot monitoring → Lane keep assist → V2V/V2X/V2I → Connected infrastructure → Full automation

Disengagement frequency (miles per E-stop) tells the story best



DeepTechLab

What did we cover?

- Cars are computers that generate and share data, supporting local and global optimization
- Connectivity supports vehicle resilience, responsiveness, and design
- Automation is not new but recent advances enable higher degrees of autonomy
- Autonomy supports low-cost, efficient fleet operations
- Technology implementation is not without challenges

Thank You & Questions and Answers

Prof. Josh Siegel, Ph.D.

j_siegel@mit.edu
jsiegel@msu.edu

Sunjay Dodani
sunjay@revvo.ai

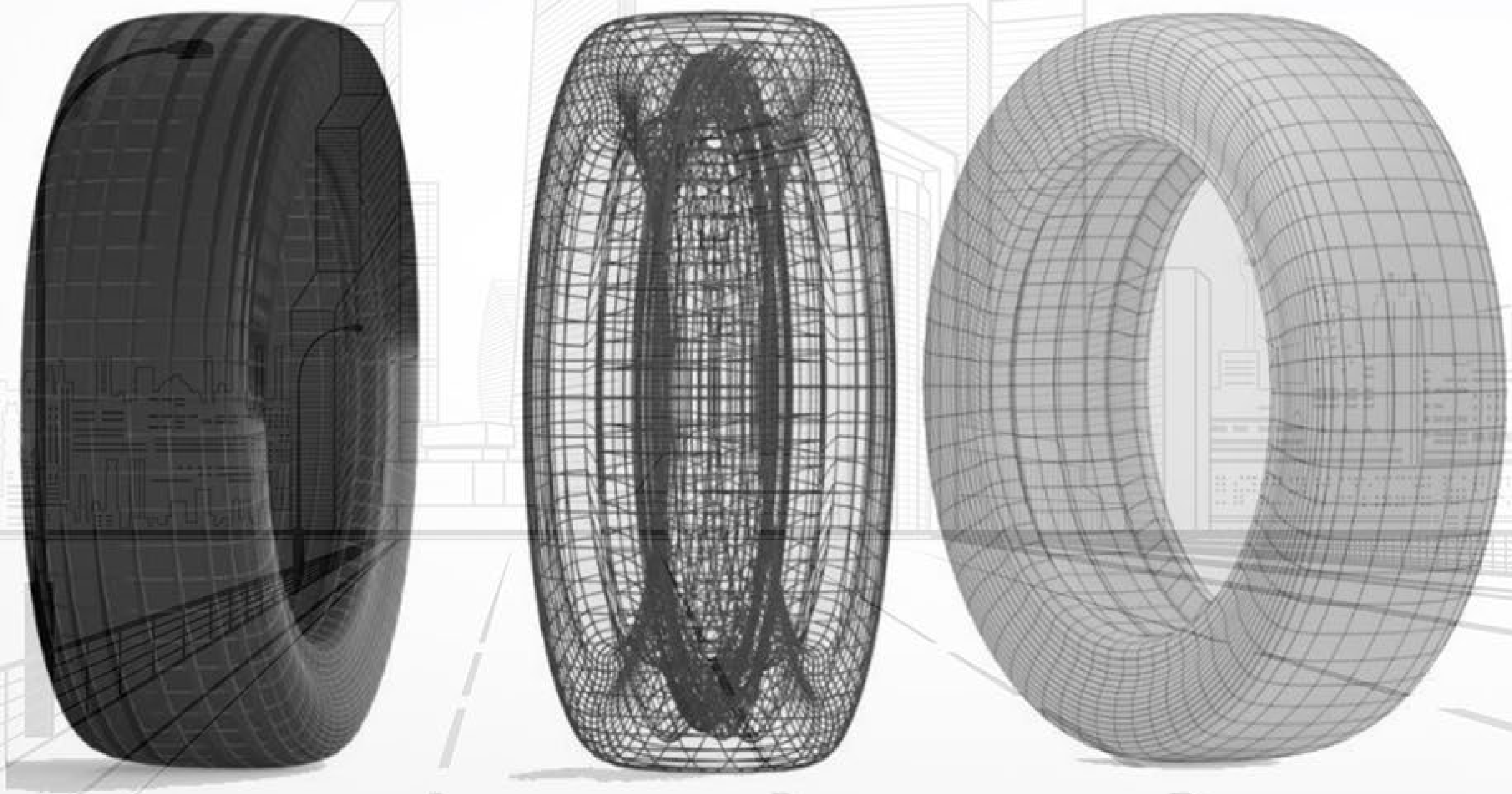
- CEO and co-founder of Revvo Technologies
- Responsible for driving the company's strategy and product vision with the mission of enabling every tire to be smarter
- Prior experience with data analytics at Medallia and an enterprise software company
- Holds multiple patents, including ones for his development of brain navigation systems used by neurosurgeons
- Avid car enthusiast and races BMW SpecE30's
- PHD, MS and BS Degrees in Electrical Engineering and Biomedical Engineering from University of Michigan

Jonathan Ford
jonathan.ford@cityoforlando.net

- Fleet Manger for the City of Orlando
- Involved in strategy and management in Green Works Orlando, a widely recognized and successful sustainability effort with attention to quality of life, economic growth, and equitable access for the entire Orlando community
- US Air Force Veteran Fleet Management and Logistics

REVVO

Enabling the future of transportation



The Data Platform for Intelligent Tires

FLEET PRODUCT OF THE YEAR FINALIST 2020 — Automotive AWARDS

TIRE TECHNOLOGY OF THE YEAR FINALIST 2020 — tire TECHNOLOGY INTERNATIONAL AWARDS

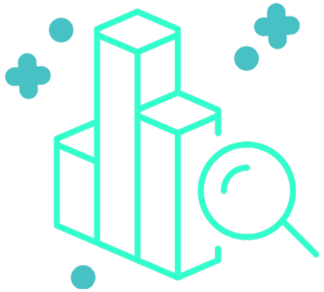
BEST MOBILITY SERVICES AWARD — NORTH AMERICAN INTERNATIONAL AUTO SHOW

Tire Pain Points We've Heard from Fleets

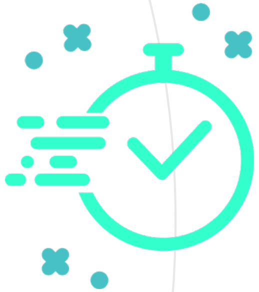
Tires are the #1 OpEx

Safety liability

Lack of data



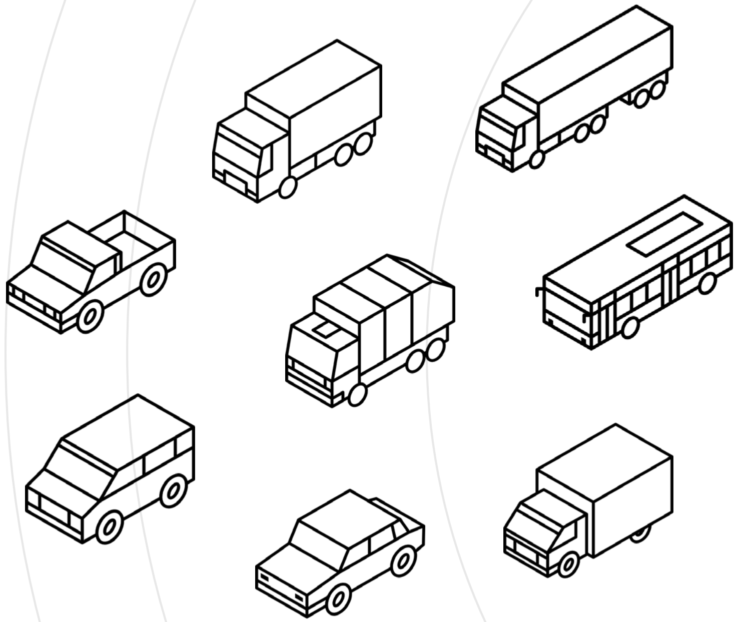
Wasted time

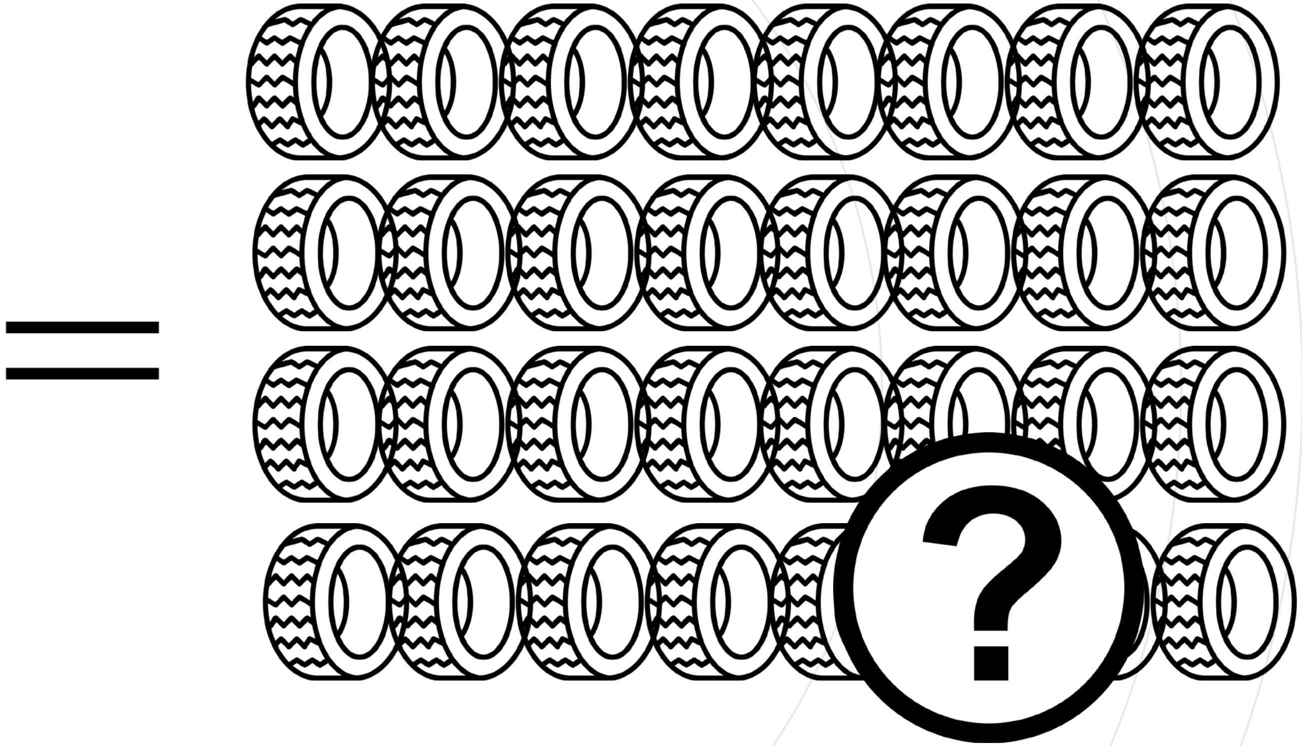


"My technicians spend too much time on basic tasks like tire pressure and tread depth checks. I wish I could free up their time to do more important work."

- Fleet Supervisor

Visibility at Scale





Do you know how many tires you have to manage?

