THE Future of Transportation

SAFETY, OPPORTUNITY, INNOVATION

A Thought Leadership Speaker Series at Volpe

U.S. Department of Transportation
Volpe, The National Transportation Systems Center

Volpe

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The Future of Transportation: Safety, Opportunity, and Innovation

Transportation connects people. We use highways, railways, airports, ports, and transit systems to get to work, school, medical appointments, and social gatherings, and to move essential goods. Safety and innovation in transportation are entwined with economic opportunity for all Americans.

The Future of Transportation, a thought leadership speaker series at Volpe, advances the conversation that began with **Beyond Traffic 2045**, Transportation Secretary Anthony Foxx's 30-year framework for the future. That framework, and Secretary Foxx's remarks at Volpe that kicked off *The Future of Transportation* in June 2016, centered on a frank assessment of challenges in the U.S. transportation system.

"We're facing a tsunami of change in transportation. We have population growth—70 million more people over the next 30 years," Secretary Foxx said. "We have changes in where those people are coalescing. Many of them are coalescing around our urban centers, many of them are moving to the south and to the west, places that historically have been more dependent upon the automobile. That [demands] tremendous rethinking of how we deliver transportation."

It's not just **population growth** that will alter transportation in America, Secretary Foxx said. **Freight dynamics** are changing. Our **bridges and roads** will need to be able to handle larger shipping containers. Infrastructure needs are also evolving due to climate change, and resiliency is now a key phrase in transportation planning. On top of this, **new technologies** are being developed at breakneck speeds.

"I'm here to frame innovation within a human context," Secretary Foxx said. "I love cool stuff, I love technology, but the message I'm trying to get across today is that it all has to be people-centered. If it's not, it could be technology for technology's sake. One fear I have over the long term is that we lose sight of what we are trying to accomplish."

While *Beyond Traffic* detailed the challenges facing transportation in the U.S., according to Secretary Foxx it also left out something big: **Opportunity gaps are widening**, and transportation professionals need to help close them. There are growing disparities in health care between the rich and poor, and in educating and housing underserved populations. The transportation community must own its role in closing opportunity gaps, Secretary Foxx said.

Take urbanization: It's not just happening in cities. It's happening in suburbs and rural areas. A solution such as adding more lane miles to improve mobility is unlikely to work in places that are urbanizing.

Take technological advances: Big leaps in transportation have historically revolved around new ways to move. From the train to the car to the airplane, new modes have revolutionized how Americans travel. But the next great leap in transportation is going to be one that creates policy and financial structures that optimize the potential of all modes, Secretary Foxx said.

"[Beyond Traffic] is essentially calling our country to start making decisions about these things so that as we integrate technology, as we build at higher levels of resiliency, as we determine how to move goods better, smarter, cheaper, as we decide how to integrate this swelling population in tighter and tighter spaces, that we're being intentional," Secretary Foxx said.

The Future of Transportation brought together leading thinkers in transportation, urban planning, technology, and government. The series addressed three main themes:

- **Safety**
  A transportation system cannot be effective if it is not safe for users and operators.
- **Opportunity**
  Transportation that provides reliable links to work, schools, and hospitals can help people climb the socioeconomic ladder—but a lack of transportation can keep people down.
- **Innovation**
  Some of the biggest leaps in automation and connectivity are happening in transportation.

Safety. Opportunity. Innovation. These are the themes sparking the future of transportation.

"If we endeavor to have a country that is connected, where everybody—no matter what zip code they come from—has a shot at the American dream, we have to come to grips with the fact that there was infrastructure built in the past that really ripped the heart out of some communities. There was infrastructure that was built to do that. As we build anew and as we repair, thinking about this now is really, really important."

–U.S. Transportation Secretary Anthony Foxx

Distinguished Experts on the Future of Transportation

Anthony Foxx
Secretary, U.S. Department of Transportation

Safety

Mark Rosekind, Ph.D.
National Highway Traffic Safety Administration

Emilio Frazzoli, Ph.D.
Massachusetts Institute of Technology

Opportunity

Edward Glaeser, Ph.D.
Harvard University

Ben Hecht
Living Cities

Jeff Risom
Gehl Studio in the U.S.

