Routes to the Future

Volume 1:
How We’ll Get Around
Welcome to the first installment of Routes to the Future

With the help of researchers at The Institute for the Future, we created the Routes to the Future series to raise awareness of the key trends that will affect many businesses over the next decade. In this series, we’ll discuss the trends and disruptive forces that could change everything – from how we live, work and travel, to the futuristic ways we make and trade things.

This first installment, How We’ll Get Around, looks at the dramatic changes we see in transportation over the coming decade. Density – not distance – is the new challenge. Getting around in a world of density is all about intelligence.

At UPS, we’re already planning for this future. We operate one of the largest alternative-fuel and alternative-technology fleets in the world – a “rolling laboratory” of vehicles running on everything from electricity to renewable natural gas made from chicken waste. And we’ve partnered with the American Red Cross, Gavi and other groups in studies on the use of drones for humanitarian aid and disaster relief operations.

Some might worry that a future filled with driverless cars, drones and robots leaves no place for humans, but I think those fears are misguided. Whatever business you’re in, there will always be the need for the human touch – and that will certainly be the case at UPS. No matter how we make deliveries in coming decades, I believe there will always be a role for UPS service providers, who solve customer problems in ways that a drone or driverless car never can.

We hope this report sparks a conversation within many organizations on what they must do to rise to the challenges and opportunities of the coming decade. If there are opportunities for UPS to be part of these conversations, we’ll bring our whiteboard.
Chapter 1: Self-managing vehicles drive new services
We’re about to enter the era of the driverless car.

We’re about to enter the era of the driverless car. You’ll continue to drive but – slowly, gradually, over the coming decade – your car will take over. It will make decisions about parking, about braking when you’re too close to the car in front, or when you’re too tired to drive. None of this will happen overnight, but in these four phases:

**Phase I.**
We’re already in the first phase of “passive” autonomous driving. Many new cars now come equipped with sensors and advanced electronics that give drivers audible warnings when they’re crossing lanes or following too closely.

**Phase II.**
Phase two – limited driver substitution – has just begun and will run probably through 2018. Over the next few years, the driver remains the primary operator – but limited functions such as enhanced cruise control and self-parking will be handled by the car’s computer.

**Phase III.**
From 2018 to 2022, we’ll experience the third phase: complete autonomous capability. During this period, new cars will accelerate, brake and steer themselves – but drivers will still take over in the event of an emergency or system failure.

**Phase IV.**
The fourth phase will kick in around 2024, with all new cars sold in the second half of the decade incorporating full autonomous capabilities that can function without any human intervention – or without a passenger in the vehicle. By 2030, expect that 25 percent of all vehicles on the road will be fully autonomous.
As autonomous technology becomes more engrained, we’ll see many ripple effects – affecting everything from transportation policy to urban planning to logistics. New business services – and business sectors – will emerge, while some established companies will see their business model come under pressure.

**Render the Fender Bender Obsolete**

The biggest benefit is that driving will gradually become much safer as human error is reduced. KPMG, the audit and professional services firm, estimates that the adoption of self-driving cars could eventually reduce accidents by 80 percent in coming decades, to just one accident for every 1.6 million miles driven by 2040. Add in the potential savings in fuel as cars collectively navigate cities more efficiently, and the economic benefits to society could be huge: Morgan Stanley estimates the U.S. alone could generate $1.3 trillion in annual economic benefits from fuel savings, productivity gains and a drop in accident-related costs.

Look further down the road, and by 2030 or 2040 accidents may become so rare that stand-alone car insurance could become a thing of the past. Auto coverage would simply become a rider on your homeowners’ policy.

Vehicles of the future will be autonomous, modular and use alternative fuels and advanced analytics.

A sharp reduction in accidents also means that cars could become lighter – and cheaper. No longer will safety-conscious mothers feel compelled to drive 5,600-pound SUVs to ferry around their children.

As self-driving cars become cheaper to build – and then to operate – we’ll see new alliances formed between the traditional automakers, the tech companies in Silicon Valley who understand software interfaces, and the ride-sharing services that are eager to deploy fleets of autonomous robo-taxis. Separate studies by the Organisation for Economic Co-operation and Development and the University of Utah each concluded using autonomous vehicles as a taxi system could reduce fleet sizes by a factor of 10.

**The Rise of the Robo-Taxi**

If the fares for any future fleets of urban taxis became cheap enough, city dwellers might choose to no longer own their own automobile – and treat car travel as a cheap utility they rent by the trip. If that sounds like bad news for car makers, fear not. Yes, moving from a culture of car ownership to a new era where we hop aboard urban taxis could mean there are fewer vehicles in circulation. But if the future is filled with robo-taxis being driven around the clock, they’ll need to be replaced more frequently. While Americans today hang on to their car for an average 11.4 years on average, robo-taxis will need to be replaced every three years.

