Urban Systems Associates, Inc.

Smart Mobility Consulting, Planning & Traffic Engineering

Overview

1980

38 years of Transportation, Traffic and Civil Engineering in Southern California

Private Business and Government

Signing and striping to Complete Adaptive Systems

Expert Witness	ITS/Adaptive Install	Smart Mobility Consulting

URBAN SYSTEMS ASSOCIATES, INC.
PLANNING & TRAFFIC ENGINEERING

Cradle to Grave

Due Diligence

Entitlements

Final Engineering

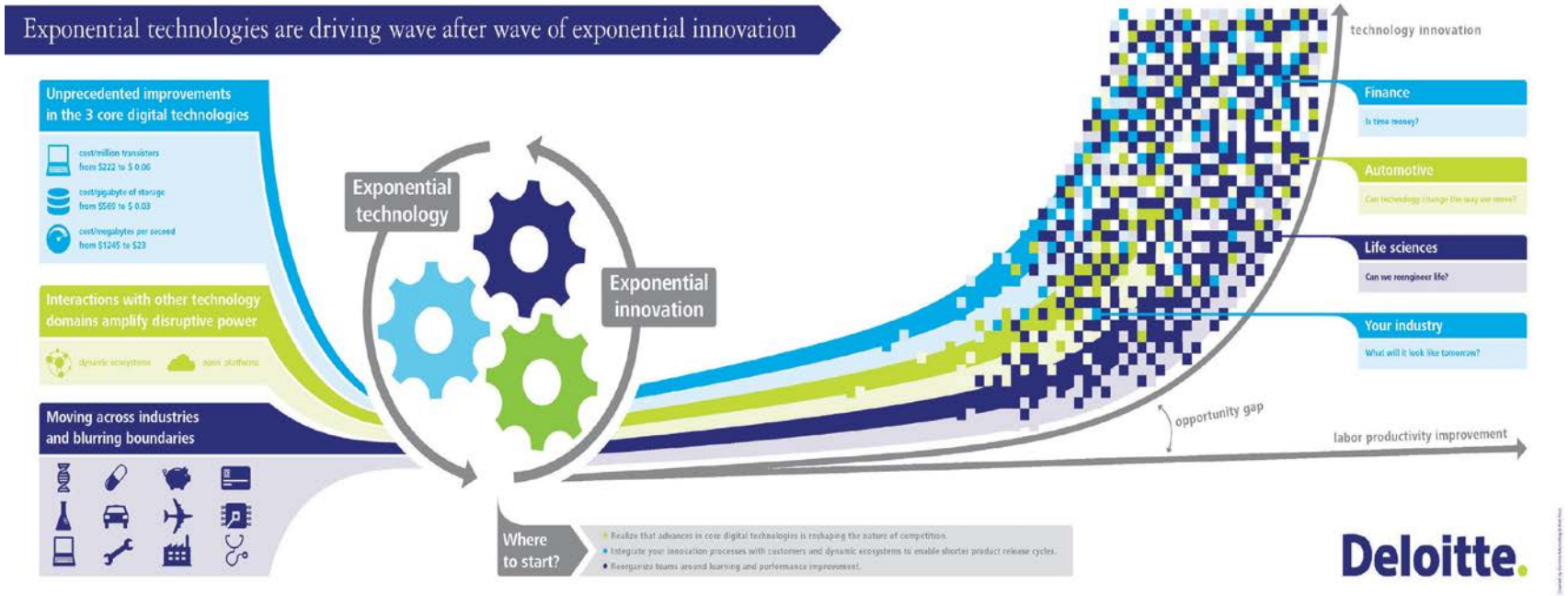
Construction specific to ITS and Smart City