Innovation

J. Christian Gerdes, Ph.D.
U.S. Department of Transportation

Robin Chase
Veniam

Anthony Townsend, Ph.D.
New York University

Daniel Doctoroff
Sidewalk Labs

The Future of Transportation: Safety

Mark Rosekind, Ph.D.
Administrator
National Highway Traffic Safety Administration

On the Road to Zero Vehicle Fatalities

Fatal crashes are increasing, but nearly all of them are preventable. Lives lost on roads account for 95 percent of transportation fatalities, and 94 percent of crashes are due to human choice or error.

"Why it's a crisis now is because that number in 2015 went up by 7.2 percent," Rosekind said. "When you look at that as a percentage jump, that is the highest percentage increase in over 50 years, pretty much since we've been measuring this. And what's the really bad news? When we look at the six month estimate? 10.4 percent increase. It's going in the wrong direction. This represents an immediate crisis."

If a 747 jumbo jet crashed in the U.S. it would be in the national news for months. Yet in 2015, there were 35,092 lives lost on America's roads—the same as a 747 crashing every week for a whole year. The challenge is for society to say, "That is not acceptable," Rosekind said. That's why NHTSA is pursuing three programs toward reducing the number of fatal crashes in the U.S.

First, NHTSA is changing its road safety game from defense (making cars safer so people walk away from crashes) to offense (preventing crashes before they happen) with **proactive vehicle safety** efforts. If you've shopped for a car over the past 40 years, you might be familiar with NHTSA's **five-star ratings**, which provide consumers with objective assessments of a vehicle's safety performance in crashes. Now, NHTSA is considering adding evaluations of innovative crash avoidance technologies and pedestrian protections to that program, Rosekind said.

"About 96 percent of all vehicles out there now get 4 or 5 stars," Rosekind said. "So we have to get them differentiating again, set the bar higher."

NHTSA is also advocating for automatic emergency braking (AEB) technology, which can detect a

potential forward collision and apply brakes if the driver does not. In September 2015, NHTSA and the Insurance Institute for Highway Safety issued a challenge to automakers to make AEB standard in all vehicles. Twenty global automakers committed to making AEB standard by 2022, covering more than 99 percent of new vehicles, Rosekind said.

Second, it's important for transportation professionals to **improve communication** about highly automated vehicles, because vehicle automation is not a monolithic term, Rosekind said. Automation is happening in stages, and at different levels. Take level 3 automation: The driver still needs to be alert and ready to take over vehicle operation. But at the highest level, the driver could take a nap, or tackle the Sunday crossword.

"People don't really understand what's here and what's coming, and that's one of the challenges," Rosekind said. "One of the things we really need to do is start communicating and helping people understand [the different automation levels]."

NHTSA's third set of initiatives toward reducing fatal crashes involves **accounting for the human driver**.

There are a few common sense, good practice things that drivers can do to reduce road fatalities. They can drive sober, avoid distractions, and get plenty of rest before getting behind the wheel.

But there is sometimes a disconnect between what drivers know they shouldn't do and what they actually do. NHTSA's Road to Zero Coalition is focusing on proven strategies for reducing road fatalities, such as encouraging seatbelt use, installing rumble strips, launching behavior change campaigns, and conducting data-driven enforcement.

What's missing, however, is a long-term vision plan,

"If you want to democratize safety, it means you cannot have all this new technology only as an option, or only in the most expensive cars. If you want to democratize safety, it's got to be available to everybody."
-Mark Rosekind

Rosekind said. NHTSA is now working toward a 30-year plan for eliminating road fatalities.

"How do you wake up and have no lives lost on our roadways?" Rosekind said. "What would be the actions and milestones along that path to get us to zero? What's exciting is you could be relatively new to being a safety professional, and you could wake up one morning and that's the world you live in."

Plans and visions are important, but **what matters is execution**, Rosekind said. Over the last two years, NHTSA has been involved with a dozen significant road safety accomplishments. For the next dozen lifesaving initiatives, and the next dozen after that, the Road to Zero can act as an overarching, integrative concept, Rosekind said.

"I think we're looking at probably the most significant change in safety on our roadways, forever," Rosekind said. "And it's not just about the technology; it's about us acknowledging where we want to be as a society, not accepting these deaths and injuries on our roadways."

Emilio Frazzoli, Ph.D.
Professor of Aeronautics and Astronautics
Massachusetts Institute of Technology

Co-founder and Chief Technology Officer
nuTonomy

Autonomy and Shared Mobility in the Urban Environment

Traffic crashes have an economic cost of about $300 billion and societal costs of about $600 billion per year in the U.S., Frazzoli said, citing data from NHTSA. Using his own calculation, Frazzoli equated the time that Americans spend stuck in traffic to about $1.2 trillion in lost wages.