Heavy truck manufacturers are testing autonomous capabilities into their rigs as well. One day, an autonomous truck will drive itself from Brussels to Amsterdam and, as it approaches its destination, pull into a truck stop where a human takes over and drives the final few miles into the city.

**Jet-like Commute**

skyTran is a high-speed elevated Personal Rapid Transportation (PRT) system that uses computer-controlled, levitating, 2-person “jet-like” vehicles that use skyTran Mag-Lev technology to move passengers in a fast, safe, green and economical manner. skyTran, a NASA Space Act company, will transport passengers above the surface traffic, and could revolutionize urban and suburban commuting.

Image credit: http://www.skytran.com/images/
No Stop Signs, No Stop Lights

By 2026, when more than 90 percent of new vehicles are fully autonomous, they’ll be able to park themselves. No longer will sports and music fans pay $20 to park in a lot next to the sporting event or concert – or commuters pay $8 to park in their office garage.

In the future, their car will drop them off at their destination and proceed to a cheaper auto-pay lot five miles away. When the game, concert or workday is over, the car will be waiting again for its owner outside the venue. And if the car was programmed to operate as a robo-taxi during the interim, the owner could even turn a profit on the vehicle.

A new era of autonomous vehicles will also bring about many changes in public policy, particularly in land policy. Given the historical inefficiencies in human-piloted driving – cars can’t follow too closely, and drivers waste time and fuel looking for a parking space – some urban experts believe that roads, parking lots and garages today make up 30 percent of urban space in cities like Los Angeles.

But as cars become more efficient – imagine a caravan of self-driven cars all following within a few feet of each other, limiting fender-benders – new freeways will require less space. Instead of eight lanes, traffic can fit into six lanes and, as the technology improves, eventually three. One-way streets become ubiquitous, while stop lights and stop signs become a thing of the past, as autonomous vehicles collectively decide to obey the algorithms managing traffic flow at every intersection.

Speed Limit 150. Strictly Enforced

If autonomous vehicles can receive wireless signals from parking lot owners of available spaces, the amount of land devoted to garages and surface lots shrinks as well. Parking decks could be built more efficiently: if cars can park and retrieve themselves, parking spaces would only need to be the width of the car. And high-rise garages could be built with each level constructed just a few inches taller than the height of most cars.

As self-driving cars become more ubiquitous, this trend will spark a number of policy questions: For starters, transportation officials will debate whether to raise speed limits – and how high. Imagine special express lanes or toll roads for autonomous vehicles that are allowed to travel at 85, 100 or – in remote areas – 120 miles per hour.

If that happens, we could see a reversal of the urban migration that’s prompted many frustrated commuters to move in-town. If you could drive at 100 mph – and with minimal delays – the notion of commuting from Rhode Island to Manhattan suddenly isn’t so far-fetched.

On the other hand, a world without stop signs, speed limits and on-street parking could wreak havoc on the budgets of local governments, which rely on the income from speeding tickets and parking fines.

If there’s a silver lining, it’s that any revenue losses here could be partially offset by reductions in municipal spending to widen roads and maintain traffic lights and signs.

The Persuasive Electric Vehicle (PEV)

The PEV is an electric, autonomous, shared-use, low-cost vehicle that moves both people and goods. Designed by MIT and Denso, the vehicle is intended to give a glimpse into fully autonomous vehicles in urban environments. It features an electric powertrain, autonomous drive and the ability to be shared. It is legal in bike lanes, and is designed for driverless pick-up and drop-off of passengers, and the autonomous delivery of packages in central cities.

Image credit: Michael Lin, PhD Candidate, Changing Places Group, MIT Media Lab and Kent Larson, Director, Changing Places Group, MIT Media Lab
Will Driverless Cars Play God?
But the biggest issues that autonomous vehicle makers could face may not be technical so much as ethical. Consider a scenario where an autonomous vehicle suffers brake failure as it approaches an intersection where several individuals are crossing – and a collision is inevitable. If two of the pedestrians were elderly and the others were a mother and her child, could the car’s on-board software system be programmed to determine which pedestrians bore the brunt of the collision? Also, would it matter if one group was crossing legally – and the other wasn’t?

An API with Wheels
So here’s how to think about the future of driverless cars. They’re not just about getting around any more than a smartphone is just about making calls. They will create a new ecosystem of activities and services that change the way we live our urban lives. They will offer up solutions to long-standing problems that plague today’s cities and challenge us to consider a host of new societal, technological and ethical questions.

And whether we own them or not, autonomous vehicles will become a new application programming interface – an API on top of which all kinds of businesses will build new futures for themselves.

No longer will sports and music fans pay $20 to park in a lot next to the sporting event or concert – or commuters pay $8 to park in their office garage.
Self-Managing Vehicles

**NAVYA ARMA**
Navya’s autonomous mini-bus, the ARMA, is designed to navigate defined routes on private sites such as airports and theme parks as public roads, allowing passengers to hop on and off at designated stops.