URBAN SYSTEMS ASSOCIATES, INC.
PLANNING & TRAFFIC ENGINEERING


Deloitte.
University Press

SMART MOBILITY VISION

URBAN SYSTEMS ASSOCIATES, INC.
PLANNING & TRAFFIC ENGINEERING

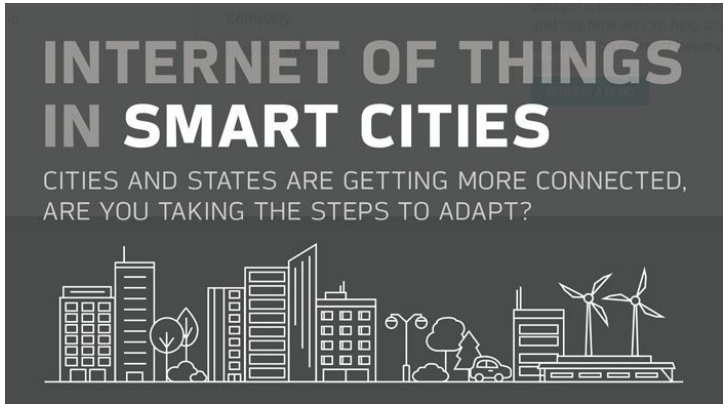

Exponential technologies are driving wave after wave of exponential innovation
Unprecedented improvements in the 3 core digital technologies
cost/million transistors from $222 to $ 0.06
cost/gigabyte of storage from $560 to $ 0.03
cost/megabytes per second from $1245 to $23
Interactions with other technology domains amplify disruptive power
Moving across industries and blurring boundaries
Exponential technology
Exponential innovation
technology innovation
Finance
Is time money?
Automotive
Can technology change the way we move?
Life sciences
Can we reengineer life?
Your industry
What will it look like tomorrow?
opportunity gap
labor productivity improvement
Where to start?
Realize that advances in core digital technologies is reshaping the nature of competition.
Integrate your innovation processes with customers and dynamic ecosystems to enable shorter product release cycles.
Reorganize teams around learning and performance improvement.
Deloitte.

EMERGING TRENDS

Six Trends Shaping Mobility

Any future mobility vision must recognize emerging trends which will create a significant impact or disruption to existing planning principles and design practices. These emerging trends will drive future development and recognizing them early as well as considering them in the planning and design process will enhance the future viability of any development. Additionally, taking advantage of improved efficiencies caused by emerging trends may reduce or offset development costs. Several of these emerging trends are briefly discussed below. A significant amount of research has been conducted by organizations such as McKinsey & Company and Deloitte University Press among others and has been summarized throughout this document.

1. **AUTONOMY**
2. **ELECTRIC VEHICLES**
3. **SHARED USE ECONOMY (MOBILITY AS A SERVICE)**
4. **EFFICIENCY MULTIMODAL NETWORK**
5. **HOME DELIVERY**
6. **CONNECTIVITY**



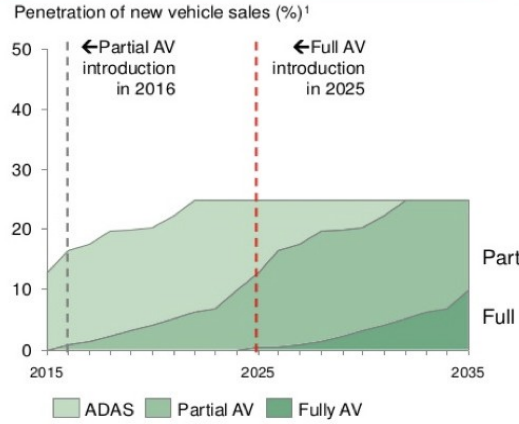
Images (Clockwise from opposite page)
ttps://www.precurio.com/intranet-development-2015-best-practices-and-emerging-trends/
http://www.cision.com/us/2015/09/the-present-future-tech-trends-prs-should-prepare-for/
https://tax.thomsonreuters.com/blog/onesource/emerging-trends-in-global-trade/
https://content.extremenetworks.com/extreme-networks-blog/smart-city-survey-results-trends-and-success-factors-survey-and-infographic

Figure 6. The future of urban mobility: Scenario 1

By 2035, 12 million full AV units could be sold a year globally

Market for partial and full AV features expected to grow from ~$42B in 2025 to ~$77B in 2035