In addition to economic and societal costs, there is lost value in land that is used for parking. Most cars are used only 5 percent of the time, Frazzoli said. Cars that drive themselves don't need parking spots in prime locations, and can be used much more than 5 percent of the time. Frazzoli estimates the value of improved land use at $1.8 trillion from car sharing at a massive scale.

"We are actually paying dearly for the privilege of not using the asset that we paid for," Frazzoli said. "Clearly this is not sustainable in the long-term at the global scale."

"I firmly believe that most of us own and drive vehicles that we do not really need. I think the future is one that is based on a different model of mobility: Shared mobility, shared vehicles. This is a future that presents a huge market opportunity."

-Emilio Frazzoli

Vehicle automation is not an either-or choice, where a vehicle either has automation or does not. Automation has many flavors. There are five generally accepted levels of vehicle automation—from level 0 to level 4. Level 0 automation represents no automation at all. A Ford Model T, for example, has level 0 automation, Frazzoli said. At level 1 there is mild automation, such as anti-lock brakes and cruise control. Level 2 combines two or more automation functions, and at level 3 the car is largely in control but could still require a driver to take over.

The aerospace community has known for decades that automation does not instantly make transportation systems safer, Frazzoli said. He emphasized that automation in aviation is augmented by highly trained operators: Pilots. Compare pilot training to driver training, which might happen once in a person's life as a teenager.

Even with training, there is still a "chasm of human factors" at Levels 0 through 3, Frazzoli said. Training can reduce errors caused by the human element, but humans cannot be designed out of those levels. It's at level 4—full automation—that the societal and economic benefits of automation take shape, he said.

Frazzoli proposed a thought experiment based on computer modeling, where a fleet of 300,000 autonomous vehicles are deployed in Singapore as the only transportation option. This large-scale fleet would provide mobility to all residents, cut the number of total vehicles by 60 percent in the city-state, and free up 1.5 to 2 million parking spaces, Frazzoli said.

"There is enormous value for people who live in the city," Frazzoli said. "You can transform these spaces and give them back, and not use them to store metal and rubber, but give them back to people."

The Future of
Transportation: Opportunity

Edward Glaeser, Ph.D.
Fred and Eleanor Glimp Professor of Economics
Harvard University

Exploring the Interplay Between Cities and Transportation

Cities are built on transportation. The sites for America's older, colder cities—like New York and Boston—were attractive because they were positioned on natural harbors. As the country expanded west, canals and rail networks allowed cities like Chicago to blossom. And when the nation turned toward vehicles powered by internal combustion engines, cities like Houston grew up.

Today as much as ever, transportation is shaping America's cities.

"We're certainly in an era in which technology is changing quickly and has the capacity to change cities quickly as well," Glaeser said. "I think that could be a very good thing if it's done well, and it could be a very unwise thing if done poorly."

The urban system came about to solve a transportation problem: How to move goods and people across a vast country. In 1900, the 20 largest cities in America were located on a major waterway, Glaeser said.

"We know that in 1816, it cost about as much to ship goods 30 miles over land as it did to ship them across the entire Atlantic Ocean, which is why we've clung to our Atlantic lifeline," Glaeser said.

As America fell in love with the automobile in the 1900s, the automobile also became the means by which to ship things inexpensively. During the 1900s, the cost of moving a ton of goods one mile dropped roughly 90 percent, Glaeser said. This dramatic decline in shipping costs set the backdrop for factories and people to move from cities that had an advantage in old transportation modes—water and rail—to those constructed to move goods and people by vehicle.

"We reshaped whole cities around the car," Glaeser said. "That's how I see the great suburbanization of America: It's a moving of people to areas in which they can get around by car rather than walking."

Glaeser recounted the apocryphal story of the Croton Aqueduct, which goes like this: New York City's burgeoning population was being ravaged by disease and infant mortality, and the culprit was a lack of clean water. The Croton Aqueduct in 1842 brought fresh, clean water from Westchester County to the city and provided the stability in basic health that let New York flourish over the following decades.

The catch? Connecting to the aqueduct cost money, so for New York's poorest residents, clean water remained out of reach for years. In reality, wide-scale declines in death rates were not seen until the city mandated in the 1860s that people connect to the aqueduct system, Glaeser said.