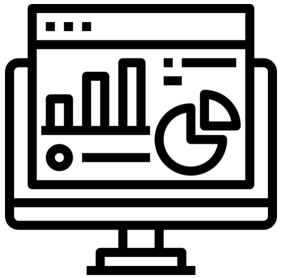
1000 passenger vehicles = 4,000 tires

500 buses = 3,000 tires

1000 refuse trucks = 10,000 tires

Revvo's smart tire platform

Smart and connected tires (**Pressure, Temp, Tread, Load**, footprint, rotation, alignment, driver behavior)



Remote tire monitoring + predictive analytics

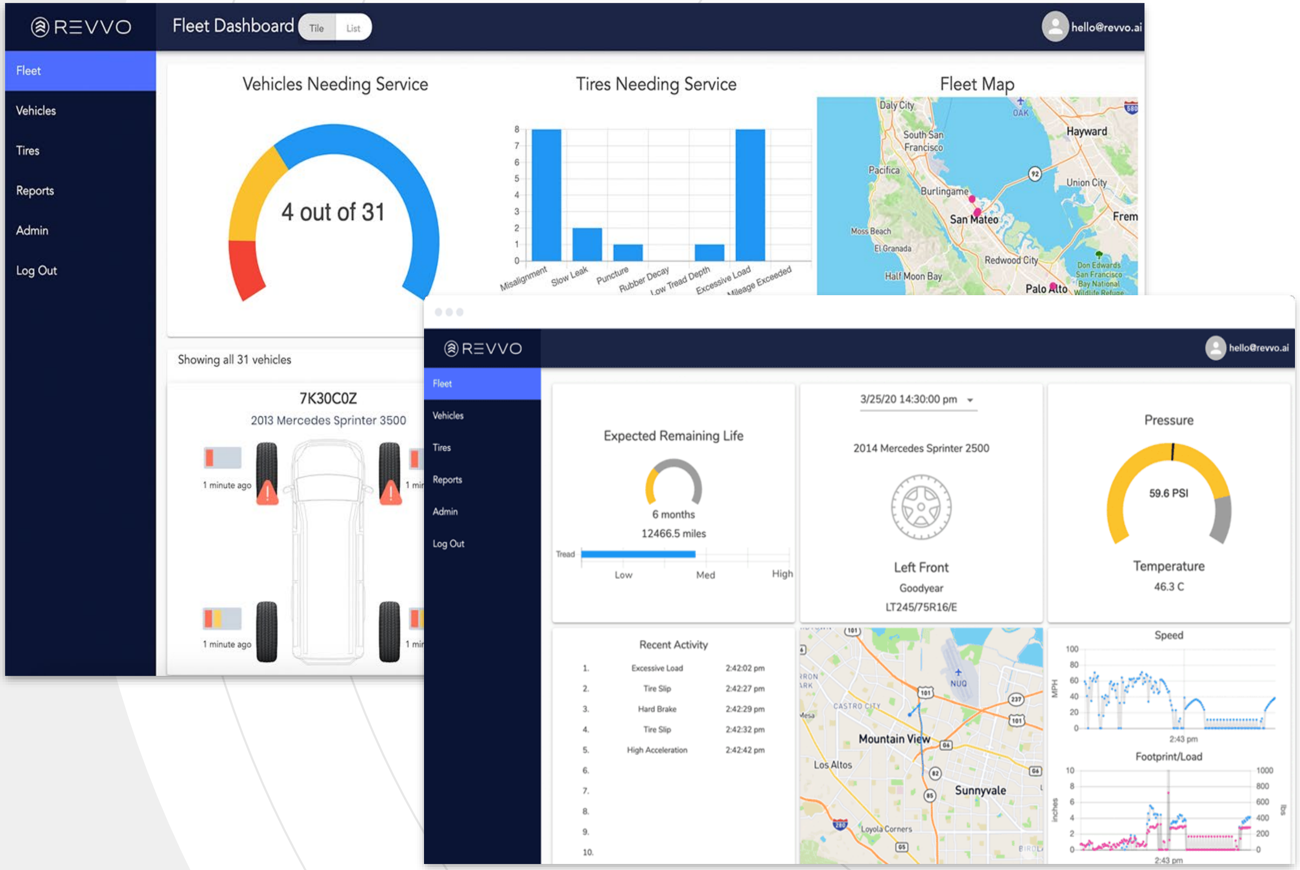
=

Best in class fleet tire management

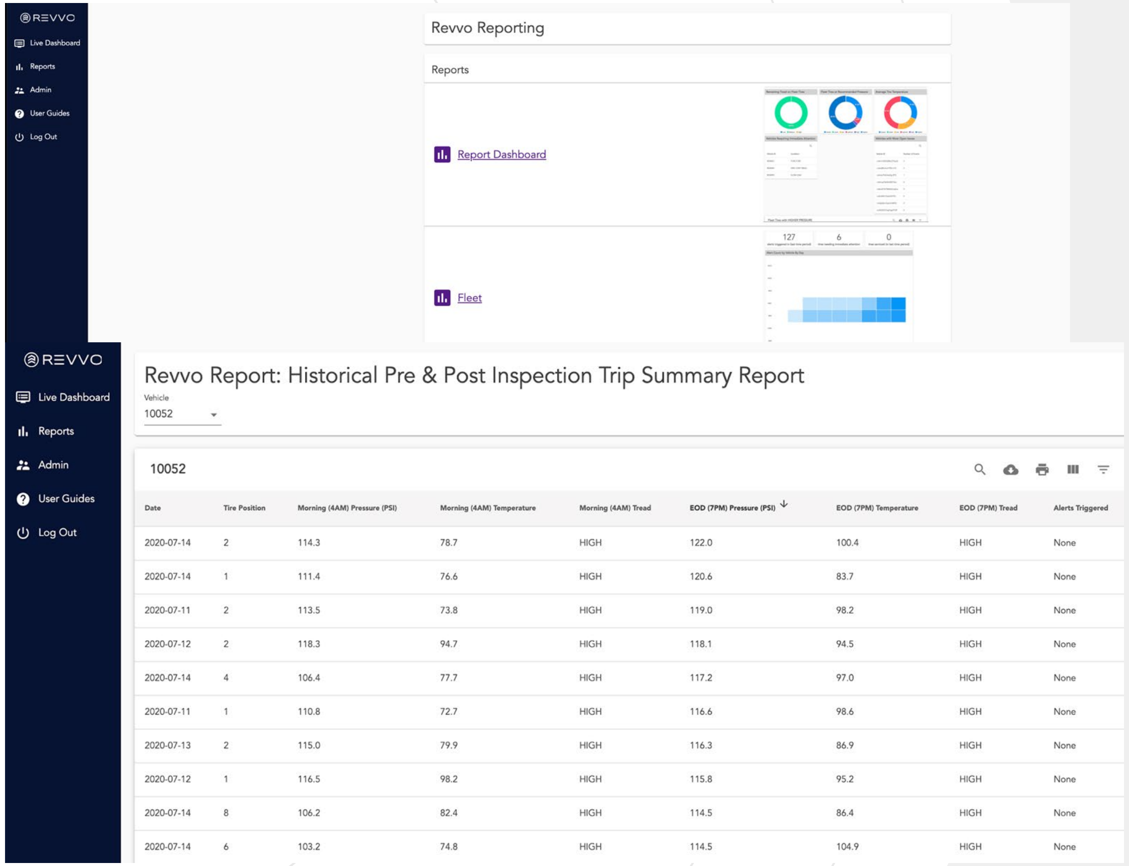
- Reduce tire costs
- Improve safety
- Increase efficiency
- Enhance productivity

Revvo enables tires to be smarter so that fleet operators can make the best data-driven tire decisions.

Revvo Dashboard & Reports



Real-time remote tire management that gives you complete visibility into the status and condition of every tire in your fleet



Reports that provide actionable tire insights so that you can make better tire-related decisions

City of Orlando has >3000 vehicles in Fleet

Revvo deployed first in Refuse Trucks → High Tire $pend

Goal:

i. Improve safety of trucks on road
ii. Reduce overall tire spend
iii. Improve technician efficiency

Orlando - Underinflated Case for ASL

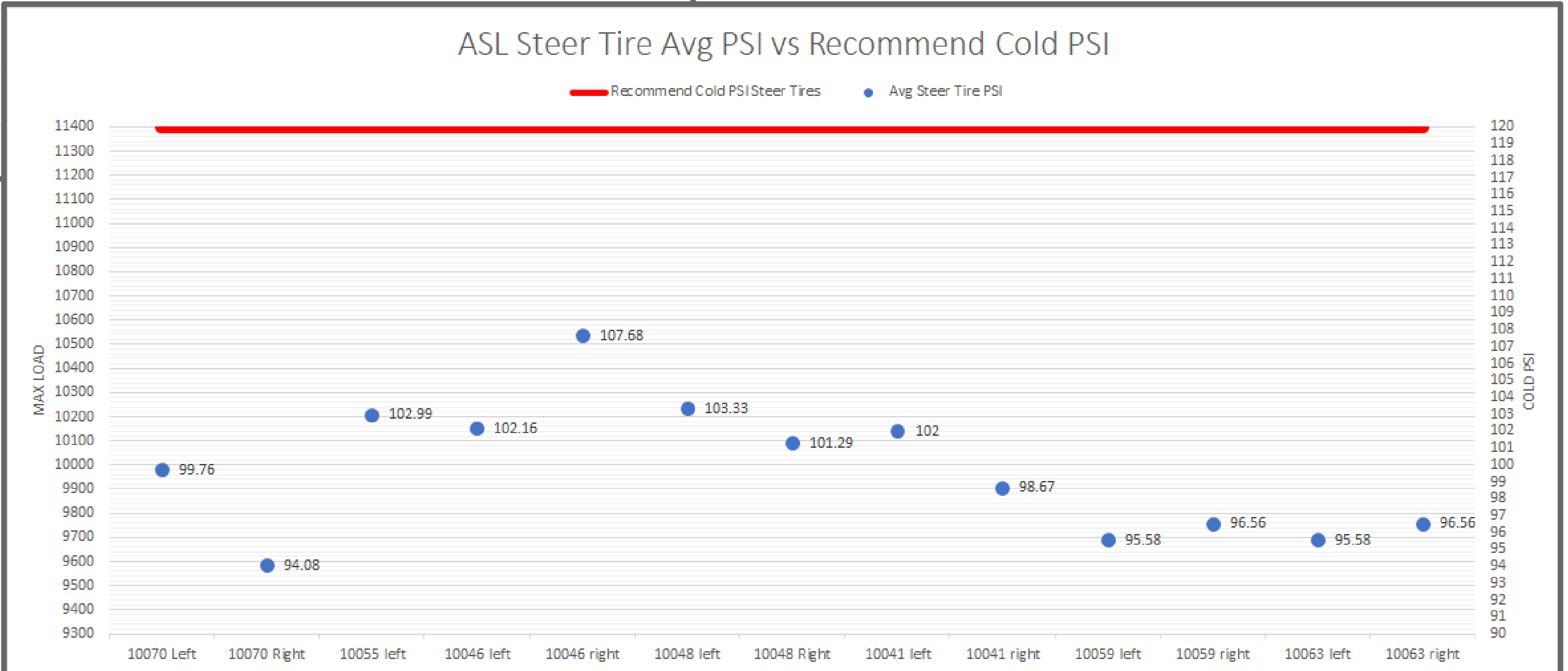
Revvo Report: Historical Pre & Post Inspection Trip Summary Report