> Click on image or here to play Arma video

**The Self-Driving Car**
Almost from the dawn of the automobile, man has dreamed of the day when cars would drive themselves. In 1925, the Linriccan Wonder was the first car that moved safely through traffic in midtown Manhattan via remote control. In the 1960s, GM showcased the Firebird IV, a concept car with an “electronic guide system that can rush it over an automatic highway while the driver relaxes”. Volvo’s futuristic Concept 26 car comes with a retractable steering wheel. When the driver wants to relax, the seat reclines and a large display emerges, allowing the driver to enjoy the entertainment option of their choice.

> Click on image or here to play the Volvo Concept 26 video

**NEXT Pods**
And Italian engineer Tommaso Gecchelin’s futuristic NEXT pods could change the face of mass transit. Imagine a Next pod (bottom left) picking you and your neighbors up and then affixing itself to other pods, traveling hands free down freeway express lanes. As modules coupled, passengers are redistributed to optimize available space, cutting energy consumption and traffic congestion.

> Click on image or here to play Next pods video

**Ropits**
In 2013, Hitachi unveiled the Ropits (bottom right), a single-seat robot vehicle that can pick up and drop off passengers autonomously. Designed with the elderly and handicapped in mind, Ropits travel at 7 mph (11 km/hr) on sidewalks and can even be used indoors for getting in and out of elevators.

Images courtesy of: Navya, Volvo Cars, NEXT Future Transportation, Hitachi
What’s Driving Self-managing Vehicles?

**Driverless Vehicle Technology**
Though driverless vehicles have been a staple of science fiction for decades, the technology for turning that fiction into reality appears to be at hand. Google has been test-driving its own driverless vehicle since 2009, and Tesla founder Elon Musk says his firm could put a driverless vehicle on highways today. The big technology question is whether it’s necessary to build out a complex vehicular communication infrastructure or whether independent, on-board sensors and massive data processing are sufficient for safe navigation. The main barriers, though, are regulatory: Transportation agencies will ultimately need to approve the cars, and new statutes will be necessary. In the United States, watch for California, Nevada, Michigan and Florida to lead the way.

**Urban Congestion**
As the number and size of cities increases, the number of hours spent in traffic congestion and the cost of that congestion in fuel and time will continue to grow. Many cities around the world already experience gridlock conditions daily, and these will only escalate over the next decade. However, studies by the Organisation for Economic Co-operation and Development and the University of Utah each indicate that autonomous vehicles, functioning as a taxi system, could reduce the necessary vehicle fleet by a factor of 10. A Morgan Stanley report puts savings at $1.3 trillion in fuel consumption, crash costs and productivity gains.

**Changing Lifestyles**
Two demographic bulges are converging to support a future of autonomous vehicles. Baby boomers are entering the age at which driving becomes unattractive – and unsafe. Many are looking forward to driverless cars as a way to keep their independence. At the same time, millennials (those between 16 and 34) are moving to urban centers and spending less on cars: In 2010, they bought just 27 percent of all new vehicles on the road, down from the peak of 38 percent for the age group in 1985.

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**Average Annual Commuter Delay***

<table>
<thead>
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<th>Year</th>
<th>2010</th>
<th>2020</th>
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<tbody>
<tr>
<td>Hours</td>
<td>34</td>
<td>47</td>
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*Delay is defined as extra time it takes a commuter to get to and from work during rush hour in comparison to overnight speeds used to identify free-flow traffic volume.

**Annual Cost of Congestion in the U.S.**
Measured in real dollars through the comparison of rush hour to free-flow traffic volume.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost</th>
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<tbody>
<tr>
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<tr>
<td>2010</td>
<td>$149B</td>
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<tr>
<td>2020</td>
<td>$192B</td>
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Source: Texas Transportation Institute, 2011
Head-Up Display

Head-up display technology has been around since the 1980s, but only in recent years have cars offered the ability to project lane-changing and other navigational information into the driver's field of vision. In coming years, these displays will be far richer, showing the ideal driving lines, acceleration or braking points. In time, vehicles such as BMW's Vision Next 100 concept car will assume the role of a personal tour guide – providing augmented information on places of interest along your route. Every journey becomes an enriched experience where you can sit back and learn more about the places you travel past.

> Click on image or here to play video
How Analytics Will Drive the Logistics of the Future

Jack Levis
Senior Director of Process Management, UPS

Today, companies mostly use data to explain what has already happened, a practice known as descriptive analytics. The more advanced companies turn to analytics to predict what might happen next. But just 3 percent of firms deploy prescriptive analytics, which goes beyond prediction and determines the optimal action to take.

Increasingly, businesses will use analytics. We’ll see them use analytics to diagnose - and solve - problems well before they even realize an issue exists. Imagine that.

Overall, data is expected to grow 50 times by the year 2020. The question is how companies will turn that data into insights to make better decisions. In the world of logistics, analytics will help us get packages to your doorstep faster and in a more personalized manner than ever before.