The lesson of the Croton Aqueduct is that for a technological advance to benefit society, policies are often needed to address concurrent behavioral responses. Today's transportation equivalent to the lesson of the Croton Aqueduct has to do with vehicle miles traveled, which increases at a roughly one-to-one ratio with each highway mile built, Glaeser said.

Cities can be cauldrons of new ideas and innovation, but they do not work for everyone. There is a line that should not be crossed between polices that address established human behavioral challenges, and policies that proscribe living in suburban areas, Glaeser said. Instead, he argued that transportation policy should aim toward mobility that has room for both urban and suburban dreams.

"We should not have social engineering that acts as if the American dream can only lie behind a white picket fence in the suburbs. Smart transportation, sensible transportation, is part of realizing a more inclusive American dream that involves all types of living."

-Edward Glaeser

Ben Hecht
President and CEO
Living Cities

Rethinking How Cities Connect Residents to Opportunity

Income and wealth among middle- and low-income Americans has risen slower than it has for high-income Americans over the past 40 years. There are many reasons for widening inequality, and many strategies for closing the gap. Transportation can be either a solution to inequality or a contributing factor. Transportation infrastructure can exacerbate neighborhood divides, or it can be a catalyst for change by connecting residents to opportunity.

"Transportation may be the most important way that we're going to address disparities of income and wealth," Hecht said.

And cities are a natural place to try to reduce inequality.

"Eighty percent of our population is in cities and metros," Hecht said. "If we want to bring about change, that's an important place to focus, especially when you have innovative leaders willing to take risks."

City-centric efforts are part of what Hecht calls a *new urban practice*, which leverages public, private, philanthropic, and non-profit capital to solve local problems. Hecht outlined four ways that transportation thinkers can address inequality within a new urban practice:

- Changing how we think about **transit**
- Defining **success**
- Intentionally harnessing **technology**
- Applying **impact investing**

Many **transit** systems in American metropolitan areas were built to move people from suburban areas to a downtown urban core. That mindset needs to change, Hecht said. Transit should not simply be about moving people from one point to another. Instead, it should be thought of holistically, as one piece of a larger system—of mobility, schooling, employment, and all the things that make up our daily lives—with an ultimate goal of helping people link to opportunities.

Transportation is one sector that needs to become better at **defining project success**, Hecht said—people who are passionate about doing good work can get caught up in the work itself without realizing that they also need measureable outcomes to make decisions on future projects.

"In transportation, there are very few results on the table for anyone doing anything other than: Let's build more of it," Hecht said. "That's not a result. That's an instrument."

New technologies are changing how we move, but many technologies have cropped up with little direction from traditional transit and transportation agencies, Hecht said. Companies like Uber and Lyft have existed for years, but their regulatory and planning implications are still playing out.

Emerging investment vehicles are putting capital toward addressing transportation and other needs in low-income communities.

"A couple months ago, the MacArthur Foundation and the Chicago Community Trust announced Benefit Chicago, which has a goal of bringing $100 million of private investment to solve public problems in Chicago," Hecht said. "You will see that movement growing dramatically over the next few years."

Income inequality, particularly along racial lines, comes down to lack of access to opportunity, Hecht said. Improving access to opportunity relies, in large part, on leaders who champion the important physical connections that transportation provides.

"What I see is an extraordinary number of leaders from different sectors—public, private, philanthropic and nonprofit—who essentially say, 'I see the future and unless I lead from wherever I sit, we're not going to get there,'" Hecht said.

"How do we make sure that people have access to opportunity? That's the key. The ultimate goal of transportation isn't just to move us. It's to connect us to things we actually know we need to be connected to: To jobs, to housing, to education, to the grocery store."

-Ben Hecht

Jeff Risom
Partner and Managing Director
Gehl Studio in the U.S.

Reformulating Cities Using People-Centric Design

Living in a modern city has its perks: Bijou cafes with al fresco dining, shopping centers within walking distance of your home, green spaces where friends and neighbors meet, and even car-free zones where pedestrians rule. But these elements of urban living aren't just nice-to-haves. People-centric design can have real, positive impacts on a city's residents.

"Things like residential density, intersection density, public transport density, and number of parks, these physical elements can invite a certain type of behavior: Up to about 90 minutes more physical activity," Risom said.

People-centric design can also improve residents' socioeconomic status, Risom said.

"Where we live, the quality of those neighborhoods can increase the probability of people from lower-income groups moving up to higher-income segments throughout their life," Risom said.