Vehicle
10052

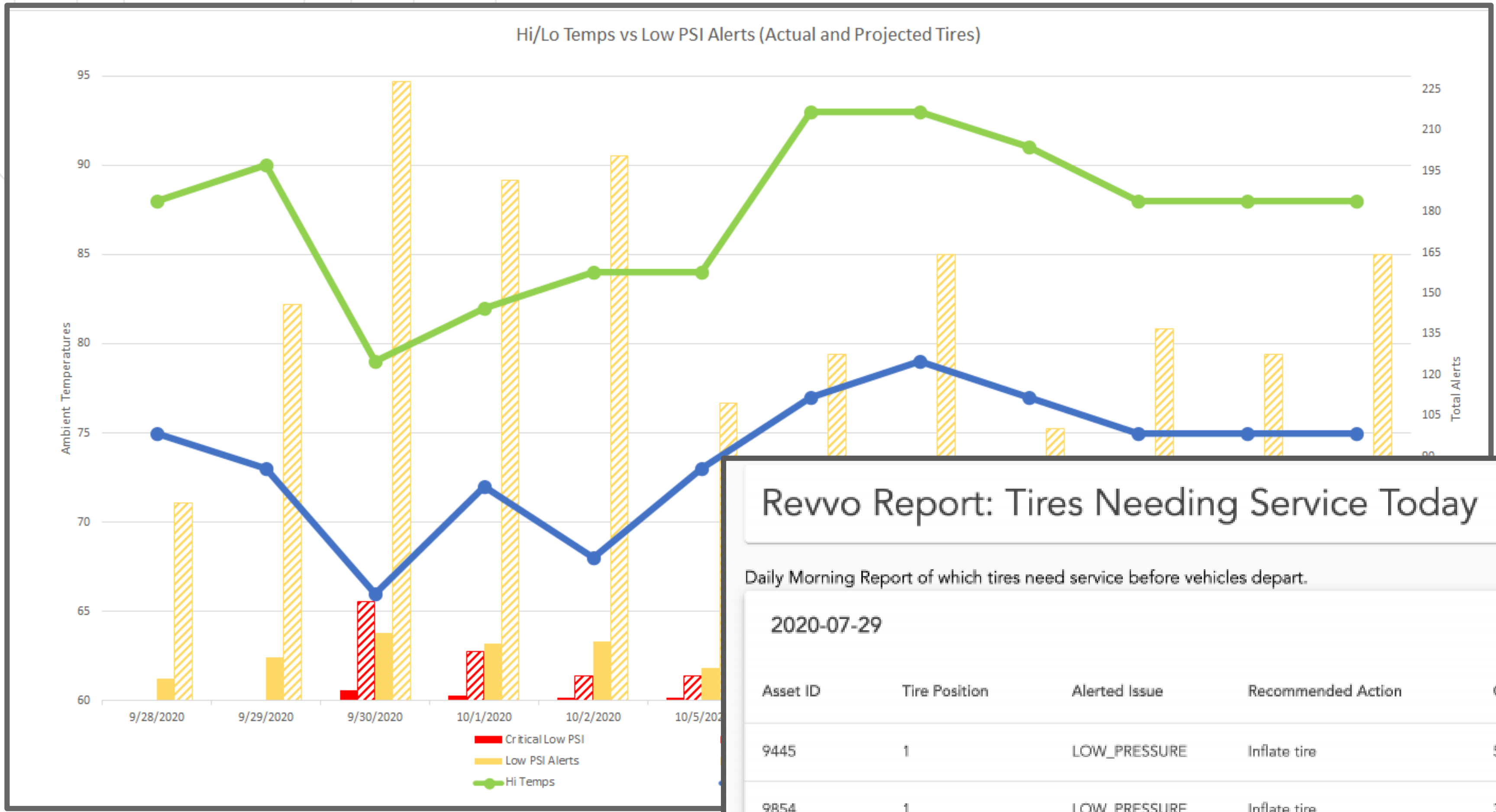
10052

Date	Tire Position	Morning (4AM) Pressure (PSI)	Morning (4AM) Temperature	Morning (4AM) Tread	EOD (7PM) Pressure (PSI)	EOD (7PM) Temperature
2020-10-19	5	92.2	80.6	HIGH	92.2	80.6
2020-10-19	7	0.5	73.5	HIGH	0.5	73.5
2020-10-19	1	119.6	130.4			
2020-10-19	2	110.5	73.8			
2020-10-19	6	0.5	85.7			

Front tires on automated side loaders (ASL) with lower cold tire pressure decrease the ability of tires to carry load...



Orlando - Temperature vs Tire PSI



A sharp decrease in ambient temperatures can result in a spike of under inflated and critically under inflated tires within hours...

Revvo Report: Tires Needing Service Today

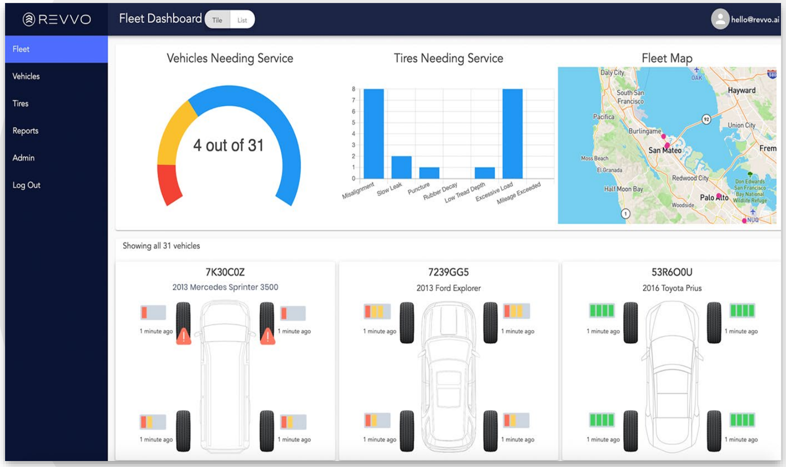
Daily Morning Report of which tires need service before vehicles depart.

2020-07-29

Asset ID	Tire Position	Alerted Issue	Recommended Action	Current Pressure (PSI)	Recommended Pressure (PSI)	Current Tread Level
9445	1	LOW_PRESSURE	Inflate tire	56.7	70	HIGH
9854	1	LOW_PRESSURE	Inflate tire	33.2	42	HIGH
9854	2	LOW_PRESSURE	Inflate tire	30.1	42	HIGH

ROI of Revvo so far..

- ✓ **Freeing up Techs** to do other work during PMs
- ✓ Electronic record of Pre/Post Trip tire inspections
- ✓ Anticipate **less tire related road call, towing**, and **lower tire spend**
- ✓ Revvo **working directly with** Orlando tire service **vendors** to improve day-to-day tire maintenance



REVVO

Enabling the future of transportation.

Interested in getting in touch?

sunjay@revvo.ai or josh@revvo.ai
(630-207-4512)

Andy Wolpert
ADWolpert@columbus.gov
614-223-2170

- Deputy Program Manager for the Smart Columbus program
- More than 20 years engineering experience from design-build projects to intelligent transportation solutions
- Has successfully led multiple technology projects designed to provide equitable, safe and reliable transportation nationally advancing mobility
- BSCE from Ohio Northern University and MSCE from Ohio State University

SMRT COLUMBUS

Transforming America's Smart City through Open Mobility

Andrew Wolpert, PE
Smart Columbus Deputy Program Manager

78 MID-SIZE CITIES RESPONDED TO THE US DEPARTMENT OF TRANSPORTATION'S SMART CITY CHALLENGE

7 WORLD CLASS FINALISTS

COLUMBUS
AUSTIN
DENVER
PORTLAND
PITTSBURGH
KANSAS CITY
SAN FRANCISCO

COLUMBUS WON THE MANDATE TO BECOME THE MODEL

SMRT COLUMBUS

WE WON
$50 MILLION

$40 M $10 M

TO BECOME THE
TEST CITY FOR SMART CITIES

BY DEPLOYING A
COMPREHENSIVE TECHNOLOGY PLAN THAT PUTS PEOPLE FIRST

AND WE'LL DO IT
THE COLUMBUS WAY

$90M JUNE 2016 → **$500M** TODAY → **$1B** 2020

MISSION

To demonstrate how an intelligent transportation system and equitable access to transportation can have positive impacts on everyday challenges faced by cities.

SAFETY | MOBILITY | OPPORTUNITY | ENVIRONMENT | AGENCY EFFICIENCY | CUSTOMER SATISFACTION

USDOT PORTFOLIO

SMRT COLUMBUS OPERATING SYSTEM

ENABLING TECHNOLOGIES

- CONNECTED VEHICLE ENVIRONMENT

ENHANCED HUMAN SERVICES

- MULTIMODAL TRIP PLANNING
- SMART MOBILITY HUBS
- MOBILITY ASSISTANCE
- PRENATAL TRIP ASSISTANCE
- EVENT PARKING MANAGEMENT

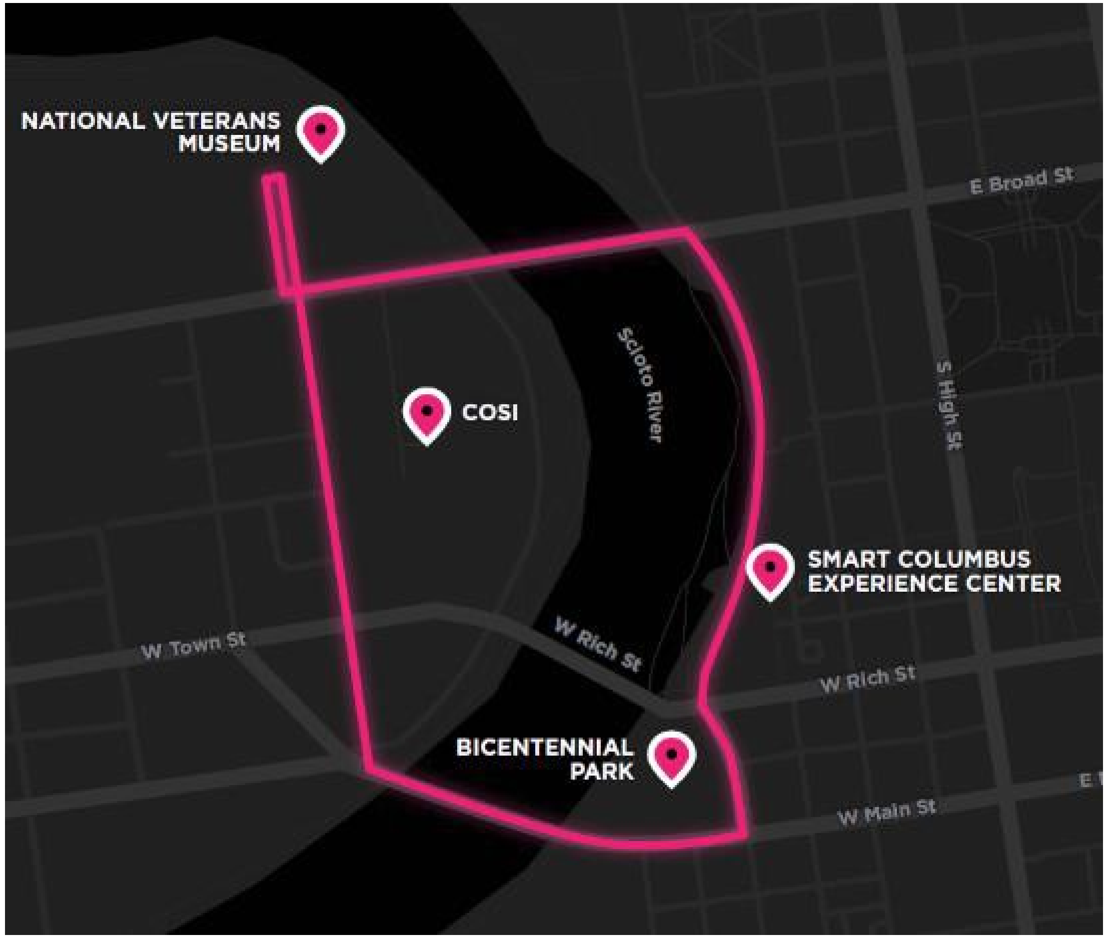
EMERGING TECHNOLOGIES

- CONNECTED ELECTRIC AUTONOMOUS VEHICLES

CONNECTED ELECTRIC AUTONOMOUS VEHICLES

SMART CIRCUIT

- Served public educational purpose and deployment learning for project team
  - Develop lessons learned
  - Use experience for other deployments in Columbus and Ohio
  - Connect educational and cultural resources