We’ve already seen the transformative power of analytics investments: I was part of a team that designed ORION, a proprietary routing software that helps UPS drivers select the most efficient delivery route.

ORION looks at all the things a delivery driver needs to do: the stops that day, required service times, even less-obvious issues like lunchtime. No matter how outwardly counterintuitive at times, ORION spits out the ideal plan for a driver to follow.

But for problem-solving purposes, even this level of technology is incomplete. We need to move from wisdom to clairvoyance. I’m talking about foresight that would make Sherlock Holmes jealous. By combining the power of predictive and prescriptive analytics in real time, systems will look clairvoyant to the user. That is the Holy Grail.

We’ll soon see systems so advanced they won’t wait for traffic issues before reacting. They’ll predict when and where gridlock will occur and communicate to smart vehicles, re-routing drivers as needed. Everyone’s commute improves.

Analytics will enhance the entire transportation network, rather than just improve an isolated step in the supply chain. This is transaction-by-transaction optimization. For example, we’ll crunch the numbers to determine the specific trailer that can best transport an individual package to its next destination. We would know the exact time a trailer should move, how far it should go, the specific moment it should stop and whether a package should go somewhere else.
But imagine a system in which we can predict, with near certainty, the fastest way to move any parcel between different modes of transportation – and in real time. The data would even tell us who should drive the delivery vehicle. A completely optimized network provides unlimited ways to get anything to any destination, making the supply chain more flexible. In the process, we would eliminate chronic inventory problems by ensuring supply never outpaces demand.

Analytics also will revolutionize how logistics companies manage their fleets, providing the equivalent of a check-engine light on steroids. Say you’ve ordered 1,000 alternators for delivery trucks. Big data will tell you exactly when the parts begin to deteriorate.

People always ask me about the next algorithm. I tell them that we have to get the data right first and make maps even more accurate. These maps will include not just a street address but the exact location of your mailbox – and better yet, the distance between various mailboxes. Coupled with every bit of available information about the weather and traffic patterns, logisticians will do more than predict the most efficient route for delivery. They’ll know when and where to send trucks – and why they’re doing it.

This will become reality at some point in the next 10 years. The logistics of the future will tap into human resourcefulness and with an assist from analytics, help us find solutions not yet imagined. Once we gather the data, innovation will follow.

**Analytics also will revolutionize how logistics companies manage their fleets, providing the equivalent of a check-engine light on steroids.**

No More Gridlock
Traffic intersections are the source of most accidents, with two-thirds of all wrecks occurring at intersections. Nearly all involve left-hand turns and human error, as drivers can’t predict who has the right-of-way or whether an oncoming driver will try to beat a red light. That’s also why UPS’s routing software, ORION, is programmed to map out each UPS driver’s routes so they don’t have to make any left-hand turns.

In the future, cars won’t have to navigate traffic lights – because traffic lights and stop signs will be a thing of the past. Autonomous vehicles will breeze through intersections by communicating and remaining a safe distance from each other. Even allowing for pedestrians and bicyclists, traffic will move twice as efficiently than today’s state-of-the-art traffic lights. Gridlock will vanish, and travel will be cut to almost zero.

Researchers at the Swiss Institute of Technology, the Italian National Research Council and MIT have developed a slot-based approach that borrows from the same “sloting” that air traffic controllers use to synchronize take offs and landings. The one difference is that researchers determined that traffic would flow faster if vehicles crossed intersections in groups, rather than one-by-one. So the cars in front slow down, those in back speed up – and they all clear the intersection faster.

> Click on image or here to play video
Chapter 2: Vehicles get modular
The Fine Art of Shape-Shifting

As vehicles turn into platforms for all kinds of services, they’ll learn the fine art of shape-shifting. Taking a page from the Transformer playbook, they’ll swap out passenger seats for cargo containers and a short chassis for a longer one. They also can add general-purpose trunk space for dedicated application containers – so they can interface with automated laundry services, produce markets and other platform-driven services.

The Mix and Match Car

In dense urban districts, the multi-car family may well fade into the past. Families, as well as businesses who operate fleets of service vehicles, may determine that one vehicle may serve many purposes – and modules will make it easy for one vehicle system to meet a multitude of changing mobility needs.

For example, suppose you occupy a condominium 10 years from now. The first floor is all garage, but that garage isn’t filled with the requisite sedan and SUV. Instead, half of it is devoted to your home 3D-printing operation.

This is where you run a small florist shop. Requests come in. You 3D print a custom flower pot and load the arrangement into a container module. When your car gets back from picking up the kids at a soccer game, you snap the passenger module off and snap the container module on. Then you send the car out to deliver the flowers. As you blur the lines between domestic life and commercial enterprise in your daily activities, you depend on a vehicle system that can be many different things in a small space.