To achieve people-centric design, planners need to know what residents like and don't like about their cities. But inherent in the traditional public engagement meeting is the problem that residents who go to them tend to be particularly vocal and do not represent an entire city.

"In terms of engagement, we believe the key is to go out and meet people where they are as part of their everyday routine," Risom said.

People-centric design is being achieved in cities across the country. Risom discussed two of the most prominent success stories: **Times Square** in New York and the **16th Street Mall** in Denver.

For decades **Times Square** was a misnomer: There was no square in Times Square. Nearly 90 percent of space there was used for roads, but 90 percent of users were pedestrians, Risom said. This mismatch between space and usage led New York to create a permanent pedestrian plaza in 2010.

"Times Square is actually just one of over 70 new plazas that New York City has created since 2008," Risom said. "Seventeen acres of new space following this very easy concept: When you have a traffic island, you can close a small piece of road and connect it to a sidewalk and create a new public space."

"We have to move beyond this idea of walkability, bikeability, and promoting landmarks into something that's much more about inviting for public life outcomes. It's not about just building a park—it's creating a place where people can spend time outside and build social connections. It's about bringing in many other institutions and backgrounds."

-Jeff Risom

The **16th Street Mall** is a 1.25-mile-long pedestrian, transit, and retail district in downtown Denver. From a transportation perspective it is a success, with 55,000 people taking a dedicated 16th Street Mall bus every day, Risom said. By other metrics, it has fallen behind increased demand for shared public spaces.

"There was a lot of antisocial behavior and the retail environment was underperforming, so we've been working with the city," Risom said. "Let's see what happens when we reroute the buses. Let's see if we can get a win-win situation by allowing 16th Street to serve a different function."

Over several weekend trials, Denver rerouted the buses and closed the mall to vehicle traffic. Risom and his team found that during these trial periods there was 1.5 times more commercial activity, and the number of people who felt strongly positive about the mall went up 200 percent.

From an urban design perspective, Risom said there are three big paradigm shifts happening around **climate change**, **transportation agency cooperation**, and connections to **opportunity**.

The major long-term benefit of reducing carbon emissions from transportation is quelling **climate change**. There are also numerous co-benefits related to quality of life that come with solutions that reduce climate change—like making a city attractive, stimulating business, and improving public health.

"People like the co-benefits," Risom said. "What if we gave people lots of benefits, and the co-benefit was the carbon reduction?"

Pedestrians, drivers, and bicyclists experience a street as a holistic entity. Yet a single street in the U.S. might have **numerous agencies** that can claim ownership over it. A planning department might be in

charge of a sidewalk. A transportation department might be in charge of the road. A parks department might be in charge of green space on the other side of the street.

"The street is probably our most prized public asset," Risom said. "Can streets actually be the great equalizer to address some of the issues we have in society? If so, it would demand for us to take off our different departmental heads and begin to talk about how we collaborate."

Achieving people-centric design requires big ideas from everyone. Cities that do not include a large portion of their population as constructive partners miss out on innovative ideas that can build social and economic **opportunity** for all residents, Risom said.

The Future of Transportation: Innovation

J. Christian Gerdes, Ph.D.
Chief Innovation Officer
U.S. Department of Transportation

Government at the Speed of Silicon Valley

Just as a painting is an amalgamation of brushstrokes and a digital image is a combination of pixels, big technological changes that seem to happen overnight are actually based on many small successes. Instead of focusing on an end product—such as a self-driving car—it's better to focus on prototypes that can help get the creative process started and tackle countless challenges in manageable chunks.

That is the power of prototyping, according to Gerdes.

"It's very much a Silicon Valley approach," Gerdes said. "Think about a big picture idea, use your imagination, and then try to develop a quick prototype that gets you closer, that allows you to learn."

There are good and intentional reasons why government entities do not move as quickly as Silicon Valley when it comes to creating new technologies, Gerdes said. Some of those reasons have to do with how government entities are set up, particularly at the federal level. There are divided branches to make sure that power isn't too concentrated. There are rules that govern job categories, so no agency becomes overly reliant on one employee or leader.

But government can suffer from lack of trust from the public, and people want more rules when they don't trust the government, Gerdes said. More rules can make it difficult for people working in government to be flexible and creative.

"The question is, can we find a way of spiraling out?" he said. "Can we harness some of these same [Silicon Valley] techniques? In fact, the government has done this in the past extraordinarily well."