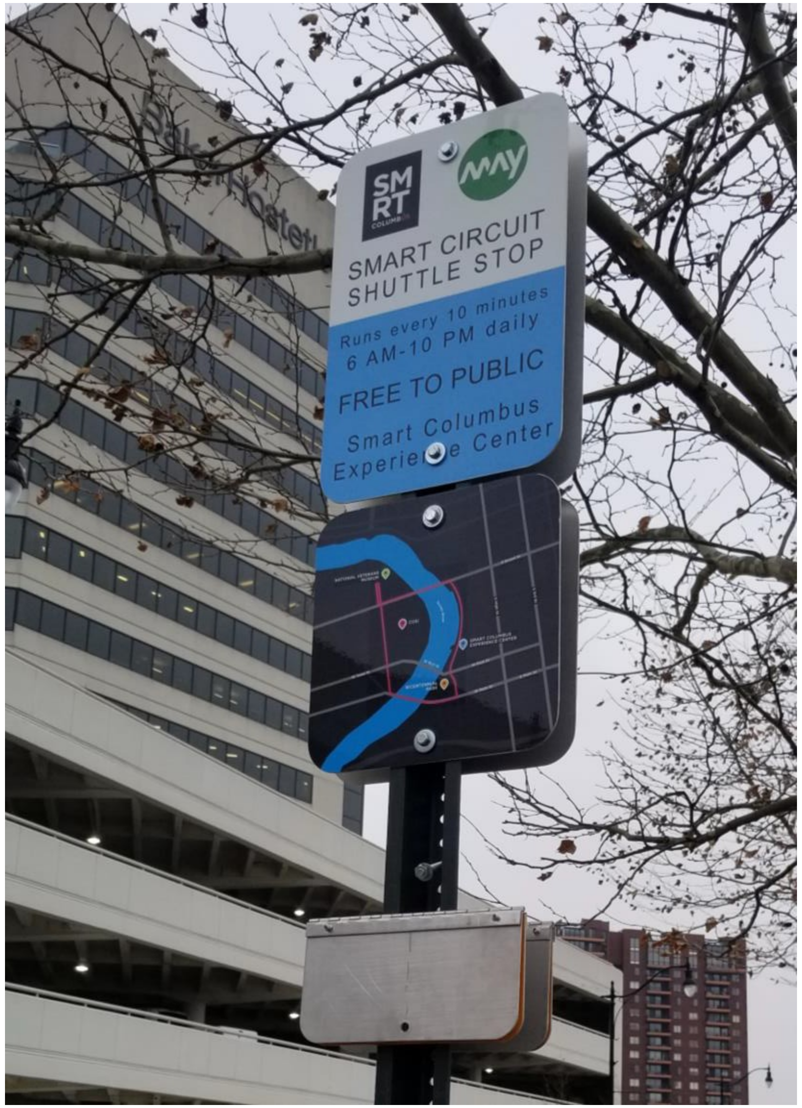


PROCUREMENT PROCESS

- Developed RFP for Turn-key AV Shuttle Operations
- One-year contract
  - Mobilize and deploy
  - 10 months of service
- Evaluated on past performance, proposed approach, and price
- Selected May Mobility

SMART CIRCUIT

- 16,062 rides
- 19,118 miles driven
- 59 average daily rides



LESSONS LEARNED

- Evaluate stop locations and traffic control
- May need to modify existing striping or signage
- Monitor other vehicle interactions with the AV Shuttle to ensure all interactions are legal

LESSONS LEARNED

- Be clear about terminology and requirements

- Ask specific questions about infrastructure needs, including power and attachments

LINDEN DEPLOYMENT

DEFINING THE PURPOSE

- Connecting the community to jobs and services
  - Community centers
  - Opportunity centers
  - Food sources
  - Support services
  - Smart Mobility Hubs
- Improving safety and mobility of travelers by mitigating First Mile/Last Mile challenges
- Validate and ensure equitable and accessible options
- Encouraging transit - Grow COTA ridership

DEFINING THE PURPOSE

- Establish a common data exchange interface
- Establish a set of procurement guidelines
- Develop a set of AV operational testing and evaluation guidelines to benchmark AVs
- Develop a methodology for evaluating the operational safety
- Summarize lessons learned

STAKEHOLDER MEETINGS

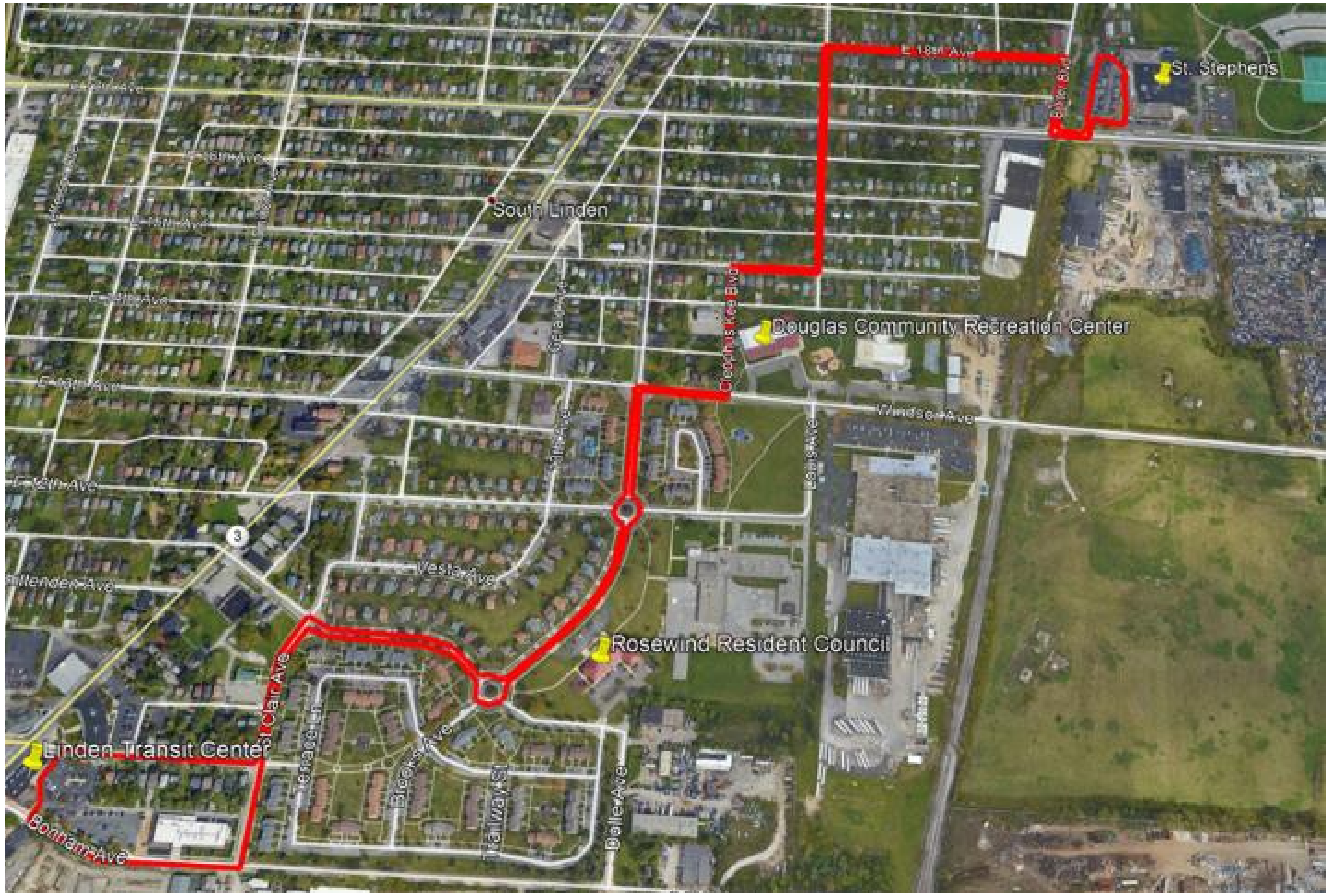
- **Multiple meetings held to identify and refine routes**
- **Provide input into RFI**
- **Reconvene to review RFI responses**
- **Final input on route and scoring**

RANKING CRITERIA

Criterion	Description
Smart Mobility Hub	The route provides a connection to a proposed Smart Mobility Hub as part of the Smart Columbus initiative.
Food and Service Access	The route connects to food and services needed within a community. The list includes: grocery store, bank, pharmacy, and food bank/pantry
Ladders of Opportunity	The route connects residents with job or opportunity centers for enhanced placement access. The list includes an Opportunity Center and Ohio Means Jobs.
COTA	The route connects to a COTA stop and acts as a FMLM connection to expand the reach of a traveler
Alignment Considerations	The route serves more as a missing link than a duplicate of an existing COTA route.
Safety and Accessibility	The route has lighting and sidewalks in the vicinity of anticipated stops.
Prenatal Support	The route connects pregnant women with services that can aid in a healthy pregnancy.
Neighborhood	The route connects to an opportunity neighborhood for increased mobility.
Storage	The route provides a nearby facility for storage and charging of vehicles.
Route navigation	The technology at the time of deployment will allow the route to be traveled.
Recs and Parks	The route connects to a City recreation center or park.

SELECTED ROUTE

- Access to 2 Smart Mobility Hubs
  - Linden Transit Center
  - St. Stephen's
- Access to Services
- FMLM Connection
- Fills Transit Gap



TIMELINE

- RFP published 1/17/19
- Turn-key shuttle service
- Notice to Proceed June 2019
- Testing December 2019
- Began Operations February 2020
- Feb. 20, 2020 – Passenger incident
- Passenger service currently on hold due to COVID-19
- Began new use case of delivering food to the neighborhood

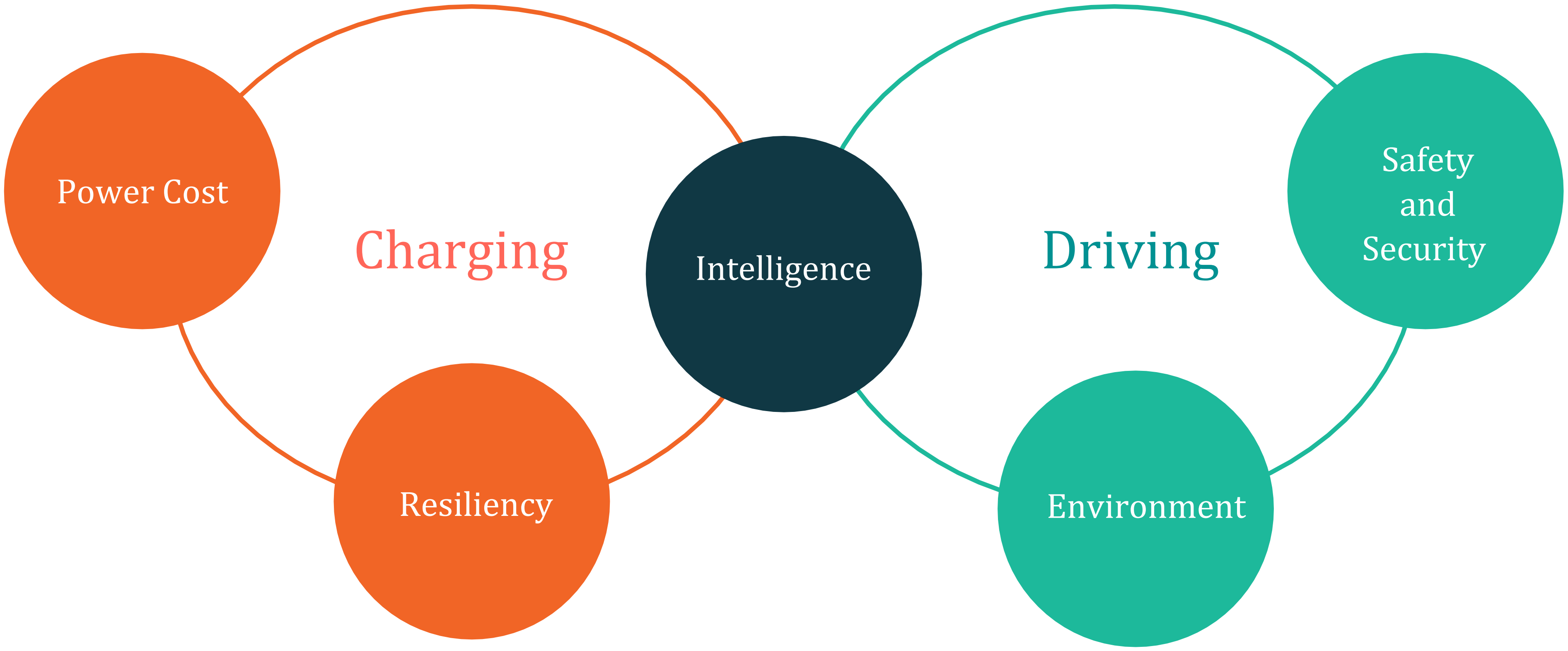
Sass Peress
sass@isunenergy.com
514-909-5047