Of course, buying such a car is quite unlike today’s car-hunting exercise. Every car system is entirely configurable – you will be able to choose the number and size of passenger modules and container modules, the appropriate energy system, the chassis and the transformer gear for snapping modules together. You become your own automotive engineer, designing the system that meets your needs – and ordering the components from multiple distributors to get the exact set of modules you want. Maybe you even mix and match brands for different components, plugging a Tesla battery module into a GM system or swapping a Toyota onboard computer for an Apple model.

Buying Mobility by the Minute

Of course, with cars or trucks that can get from here to there by themselves, we denizens of the city may invest less in owning individual cars and more in the services they provide. The smart vehicle of the future quite literally becomes a “service” in this scenario, showing up as a refrigerated van one day and a limousine the next. Service providers manage entire fleets, and mix-and-match modules give them the flexibility to optimize those fleets for the logistics of the day. Meanwhile, as a customer, you pay a monthly fee only for the services used, up to a maximum number of “road minutes.”

Whether we own our modular vehicle systems or subscribe to their services, the advantages of open architectures and APIs will likely prove irresistible. Just as these basic strategies support a thriving mobile device economy, they’ll also deconstruct today’s automobile or truck into tomorrow’s platform for modular innovation.

The smart vehicle of the future becomes a “service,” showing up as a refrigerated van one day, and a limousine the next.
A Vehicle for Every Need

Designed by French company Fritsch Durisotti, Soon car’s modularity allows a single vehicle to accomplish multiple tasks. Different components can be combined to create a vehicle based on various needs, i.e. moving, transporting goods. Add-on containers could also be rented for certain situations. Unlike a traditional car salesman, the Soon dealer would be an assembler of components whose goal is to fit every customer’s needs.

The Soon car is a modular concept vehicle that allows a single chassis to be fitted with cargo space or passenger space in different configurations.
What’s Driving Modularity?

Military and Manufacturing Innovation
Although modular vehicles for the consumer market are still in the concept stage, leading-edge development in both the military market and basic automobile manufacturing may lay the tracks for cars and trucks with swappable components. Lockheed Martin’s Havoc armored modular vehicle can swap out a variety of its components for different missions. On the factory floor, Volkswagen is using its Modular Toolkit Strategy to standardize components of diverse brands and models to produce them more efficiently. Such modular production could eventually enable modular consumer choices.

New Automobile Materials
Driven by demands for fuel efficiency, automobile manufacturers are aggressively seeking more lightweight and flexible materials for vehicles. High-end luxury vehicles increasingly include lightweight materials such as aluminum and carbon fiber in their mix. The National Center for Manufacturing Sciences has launched a Lightweight Automotive Materials Program to develop tools for modeling and digitally testing new materials and designs. Such efforts will be critical to make modular concept cars and trucks commercially viable.

The Domestic-Commercial Blur
In the U.S. and most industrialized economies, a growing “maker movement,” combined with small-scale fabrication technologies like 3D printing, is bringing production back into garages and home workshops.

Home offices are now standard features of many homes as the freelance workforce grows. Sharing exchanges like Etsy and eBay support a robust economy of home marketers, while the new “maker studios” give garage inventors access to 3D printers and other tools that enable them to build new products in a collaborative environment. The result is a growing blur between domestic and commercial activities, which in turn creates demand for new kinds of pick-up and delivery for everything from artisan foods and furniture to 3D-printing supplies.
Chapter 3: Batteries re-invent the electric grid
Blurring the boundaries of transportation and energy

In the coming decade, cars may not only provide transportation and delivery services - they may also provide basic energy services.

Here’s the scenario: You own an electric vehicle. You also have solar panels on your roof or built into the windows of your home. You’ve just invested in a home car-charging station that plugs into your home’s nanogrid, your neighborhood’s microgrid and your city's smart grid. You're investing in all of this because the writing is on wall: Fossil fuels cause a growing number of problems. Besides, battery technology is the hottest technology on the market: Scientists at the EPFL Energy Center and Industrial Electronics Lab have developed a charging station system that can charge electric vehicles with 80 to 100 kilowatts of power in just 15 minutes (albeit from a Lithium Ion-based intermediate storage device that today is the size of a shipping container).

You do the numbers. A full charge in a hybrid vehicle can power your house for a day. A full charge in an all-electric car can power your house for five to six days. Even if you drive nearly 500 miles per day, using today’s technology, it would take only a little over nine hours to recharge your battery. That leaves you nearly 15 hours of charge to power your household, sell a little excess power to your neighbor or sell power back to your regional smart grid – some of it generated by your solar panels. The same principle also applies to businesses, which can use their service vehicles or even their employees' parked cars to power a small warehouse or support center.

Worst case, in a power outage from a super storm, your vehicle becomes your backup generator. Best case, you become a distributed power generator – filling your savings account as you power your home or business.

This scenario, of course, assumes a future that looks a lot like our suburban past – a future where everyone owns a car and the house they want to power. But what about our dense urban future, where people live in apartments and condominiums and eschew private ownership of automobiles?