The moon landing was an iconic milestone in American history. An estimated 530 million people were watching in 1969 when Neil Armstrong stepped out of Apollo 11 and became the first lunarian. The moon landing was also a paradigm of prototyping. While the term "moonshot" has come to mean an extraordinary, seemingly impossible feat—exactly how the moon landing may have felt for those watching at home—that definition misses some important context, Gerdes said.

"For those of you who are fans of The Princess Bride, [moonshot] brings to mind the words of Inigo Montoya: 'You keep using that word. I do not think it means what you think it means,'" Gerdes said.

The moon landing—the moonshot itself—was not, in fact, a singular event, but was built upon committed stakeholder engagement through a lengthy process of successes and failures.

Dreaming big is the first step. Being realistic about getting there comes next.

A fully automated road future where crashes are rare might look something like this: Vehicles that drive themselves share information with each other and with bicyclists, pedestrians, and infrastructure.

"There's a temptation to say, 'Well that looks too hard,'" Gerdes said. "So, how do you get people to move toward that big picture dream? Again, it's through prototyping."

There are several real-world prototypes now underway related to automated vehicles, and U.S. DOT is working collaboratively with partners in government, academia, and the private sector.

These prototypes began with the Connected Vehicle Safety Pilot Model Deployment conducted by the University of Michigan—conceived and funded by U.S. DOT—which allowed drivers to test nearly 3,000 connected vehicles in Ann Arbor from August 2012 to August 2013.

"What could we do if all vehicles could communicate with each other? That's a big-picture dream, and getting every vehicle on the road to communicate with every other vehicle and every pedestrian is a huge challenge. There's a temptation in light of those challenges to say, 'Well, that looks too hard.' So how do you get people to understand this concept? How do you get to move towards that? It's through prototyping."

-J. Christian Gerdes

The success of that pilot led to three more pilots announced in 2015, with up to $42 million in funding from U.S. DOT:

- New York City is installing vehicle-to-vehicle (V2V) communications technology in 10,000 city-owned vehicles. This pilot will focus on improving traffic signaling and intersection safety.
- In Tampa, pedestrians who are pilot participants are having their smartphones equipped with technology that connects them to vehicles, with a focus on safety and alleviating congestion.
- In Wyoming, V2V and vehicle-to-infrastructure technology is being used to decrease weather-related crashes and improve the movement of the more than 11,000 heavy-duty trucks that haul freight every day through the Interstate 80 east-west corridor.

These and subsequent prototypes from U.S. DOT may, in fact, lead to a future where automated vehicles can be summoned with a smartphone, Gerdes said. But not having a smartphone shouldn't mean you lose out on access to opportunity.

That's part of the reason Columbus, Ohio, was chosen as U.S. DOT's first **Smart City Challenge** winner and awarded $40 million—because Columbus targeted transportation improvements for the underserved who may not have access to the latest technology.

Part of Columbus' winning package included a strategy to improve health care access in a neighborhood where infant mortality is four times the rate of the national average, by providing patients with a transportation plan at the same time that a medical appointment is made.

"[Columbus is] a prototype that can be demonstrated and hopefully rolled out as a model," Gerdes said. "That was really the idea behind the Smart Cities Challenge, which in many ways was a prototype in and of itself: Going out to cities and saying, give us your vision of what you could be as a smart city."

Robin Chase
Co-founder and Executive Chairman
Veniam

Co-founder and former CEO
Zipcar

Automated Vehicles Are Here

No longer the stuff of science fiction, cars and trucks that drive themselves are nearly a reality, according to Chase.

"Someone said to me, 'So [are automated vehicles] five years away? Everything is five years away,'" Chase said. "Not only is it not five years away, it's three-and-half years away—three years away."

There are two futures for tomorrow's automated vehicle revolution, Chase said. One future is what she calls "hell," where automated vehicles are a nearly one-to-one replacement for current personal vehicles. The other future is "heaven," where shared vehicles are the norm.

"We have autonomous vehicles that we are going to swap out for our internal combustion engines," Chase said. "They may be electric, it's not guaranteed. Or they can be something I'm calling FAVES: Fleets of Autonomous Vehicles that are Electric and Shared. This is really a huge choice."

In the "hell" scenario, automated vehicle owners go to work or to the store and their vehicles drive around until needed, or they drive home. Businesses, too, may replace traditional storefronts with automated vehicles that go where customers are. Taxi drivers and truckers may lose their jobs, and more vehicles driving rather than in parking spaces means more wear and tear on roads and bridges.