- CEO of iSun Energy & Renewable Energy Ambassador
- High-energy, innovation architect with achievements in global renewable energy product development and marketing, public company leadership and community involvement
- Passionate champion of renewable energy and clean mobility since launching ICP Solar in 1988
- Founded Quebec's first ever solar panel factory in 2001
- Currently enjoying true sustainable living in a fully hydro-electric and wind powered home
- Assisted in Tesla's design of their own solar canopy for their SuperChargers
- Involved daily in the electric vehicle communities both on and offline

#thinkbeyondthebarrel

iSun OS

A fleet goes beyond the vehicle…



Optimize your fleet charging for…

CARBON FREEDOM

DATA CAPTURE

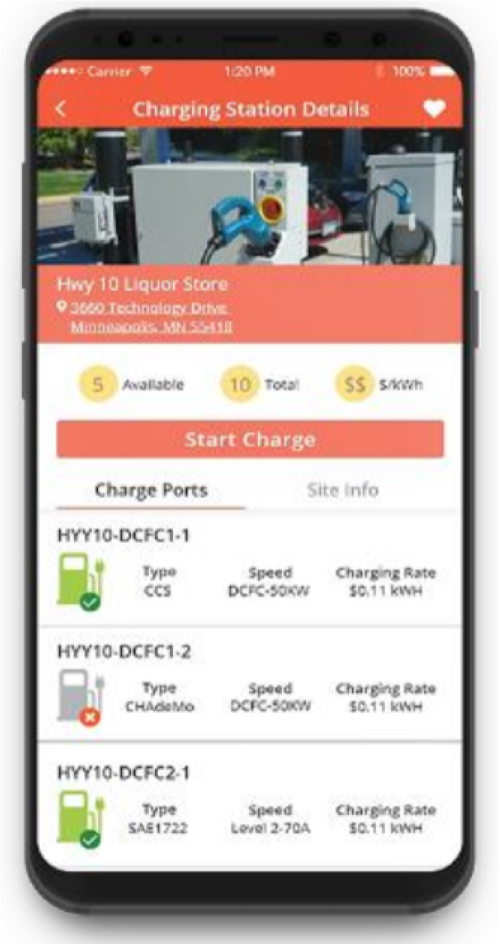
RESILIENCY

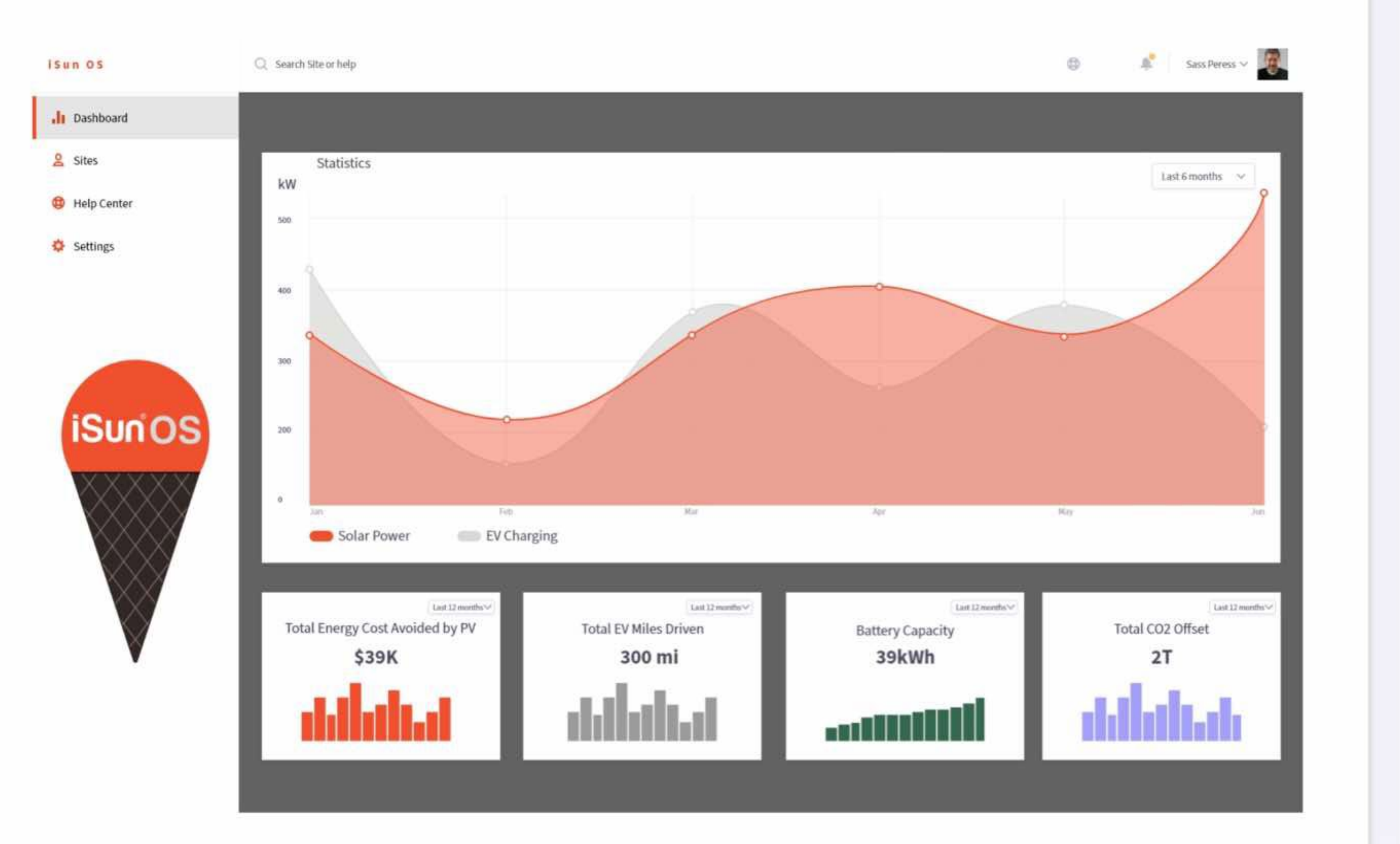
FLEXIBILITY

INTEROPERABILITY

iSunOS

…make it easy and smart





Key characteristics of EV charging best practices

Resilient

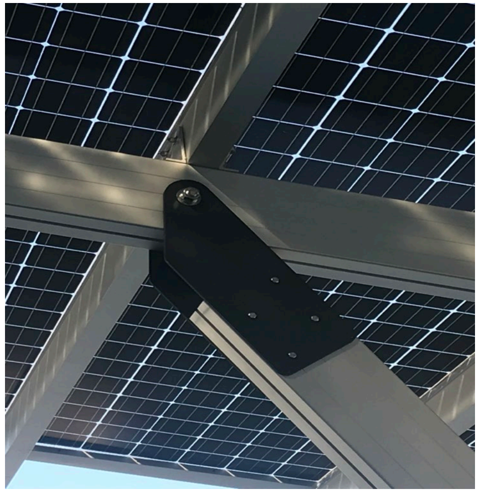
Scalable

Branding

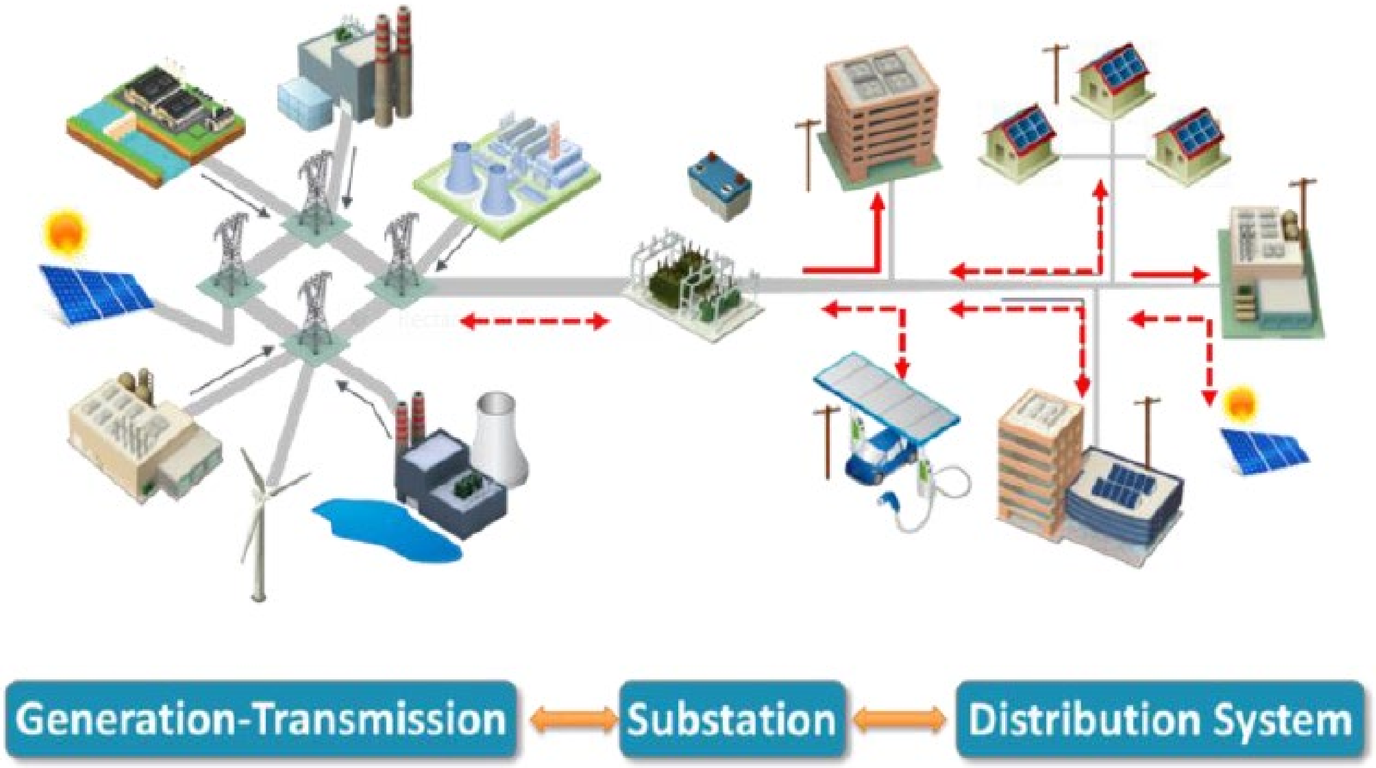
Intelligent

Clean

Low Maintenance



…with returns on your investment services



iSunOS

…and returns on impact

Mothers &Others FOR CLEAN AIR

Home | About Us » | Fight For Clean Air » | Stay Informed » | Training Center » | Join Us » | Press

Prenatal Exposure to PM2.5 Linked to Growth Delays After Birth

A study published in the journal Environment International shows that children born to women who are exposed to higher levels of fine particle air pollution (PM2.5) are more likely to have decreased weight and BMI at 4 years of age.