Multitasking Fleets

Recall the self-managing vehicle as a service. In 2026, it’s quite possible that we will have fleets of electric vehicles - some owned by cities, some owned by private services and some cooperatively owned by investors. They will be multitasking service fleets, designed to pick up people, prescriptions or food. And one of the services they provide is power.

Maybe they load-balance power demands on hot summer days, swarming an industrial park to provide power at micro-market rates. Or maybe they offer a special subscription-based service to a medical office complex with scheduled periods of high demand. And in the case of that super storm – where ice and snow bring down an entire borough in NYC – they plug into the local neighborhood microgrids to make a low level of power service available to households that would otherwise be shivering and unable to cook.

What all of these scenarios point to is a future, likely within the next decade, where the boundaries between transportation and energy blur, and a dynamic market for micro-charges turns electric vehicles into a mobile energy source.

In a blackout, your vehicle powers your home or business. The rest of the year, you turn a profit by selling energy back into the grid.
EV Integration in the Grid

The National Renewable Energy Laboratory is studying vehicle-to-grid (V2G) charging, setting up communications protocols between electrical grids and hybrid electric vehicles as a way for grid operators, charging stations and vehicles to decide when and how to charge for maximum performance of all three. Their goal is to create smart charging options while allowing on-demand use of the vehicle and load-balancing of the grid.

The boundaries between transportation and energy will blur. A dynamic market turns electric vehicles into a mobile energy source.
What’s Driving Vehicular Grids?

Growth of Plug-In Electrical Vehicles

Just 345 plug-in electric vehicles (PEVs) were sold in the United States in 2010, when first introduced, compared to 9,790 PEVs sold in December 2013. If we assume a 20 percent growth rate in the future (as researchers at the University of California at Berkeley did), we would expect annual sales of about half a million PEVs by 2023. Other reports suggest that the worldwide market for PEVs will reach 1.8 million annual sales by 2023. By comparison, 17.5 million new (and conventional) cars and light trucks were sold in 2015.

Battery Technology

At scales both small and large, battery technology may be the defining zone of innovation and disruption over the next decade. Government agencies, university labs and venture-backed startups are all pushing the edge of battery capacity, performance and charging technology. While capacity may seem like the most important measure – just how far can you drive your car on a charge? – cost, volume and weight of the battery all figure into the equation. So will ease and speed of recharging, as well as the ability to detect accurately how much charge is left.

Some vehicle manufacturers are also looking at ways to reconfigure batteries to make it easier to swap out small battery modules rather than the entire battery. The result might be convenient drop-in battery packs that can be rotated in and out of a home or office charging station or simply recycled at a roadside charging station.

Smart Grids

The growth of renewable energy sources such as solar and wind promise to reduce atmospheric carbon, but they also create problems for balancing supply with demand: They are unpredictable or intermittent sources of power. The smart-grid movement is attempting to solve this problem by using software to manage the flow of energy to and from sources and users – balancing supply with demand and optimizing the cost of power for everyone. As electric vehicles plug into the grid, the software for managing them as nodes on the grid will make them part of the future energy infrastructure.
As concerns grow over climate change, pollution and how much oil we actually have left, there’s clearly a need to develop alternative fuels. The good news is that researchers have proven that vehicles can run on natural gas, electricity, hydrogen, nitrogen, biofuels like elephant grass – and even biodiesels based on restaurant grease or chicken waste.

The question, then, is which of these “alt fuels” offer the most promise.

Since there’s no single alternative fuel that by itself can replace gasoline, we’ll need to rely on more than one fuel source. What’s more, the transition will be relatively gradual. Yes, we’ll see more and more “alt fuel” vehicles on the road. But new fuel technologies can take decades to fully implement on a massive scale. As a result, it could take decades before the last internal combustion engine finally makes its way to a junkyard.

UPS can adapt no matter which fuel source emerges, since we’ve long used our truck fleet as a “rolling laboratory.” We plugged in our first electric vehicles in the early 1930s, added the first liquid natural gas/diesel-powered tractors in 2002 and in 2015 became the nation’s largest user of renewable natural gas (RNG) in the shipping industry. In face, we’re using up to 500,000 gallons of renewable liquefied natural gas every year to operate our fleet in Texas. And sometime during 2017, we’ll log our one-billionth mile using alternative fuels.

In the meantime, here is my take on the fuels of the future.

Natural Gas
Compressed natural gas (CNG) and liquefied natural gas (LNG) have been around for some time, but the fuel we’re optimistic about is renewable natural gas (RNG). Also known as biomethane, RNG can be derived from many abundant and renewable sources, including decomposing organic waste in landfills, wastewater treatment...
and agriculture. As a result, the criticisms of natural gas – including methane leakage and water contamination – aren’t issues with biomethane. Pipeline-quality RNG’s big selling point is that it’s one of the least “carbon intensive” of various alt fuels.