In the "heaven" scenario, transportation agencies and professionals take a proactive approach, Chase said. The FAVES concept combines car sharing and ride hailing using mobile devices or computers, with these net benefits:

- Car sharing eliminates the need for parking.
- Ride sharing reduces congestion.
- Individuals save thousands of dollars per year by not owning a personal vehicle.
- Only 10 percent of cars currently in cities would be needed.

Despite potential benefits, there would still be major challenges related to loss of employment in industries that depend on cars with human drivers, Chase said.

"No matter what people say, economics leads them," Chase said. "If they can get someplace for cheaper and the quality is still there, they will go for the cheaper path."

The five-years-or-less path to autonomous vehicles could look something like this, according to Chase: A pilot project with a 100-vehicle fleet of FAVES begins in a major city. It's mostly used by students, tourists, and people who work nights.

Between years two and five, the pilot expands to 1,000 vehicles. More people have a reason to try it out—maybe their second car breaks down. They'll find the shared autonomous vehicle system works, and works well. The next time they have to make a major financial decision, such as buying a new car, they may opt instead to rely solely on cheaper, reliable FAVES, Chase said.

"That's why I think it will be a very fast transition," Chase said. "Within five years, people will be able to reflect, 'What the heck? Why am I owning a second car? And why am I owning a first car?'"

"What do the upstarts say? Elon Musk: In 7 to 8 years, 50 percent of the cars sold will be autonomous. John Zimmer: By 2025, private car ownership will all but end in major U.S. cities. And I would say I'm in that camp. This is not a side project, this is existential for us. Which is just to say it really truly is happening now and the transition in major metro areas I think is going to be really, really fast."
-Robin Chase

Anthony Townsend, Ph.D.
Senior Research Scientist
New York University Rudin Center

The Emerging Policy Landscape for Autonomous Vehicles and Cities

Cities and automation go hand-in-hand, Townsend said. With vehicle automation, cities are safer, more efficient, and more connected. But automated vehicle technology has caught many cities by surprise, and urban policy has not kept up, he said.

"What we're confronting ahead is this 20-year period of automation," Townsend said. "It's primarily about reinventing the automobile. It's involving a massive amount of private investment and I don't think we really have an urban lens yet."

Townsend proposed a policy framework that promotes accessibility and allows cities to confront challenges related to automated vehicles. An ideal policy framework for cities preparing to manage an influx of automated vehicles would address safety, economics, and land use, Townsend said.

Safety is the top governmental and industry priority, Townsend said. If the technology is not safe, the conversation around automated vehicle policy can't happen.

Loss of ridership and revenue for transit agencies and a decrease in employment for workers in vehicle-related industries could happen concurrently, Townsend said.

Austin Brown, Ph.D. (left), Assistant Director for Clean Energy and Transportation at the Office of Science and Technology Policy in the Executive Office of the President, facilitated a panel discussion on urban mobility with Chase and Townsend.

Leaders in cities will also need to rethink how they repurpose land currently used for vehicle infrastructure. How cities use their physical space is among the most important open questions related to vehicle automation and solutions to this question will take the most time to develop, Townsend said.

"It's useful to think from point of view of the user," he said. "This is about providing accessibility and getting people where they need to go. It's not about transportation."

"What we're confronting ahead is this 20-year period of automation. It's primarily about reinventing the automobile. It's involving a massive amount of private investment, and I don't think we really have an urban lens yet. I think it's key to understand there's nothing inevitable about the direction this goes. It's really up to us to design the outcome and to influence that through policy."

-Anthony Townsend

Daniel Doctoroff
Chairman and CEO
Sidewalk Labs

Reimagining Transportation from the Internet Up

The biggest revolutions over the past two centuries in urban environments have happened where technology and city life meet, according to Doctoroff.

"For better or worse: The steam engine, the electric grid, and the automobile," Doctoroff said. "Now, I believe, we are on the verge of what I like to call the fourth technological revolution in cities."

That revolution is part and parcel of the digital age—and it's happening where vehicle automation and the Internet converge on city streetscapes. Cities and citizens are still determining how this revolution will play out and change urban life.

Imagine a city that is ubiquitously connected to the Internet, Doctoroff said. The Internet is the starting point for technological change in this city. The city itself becomes a platform to gather a wealth of intelligence. Data is harnessed to improve urban life, with infrastructure and policy decisions guided by previously unseen amounts of information on road quality, cycling patterns, emissions, and more.