The study was conducted in multiple cities in Spain as part of the Infancia y Medio Ambiente (INMA) study. Air pollution was assessed during all 3 trimesters of pregnancy, and during the child's first year of life. Children's birthweight and length, and height and weight at 4 years old, were measured.

The results showed lower weight at 4 years of age for children whose mothers had higher PM2.5 exposure during the first trimester. The researchers adjusted for air pollution exposure in the other trimesters of pregnancy


ROI
IS NOW
RETURN ON IMPACT
iSun

Automotive
Technology Consulting

Derrick Redding
derrick@automotivetechnology.tech
734-548-2604

- Partner at Automotive Technology Consulting
- Identifies and executes value creation in new technology innovation
- Broad and diverse experience with Toyota from assembly to finance, cost reduction, product development & innovation
- Recent innovations include camera/sensor cleaning for AVs, Driver Monitoring Systems for drowsiness detection, and creating upfit processes for Connected Vehicles
- Led the Technology Maintenance Council task force to improve visibility for truck drivers and currently working on their Future Cab task force

Technology Adoption of Fuel Economy and Safety Technologies for Commercial Vehicles

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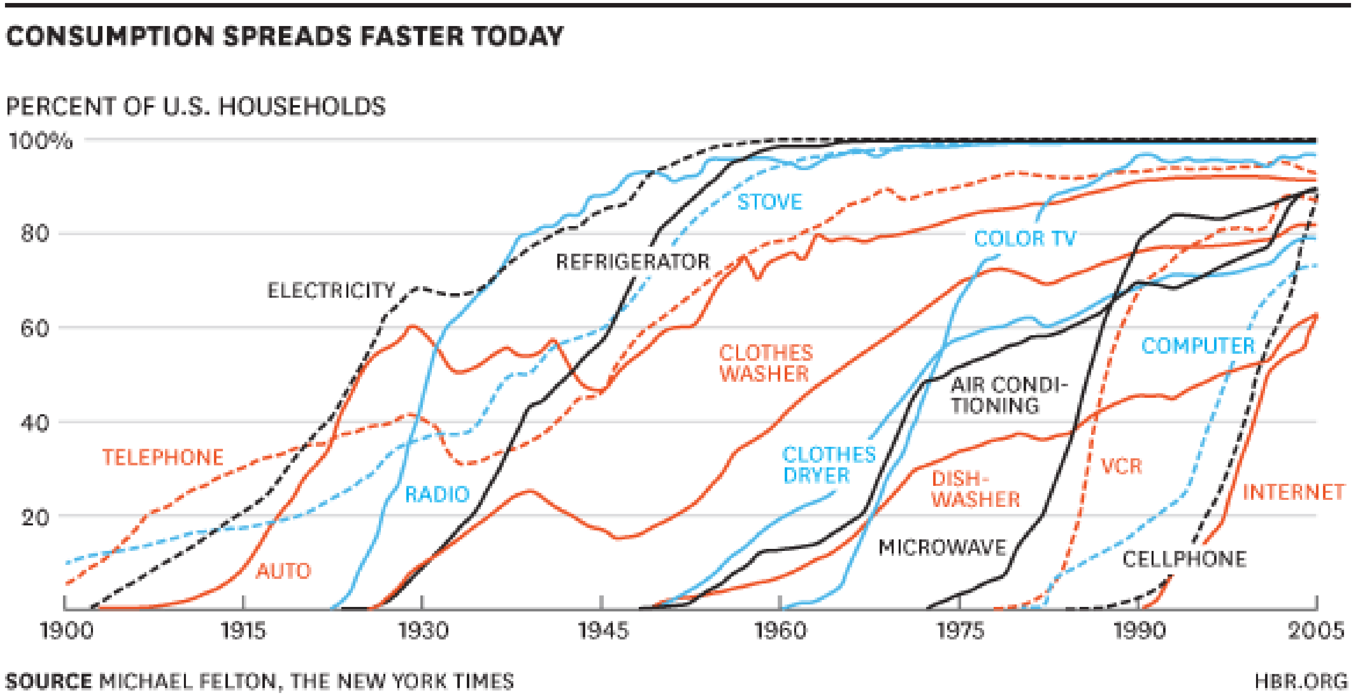
Automotive
Technology Consulting

Adoption Rates for New Technology are Accelerating

Automotive
Technology Consulting



1900-1930: many technologies took ~60 years to reach 80% adoption.
2000: the cellphone took 8 years to reach 80% adoption.

Many new options for vehicle technology. However, more challenges to evaluate new technologies that work <u>and</u> deliver the promised benefits.

Automotive Technology Consulting

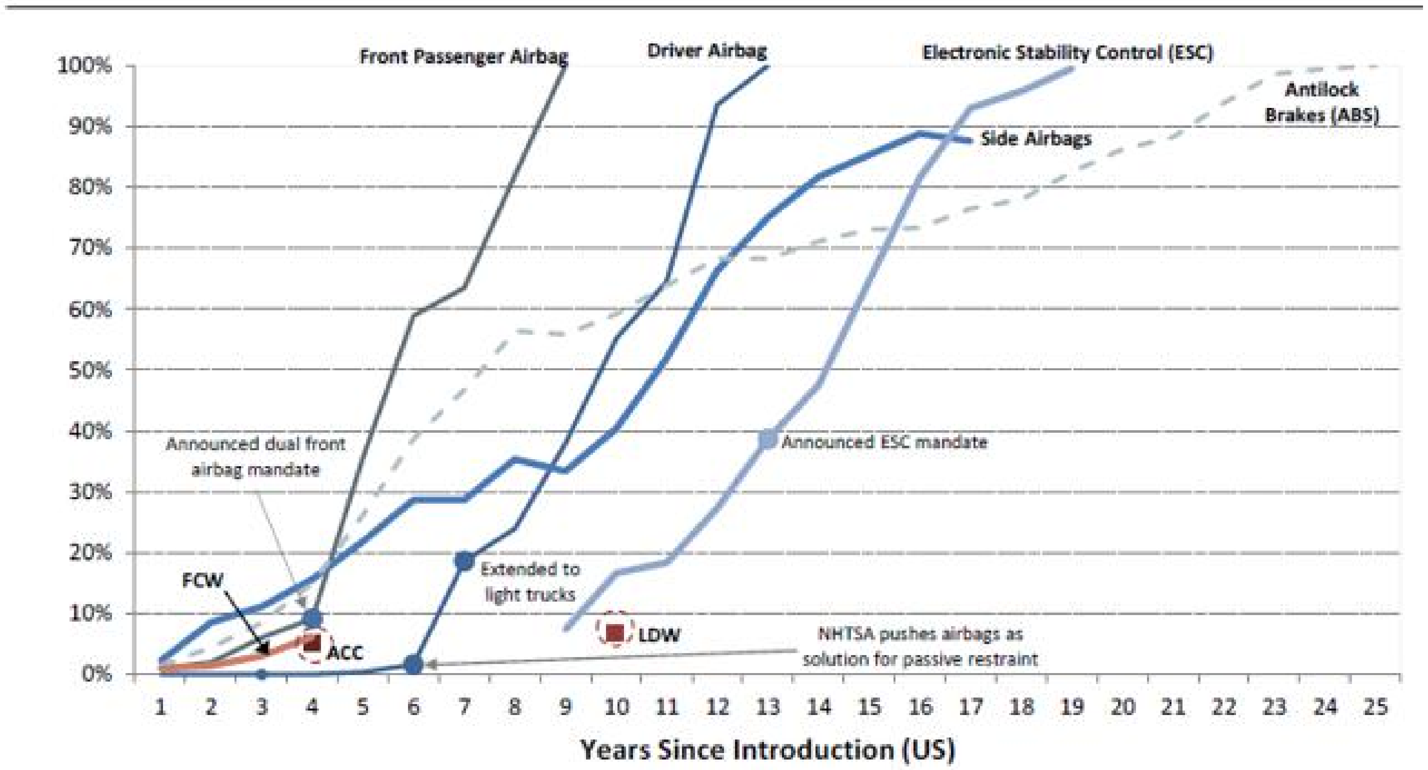
Discussion Agenda

1. Safety Technology Adoption in Passenger Car
2. Technology Adoption in Commercial Vehicle
3. Implications for Commercial Vehicle
4. Best Practices in Technology Evaluation

Safety Technology Adoption in Passenger Car

Historical Adoption Rates for Automotive Safety Technology

Automotive
Technology Consulting



Key:
ABS: Antilock Brakes
FCW: Fwd Collision Warning
ACC: Adaptive Cruise Control

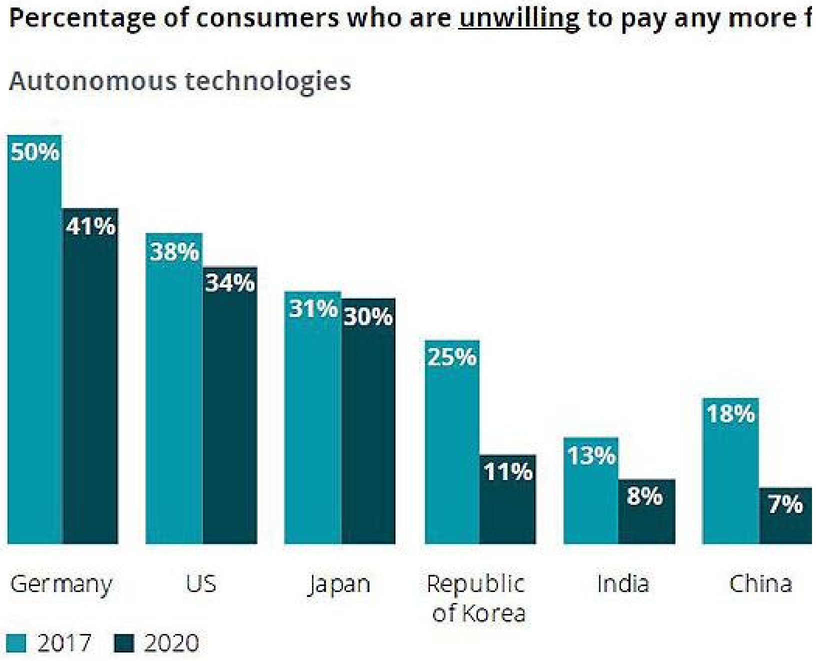
Without Regulated Mandates, about 20-30 years to reach 80% penetration. E.g. ABS
With Mandates it takes ~7 to15 years to reach 80% penetration. E.g. Driver Airbag: 10 yrs

<u>In-progress and Not-Mandated:</u>
Radar: at 20 years, 65% penetration. Blind Spot Detection: at 11 years, 10% penetration
FCW & ACC are adopting at rates even below ABS.

Challenges to Safety Technology Adoption in Automotive

Billions spent by Automotive OEMs and Suppliers on safety and AV Tech.
Many exciting new technologies are ready or near ready for Level 3/4.
But, adoption has been much slower than expected.