**Biofuels**

We all know the ethanol story, but researchers have made great strides with second-generation biofuels using palm oil, miscanthus (elephant grass) and prairie switchgrass to power vehicles. The problem is these biofuels have a relatively low yield rate. For instance, an acre of switchgrass only produces 200 gallons of fuel.

Think of it this way: To power all U.S. energy needs in 2040, it would take a land mass a little larger than the size of the U.S. (3.3 billion acres). In fact, to replace just liquid fuels, it would take a land mass just under the size of the continental U.S.

**Electricity**

As much as I love the throaty rumble that a muscle car makes when it starts, the perfect driving machine may actually be the electric car. My Nissan Leaf is elegantly simple. With no mechanical parts, the only time I’ll visit a repair shop is when I replace the tires.

As battery technology improves and recharging stations become ubiquitous, you’ll be able to take your electric cars on long trips, too. While many electric car owners feel proud, odds are you’re getting electricity from fossil fuels such as coal and natural gas. So to make electric cars truly green, we need to develop cleaner sources of electricity.

Alternative fuels like solar, wind, geothermal and hydroelectric utilities are growing fast. But keep your eye on nuclear. Nuclear power developed a stigma following the Fukushima and Chernobyl disasters, but the energy source has come a long way in safety, technology and output. The big issue has been cost, since large plants run $7 billion each.

But a new breed of smaller, modular nuclear plants has the potential to bring that cost down significantly. These smaller reactors have a maximum capacity of 300 megawatts, or enough to power a mid-sized city. But they could be made in factories and shipped to sites, dramatically reducing the cost while improving safety. If we’re looking for a clean energy source to fuel all of the electric cars that’ll hit the roads over the next decade, we’ll need to embrace nuclear.

UPS has created innovative, zero-emissions delivery alternatives for Hamburg, Germany, and continues to create solutions that help cities reduce congestion and emissions, while meeting service needs.
Chapter 4: Cars meet the quantified self
The Future of Self-tracking

Not quite a decade ago, Gary Wolf and Kevin Kelly launched the quantified-self movement as a “collaboration of users and tool makers who share an interest in self-tracking” – that is, using sensors and personal data to better understand our individual health and fitness, our productivity, our relationships and ultimately our collective well-being.

To join this movement today, you might acquire a number of tools. Simple wearable sensors such as pedometers help you keep track of how far you've walked. Smart wearables like fitness bracelets track not only your footsteps, but also your heart rate, your sleep patterns and other basic biometrics. Life-logging cameras eventually might record virtually every moment of your life.

From Miatas to microbiota

Now enter the quantified vehicle. As cars and trucks acquire more and more sensors to mediate between you and the road, they become tools for measuring everything from your fatigue to your stress levels.

Over the next 10 years, vehicle sensors will likely follow the path of Apple’s HealthKit, collecting hundreds of health metrics automatically and perhaps even predicting heart attacks or neurological disorders. They may also measure your microbiome – the bacteria that live in and around your body – to provide early warnings of infections.

In short, the quantified vehicle becomes one very big wearable computer. Now add self-driving smarts to your quantified car or truck, and you can go beyond the quantified self to the augmented self. The autonomous vehicle of the future not only knows where you want to go, it knows your favorite drive-thru espresso bar along the way. If it senses that you’re fatigued or drowsy, it can call ahead and order a double latte – a little brain boost as you go.

It also can set up geofences: virtual zones where you typically need some kind of assistance. Maybe it’s as simple as a reminder to pick up the chocolate bar that’s only available at one artisan shop in your city. Or perhaps it’s a custom briefing for a meeting that you’ll arrive at in just 20 minutes. A geofence might trigger your vehicle’s sound system to play calming or focusing music if it senses that you’re stressed or distracted.

As our vehicles learn more about us, they will learn how to make us better at what we already do. They may also help us learn what we don’t yet know how to do. So rather than dumbing us down by taking the wheel, they’ll be laying the groundwork for us to become smarter, faster and more effective in our daily lives. And they’ll do all this whether we own them or whether they’re service vehicles that have access – using our biometric IDs – to our data in the cloud.

And speaking of all that data in the cloud, it may actually help our city agencies manage traffic flows, plan bridges and new developments, or even issue licenses to businesses. The meta-patterns from quantified cars will map cities as they have never been mapped before – revealing patterns that will amplify the work of city planners and real-estate brokers, law-enforcement officers and social services.

In the end, quantified vehicles may not only augment our individual minds and bodies, they may increase the intelligence of our cities.
What's Driving Quantified Cars?

**Connected Sensors**

Today's cars already have hundreds of sensors and dozens of microprocessors, all designed to make sure the vehicle is operating correctly and safely. This instrumentation is expected to continue over the next decade as the global market for vehicle sensors continues to grow at a compound annual growth rate of 11.9 percent. More important, perhaps, is the introduction of new kinds of sensors that are connected to the Internet and – via local area networks like Bluetooth – to the emerging class of wearables. All of these will create personal data streams that can then be analyzed algorithmically to produce the kind of mobility that's augmented by Artificial Intelligence (AI).