Cities that provide transportation access that is harmonious and multimodal—and not dominated by automated vehicles—will be built upon **four pillars**, Doctoroff said.

The **first** pillar is **personalized transportation**. In a city built from the Internet up, citizens enter a destination into a smartphone app and then find, reserve, and pay for a parking spot—all before leaving the house. There's no circling for parking, and there is less congestion and pollution. Travelers might also find cheaper or faster options by virtually hailing a taxi or taking public transportation.

"That means cleaner, more equitable cities," Doctoroff said. "The result is a much more personalized mobility experience."

The **second** pillar is adaptability. With real-time data collected through smartphones or other technology, transit systems are reconfigured based on precise pictures of fluctuating travel demand.

"That doesn't mean cities would magically have the money to run buses everywhere," Doctoroff said.

"But you would know with much more certainty whether or not you were meeting the challenge of transport equity and be able to deploy bus service as efficiently as possible to meet local goals."

The **third** pillar is about new, granular data providing better performance measures. Today, cities measure transit quality by how often a vehicle operates, and how far citizens are from transit stops. But there is little data on whether people get to their destinations on time, or the percentage of jobs accessible by transit, Doctoroff said.

The **fourth** pillar is about improving transparency and accountability. Traffic laws can be enforced with objectivity. Toll booths become completely wireless, and people operating toll booths are transitioned to more critical jobs such as security, Doctoroff said. As the urban environment becomes more instrumented, protecting privacy also becomes more paramount.

"The future is not just for technologists to reimagine, because imagination on its own doesn't change the world," Doctoroff said. "It's the policy makers who can bring these ideas from the digital cloud to the actual curb that will determine what shape our future cities ultimately take."
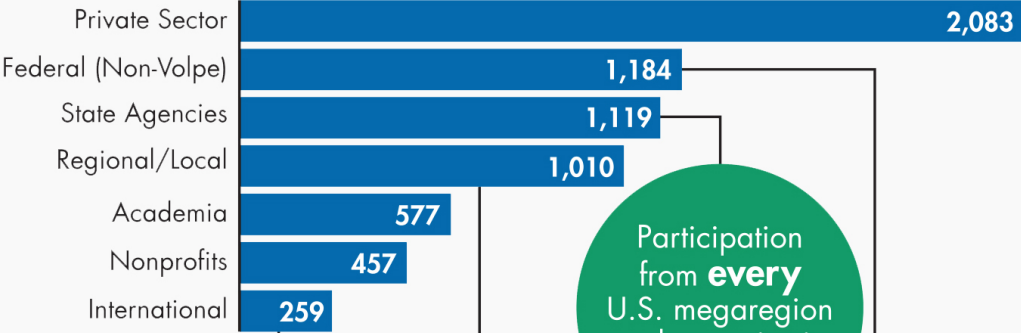
"When you imagine a city from the Internet up, you get a place that is personalized for our needs and desires. A place that is adaptable, constantly evolving with changing demands, technologies, and tastes. A place that feels like a city, but functions like a community."

-Daniel Doctoroff

How Volpe's Thought Leadership Engages Stakeholders

The Future of Transportation: Safety, Opportunity, and Innovation built on the themes of innovation, safety and mobility, socioeconomic opportunity, and sustainability discussed during our 2015 speaker series, **Beyond Traffic 2045: Reimagining Transportation** and our 2014 series, **Transportation and the Economy**. Volpe's speaker series engage a range of stakeholders in government, academia, and non-profit organizations in dialogues that shape tomorrow's visions of transportation in the U.S. and globally. In addition to **2,100 seats filled** and standing-room only guests there were more than **7,800 online registrations** across these three series.

Stakeholder participation in Volpe's *Future of Transportation, Reimagining Transportation,* and *Transportation and the Economy* series.

Over **7,800** registrations, and **2,100** seats filled.

Private Sector	2,083
Federal (Non-Volpe)	1,184
State Agencies	1,119
Regional/Local	1,010
Academia	577
Nonprofits	457
International	259

Participation from **every** U.S. megaregion and agencies in all **50** states.

Over **400** local and regional government agencies represented.

Stakeholders from **24 countries** linked in from Europe, South America, the Middle East, and East Asia.

In addition to extensive participation from all U.S. DOT modal administrations, over **45 federal agencies** joined the conversation.

For More Information

For more information on Volpe's thought leadership programs, please contact:

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Visit our *Future of Transportation* **series page** for feature stories, video highlights, and speaker bios.

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