Why? Major barrier is that consumers won't pay extra for technology in cars:



Source: Deloitte 2020

Challenges to Safety Technology Adoption in Automotive

Automotive
Technology Consulting

Additional causes affecting adoption in automotive:

1. New car prices are frozen

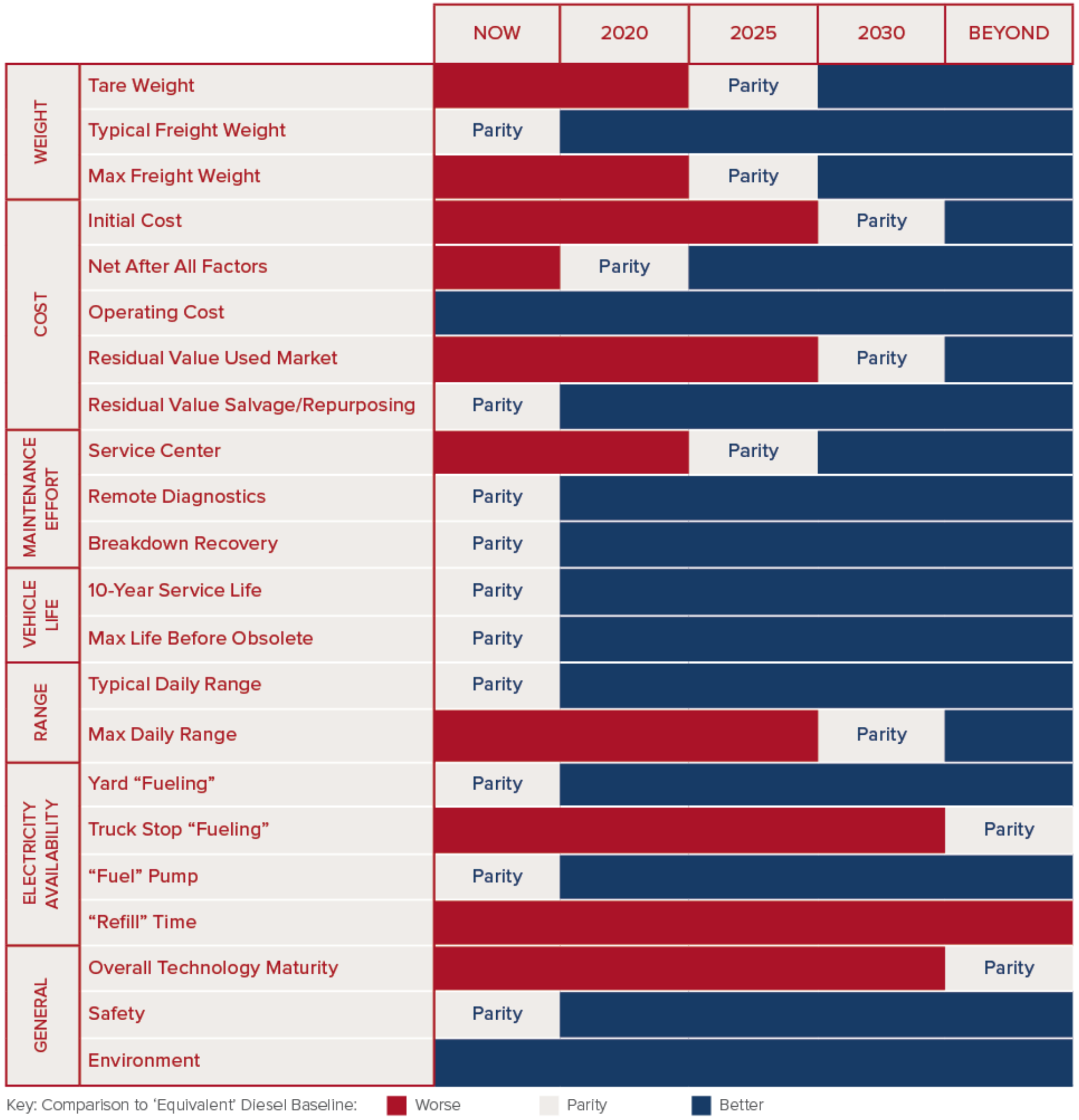
2. NHTSA not mandating new safety technologies.
   However, Europe and China are moving forward.

Significantly different dynamics at play in Commercial Vehicle for new technology and seeing some examples of faster adoption in CV compared to car.

Technology Adoption in Commercial Truck

EV Adoption in Medium Duty Truck

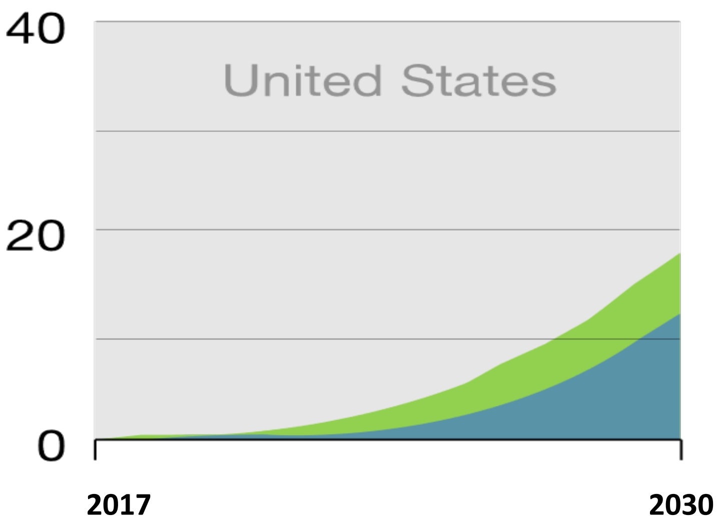
CLASS 3 THROUGH 6 CBEV PARITY VS. DIESEL SYSTEM (NACFE)



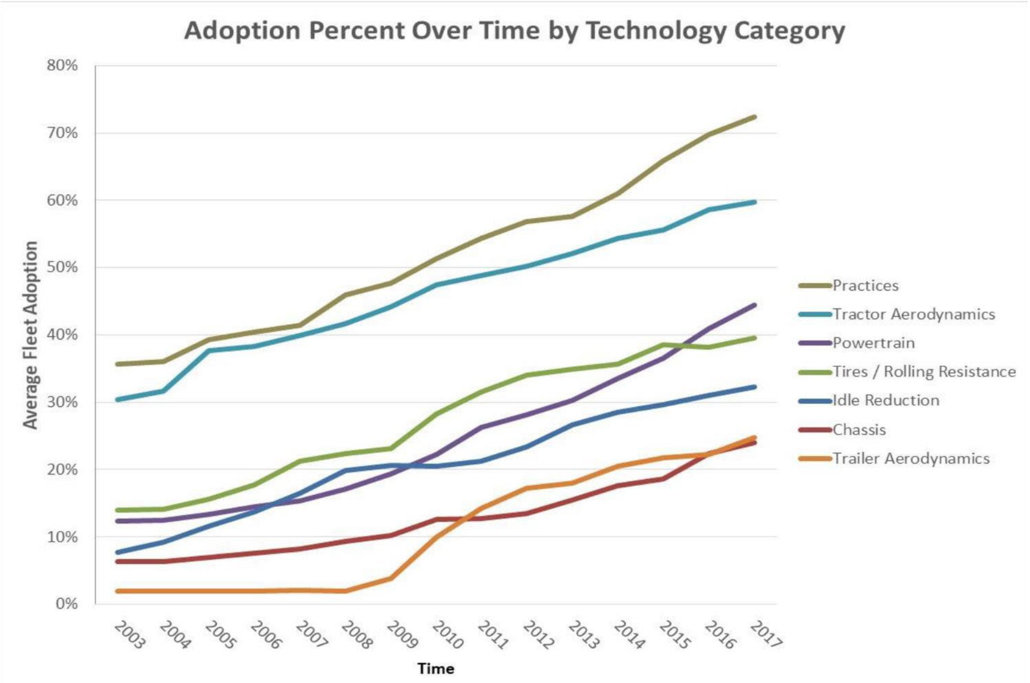
Economics for MD EVs make sense:

1. Inter-city trucks run ~100-200 mi/day
2. Start and end in the same place
3. Parked overnight for easy charging
4. High upfront fixed cost vs. lower operating costs.

Projected MD EV Adoption:



Fuel Efficiency Technology Adoption in Class 8 Truck



Source: NACFE

Over 85 fuel saving technologies available in 2019.
Not all are effective. Many are being implemented at the same time.

Technology alone typically doesn't deliver all of the benefits. The driver interface and driver behaviors are very important to making technology work and optimizing operational improvements.

Results of Fuel Saving Technology in Class 8 Trucking

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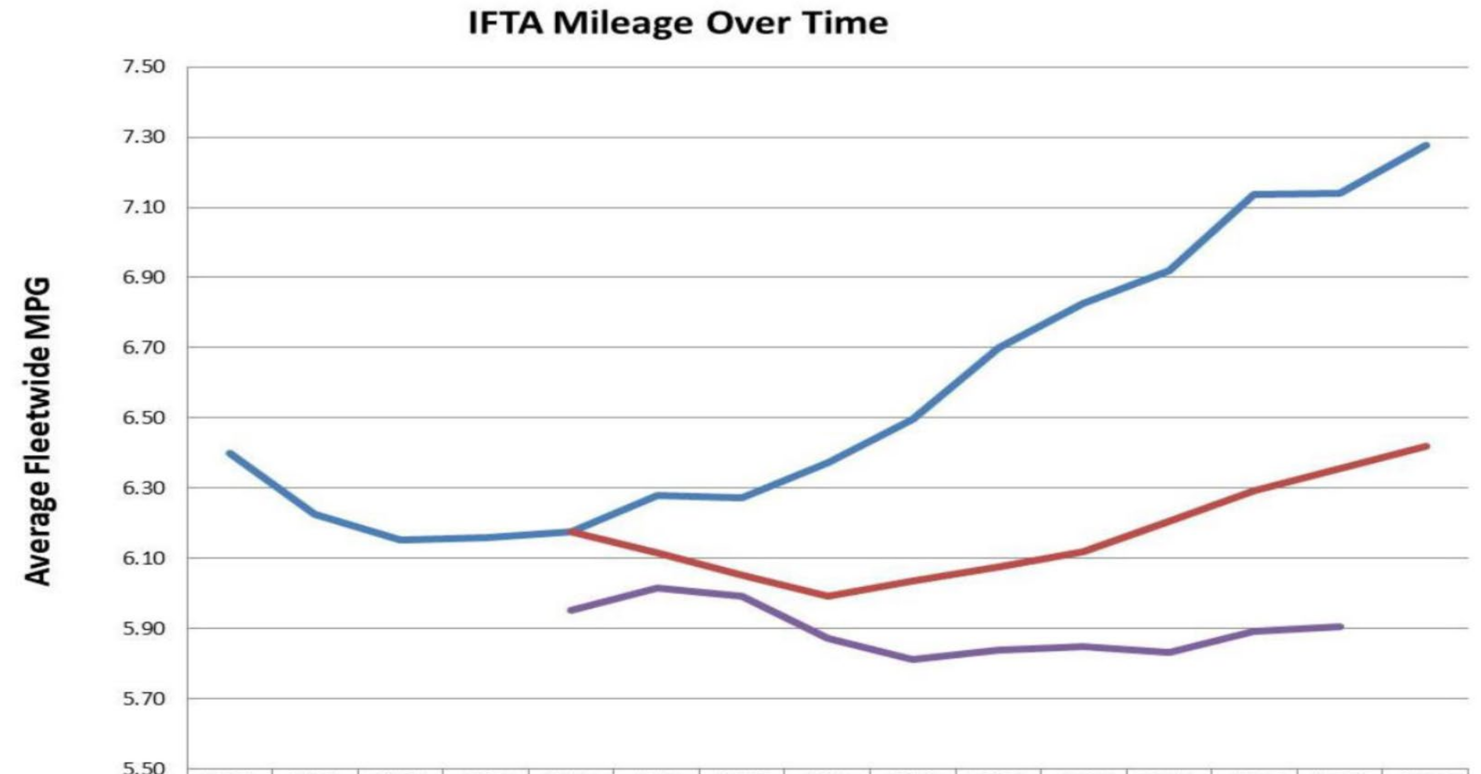

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Average MPG	6.40	6.23	6.15	6.16	6.18	6.28	6.27	6.37	6.50	6.70	6.83	6.92	7.14	7.14	7.28
Business as Usual					6.18	6.11	6.05	5.99	6.03	6.08	6.12	6.21	6.29	6.35	6.42
All U.S. Trucks (FHWA)					5.95	6.02	5.99	5.87	5.81	5.84	5.85	5.83	5.89	5.91	

Source: NACFE

Progressive fleets operating at ~7% higher fuel efficiency than the average fleet. When new technologies are used, fleets operate at over 20% better than average.