**AI-Augmented Mobility**

Artificial intelligence is rapidly entering the realm of mobility applications, creating new opportunities to connect users to just-in-time support for their critical-path activities. For example, smart calendaring systems already integrate personal and group calendar information into location-based information and cue up key documents you might need here and now.

These applications use predictive intelligence about where you'll be and what you'll need to minimize switching between applications and give you a single window on the most important information at the moment. This same kind of predictive intelligence will be integrated into the quantified car of the next decade.

**Open City Data**

More and more cities worldwide are opening up their civic databases, inviting both public and private organizations to create applications that make this data useful for their citizens. From Seoul and San Francisco to Barcelona, cities are using open data as a way to solve their urban problems. One of the opportunities of the quantified and connected car is to feed these shareable databases with information that could improve everything from traffic congestion to public health.

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**Forecast of Global Motor Vehicle Sensor Market**

<table>
<thead>
<tr>
<th>Year</th>
<th>Market Size</th>
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<tbody>
<tr>
<td>2011</td>
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<td>2012</td>
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<td>$33.4 billion</td>
</tr>
<tr>
<td>2018</td>
<td>$35.4 billion</td>
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Source: Transparency Market Research
To Your Doorstep, Faster than the Speed of Sound

Bala Ganesh
Senior Director of Marketing, UPS

Autonomous vehicles dominate the headlines. But they’re just one of the many futuristic technologies we could use to make deliveries in coming decades.

Indeed, at some point in the future, the logistics landscape could barely resemble what we see today. Here’s an admittedly fanciful look at some of the cutting-edge technologies we could use one day to move goods faster, safer – and greener.

Let’s begin with the Hyperloop, a vacuum-tube transportation network that sounds like something out of a science-fiction movie.

People and packages could travel through low-pressure steel tubes in a capsule riding on a cushion of air. As envisioned by entrepreneur Elon Musk – and the numerous companies intent on implementing a version of his blueprint – the tubes would run at least partially on solar power.

The Hyperloop could move people from Los Angeles to San Francisco in roughly half an hour. As remarkable as that is, we also should consider the potential of the Hyperloop to revolutionize the delivery of goods as well. Truth is, packages could travel even faster than people between any two cities.

With a cargo-based network, you don’t have to worry as much about acceleration. Packages could move at higher speeds, along winding routes bringing cities closer together.
Goods could travel from Jacksonville, Fla. to Los Angeles in just a few hours – connecting two of the nation’s busiest ports, on opposite coasts.

While much work remains before people can safely take this G-force-inducing ride, there are well-funded groups of entrepreneurs and investors who have dedicated themselves to solving these engineering challenges. With test tracks being constructed, it looks more like when, not if, the Hyperloop is going to be up and running. Developers are planning to soon test pods at speeds of some 300 miles per hour. However, the Hyperloop is expected to eventually move passengers at speeds in excess of 500 miles per hour – cargo will travel at even higher speeds.

Speaking of high-speed options, the Electromagnetic Railgun – a futuristic technology unveiled by the U.S. Navy in February – could also transform the logistics industry.

The tool uses electromagnetic energy to fire projectiles up to 4,500 miles per hour and can reach targets more than 100 miles away. The projectile is launched up to Mach 6 – more than six times the speed of sound.

The Electromagnetic (EM) Railgun was designed as a weapon of war, but just imagine its potential reach as a delivery device. Instead of UPS flying a jet in the dead of night between Chattanooga and Atlanta, for example, we could shoot a series of bundled packages – equipped with parachutes – and land them in a UPS-owned field.

By 2050, two-thirds of all people will live in a city. Roads will get even more congested, and the demand for goods in megacities will further test already strained transportation networks.

Cities like New York, New Delhi, Shanghai and London could become impassable in 30 years, forcing logisticians to rethink how they transport goods to the final stop.

Unmanned aerial vehicles could deliver bulk packages at night, gently setting down the parcels on rooftops. At UPS, we’ve been testing drones for their ability to deliver to hard-to-reach places. During the day, delivery workers – or even robots – would whisk these packages to their recipients using an array of small, green friendly vehicles. Think electric mopeds, golf carts, Segways and other lightweight vehicles, such as UPS’s three-wheeled Cargo Cruiser, a pedal-assisted electric bike.

With the aid of such technologies, people would get what they want whenever they want it – and this ever-shrinking world would become more sustainable.

Harken, the acronym for Heart and Respiration In-Car Embedded Non-Intrusive Sensors, is a European Union initiative to design a seatbelt and onboard computer to detect when a driver is getting drowsy.
Routes to the Future Series:
Volume 1: How We’ll Get Around
Volume 2: How We’ll Make the World
Volume 3: How We’ll Trade
Volume 4: How We’ll Interact
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