Safety Technology Adoption Example – Automated Emergency Braking (AEB)

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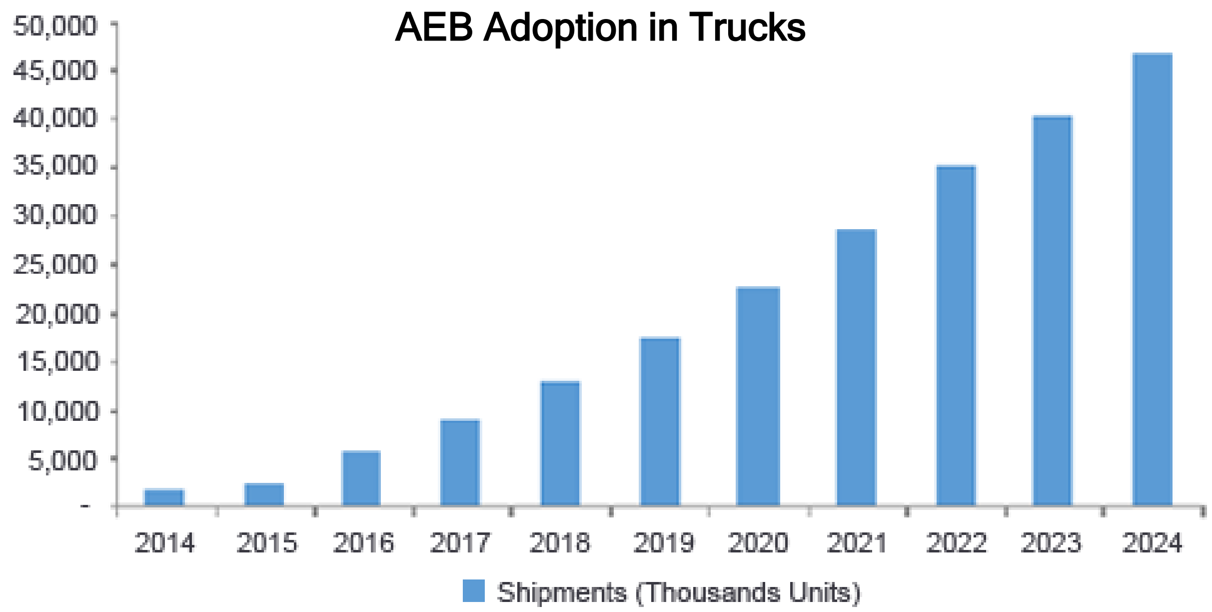
AEB has shown a 40-70% reduction in rear crashes.

Car adoption started strong, but has slowed, especially in the US.

Truck adoption has taken off, especially on Class 8 trucks.



Driver Monitoring Systems – Measuring Attention

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What is an "Acceptable" Off-Road Glance?

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Glance:
On-Road

Glance Length (s):
2.50

Percent Off-Road:
41

Max Off Road Length (s):
1.53

Significant "Over trust" issues emerging as active safety is adopted.
Truck OEMs do not have the answers on how to measure and optimize driver attention

Driver Monitoring Systems – Measure Attention

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Attentional Buffer – Measuring Attention over Time

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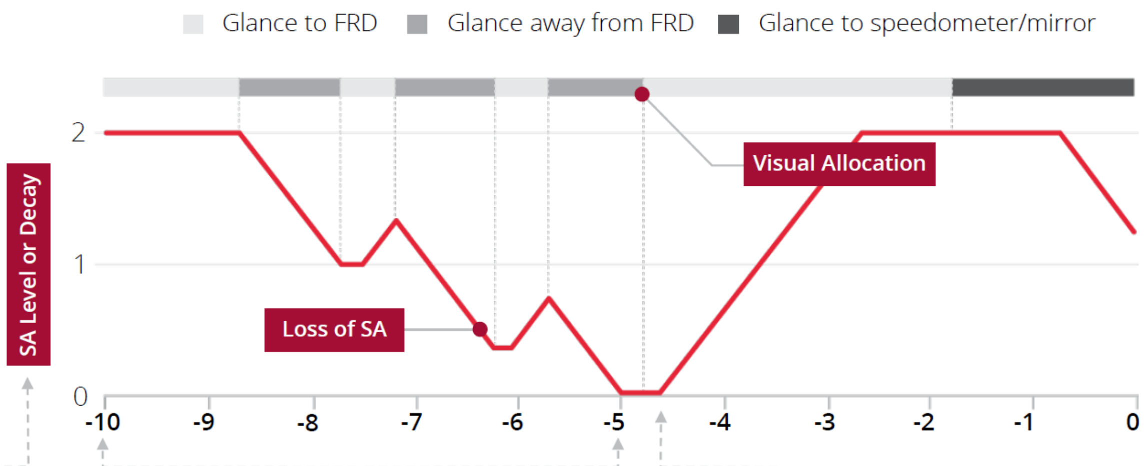
The concept of an 'attentional buffer' can be used to describe both visual allocation and attention.

Figure adapted from Kircher & Ahlstrom (2009)



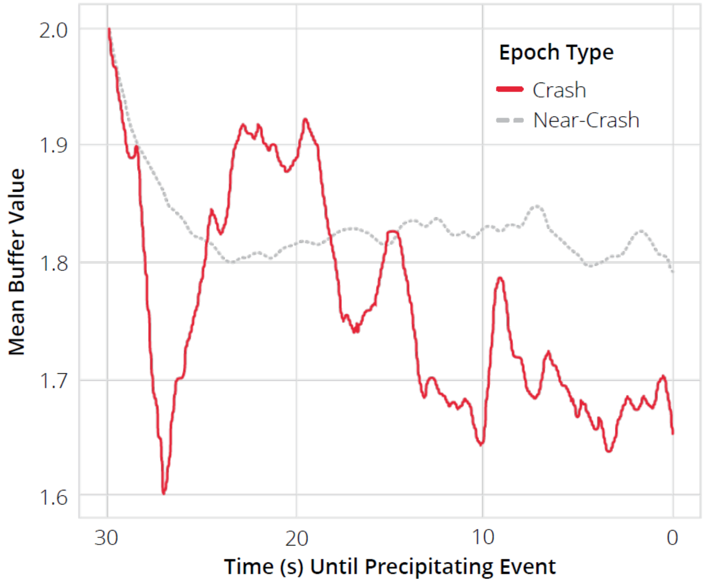
Depth of buffer reflects sampling rate required to keep vehicle in lane (every 1.8-2s; cf. Senders, 1967) – potential changes with automation etc.

Driver's focus away from road - awareness of road situation declining

Driver needed to look back at the road and attend to it in order to refresh their awareness of the road situation.

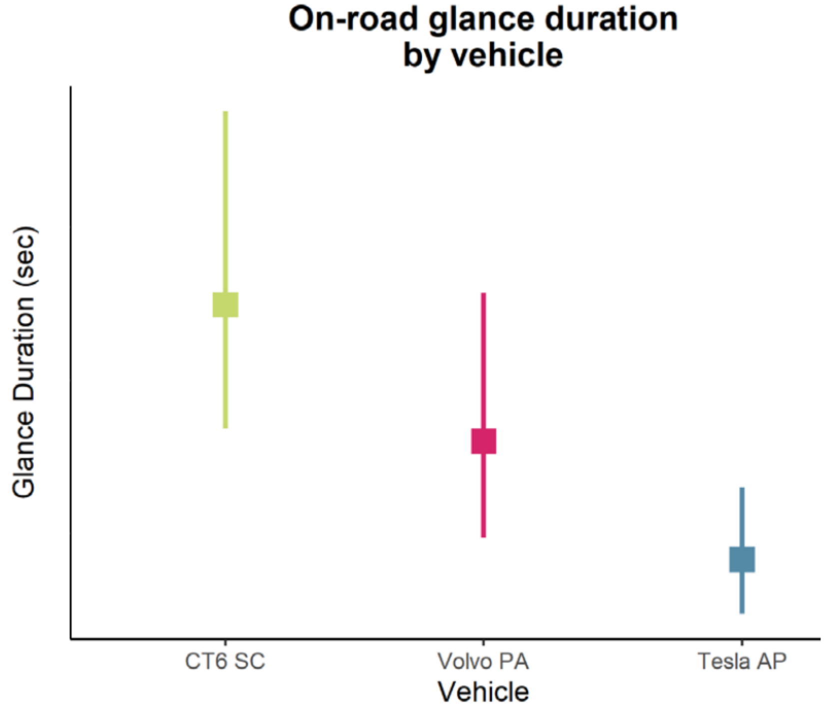
Driver Monitoring Systems(DMS) measure driver engagement to determine the ability to safely re-engage.

Driver Monitoring Systems – Measure Attention



A larger loss of situation awareness (SA) Precedes crash vs. near-crash epochs as measured by the buffer

Seppelt, B.D., Seaman, S., Lee, J., Angell, L.S., Mehler, B., Reimer, B. (2017). Glass Half-Full: Predicting Crashes From Near-Crashes in The 100-Car Data using On-Road Glance Metrics. Accident Analysis and Prevention.



Using DMS with attention buffer measurement will be required to compare the effectiveness of different technologies for keeping drivers safely engaged in driving.

Technology Adoption in Commercial Vehicle

Many Differences versus Passenger Vehicle favor CV:

1. Cost / Benefit analysis using Total Cost of Ownership (TOC)
2. Cost ratio a new technology vs. total vehicle cost
3. CV prices are not frozen
4. Technologies benefit drivers and must gain the support of drivers for adoption
5. CV owners have more ability to customize vehicle with the OEM & upfitting

Implications for Commercial Vehicles:

1. Many new technology options available for operational improvement
2. Some of these technologies are adopting faster in CV compared to Car
3. New technology must support the driver, not replace the driver
4. Evaluation is more challenging due to more options & highly integrated tech

COMMON TECHNOLOGY EVALUATION ISSUES

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1. No process
2. Reliance on OEM or supplier sales
3. Lack involvement of:
   - senior leadership
   - cross-functional team
   - end user / driver
4. “Silver Bullet” syndrome
5. Poor operational data
6. No tracking tool
7. Limited testing capabilities

Best Practices in Technology Evaluation

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- Stage Gate Process
- Organization & Roles Defined: Exec Sponsor Project Lead, X-functional team
- Meaningful operational data
- Monthly Review: Project Status, Accountability, Prioritization, Idea Tracking
- Engineering Capabilities for Prototyping and Testing
- Voice Of The Customer: Drivers
- Confirmation of Financial Impact

<u>Following a systematic process leads to</u>:

1)Effective evaluation of technology

2)Significant Operational Improvement

3)Engaged team

SEEVA

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THANK YOU

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