In 2035, 25% of market to be AV sales with 15% partial and 10% full AV systems



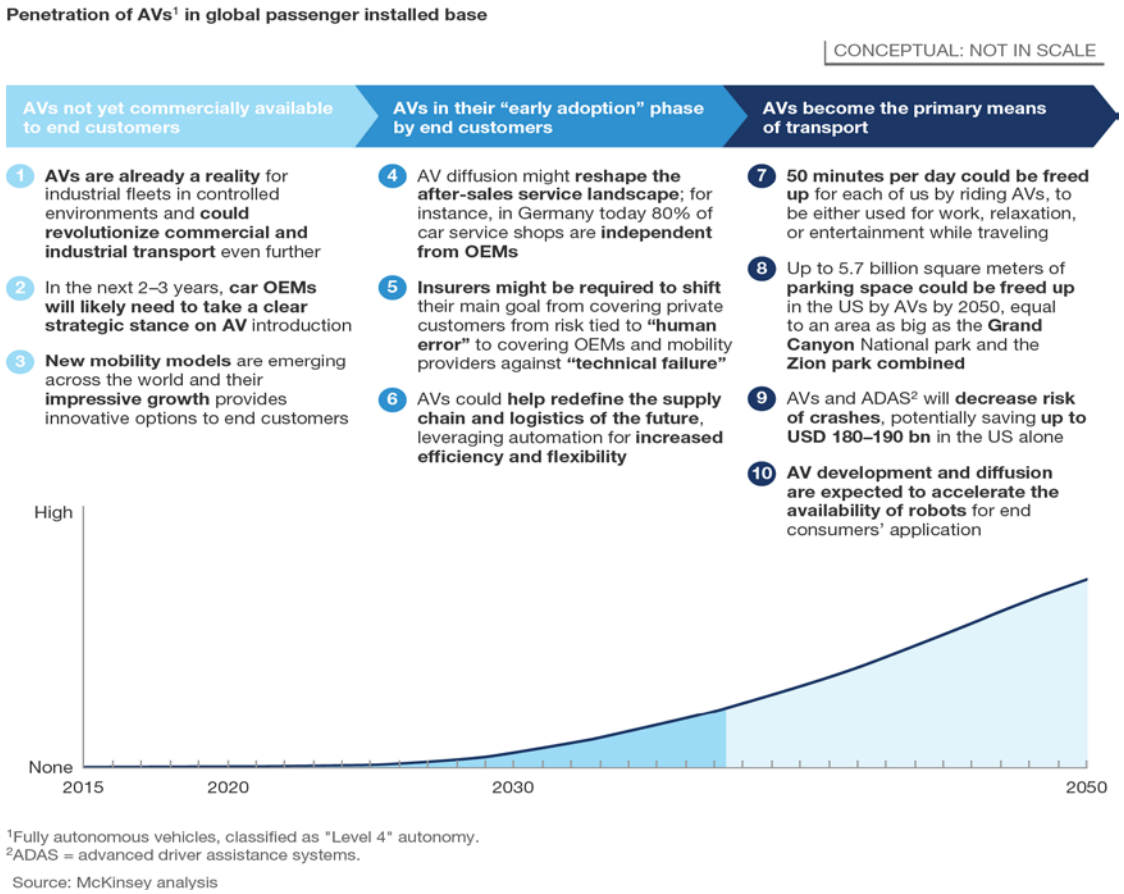
Represents 12M full AVs and ~18M partial; ~$77B market for AV features in 2035

	2025 global sales			2035 global sales		
	Share (%)	Volume (M)	Sales[3] ($B)	Share (%)	Volume (M)	Sales[3] ($B)
	Estimated global new light vehicle sales: ~111M[2]			*Estimated global new light vehicle sales: ~122M[2]*		
Partial	12.4%	13.9	36	15.0%	18.4	38
Full	0.5%	0.6	6	9.8%	12.0	39
Total			$42bn			$77bn

1 Autonomy

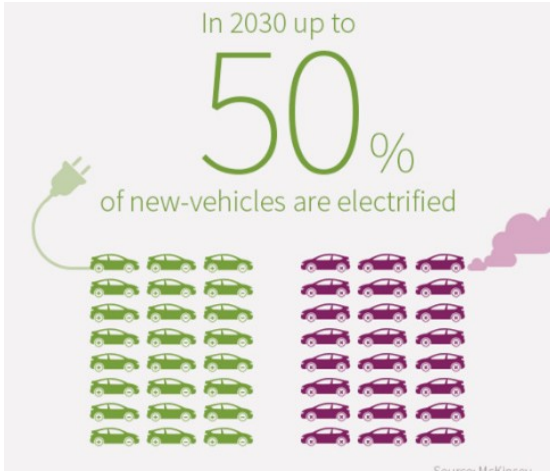
According to research completed by BCG, up to 25% of the vehicle market could be Autonomous Vehicles (AV) by Year 2035. Research by McKinsey & Company shows that the advent of AV technology could be the single most disruptive factor from a planning and design perspective. For example, up to 50 minutes per day could be freed up for work, relaxation or entertainment for passengers currently commuting. This will significantly change our overall work patterns and environment. Additionally, research shows that up to 5.7 billion square meters of parking space in the United States could be freed up through AV technology. Finally, up to $190 billion could be saved through reductions in the number and severity of crashes.

Early adoption of AV technology is ongoing. Technologies and design options to consider which will position a development for an autonomous environment include the following:



A LOOK AHEAD

- **Mobility Hubs**
- **Improved Pickup/Drop-off**
- **Parking Management Systems**
- **Connected Vehicle Technology**
- **Intelligent Transportation Systems**
- **High Speed Communication Infrastructure**



2 Electric Vehicles

Electric Vehicle (EV) technology is already changing the way we design in many large cities. The City of San Diego has EV charging requirements documented in the Municipal Code and in the Climate Action Plan. City planners are eagerly encouraging adoption and incorporation of EV technology in projects of all sizes. According to research by McKinsey & Company, as much as 50% of the vehicle market in 2035 will be electric.

Significant strides are being made in providing cost-effective and convenient services for individuals interested in EV ownership. This includes Tesla fast charging technology and others. In the near future, vehicles could be charged in as little as 15 minutes with ultra fast charging technology.

Images/Resources
https://phys.org/news/2016-01-electric-car-fast-tank-gas.html
https://i.blogs.es/21cc3c/chademo-and-sae-plugs/450_1000.jpg
http://www.ehcar.net/news/records09.htm
http://insideevs.com/evgo-installing-first-350-kw-ultra-fast-public-charging-station-us/

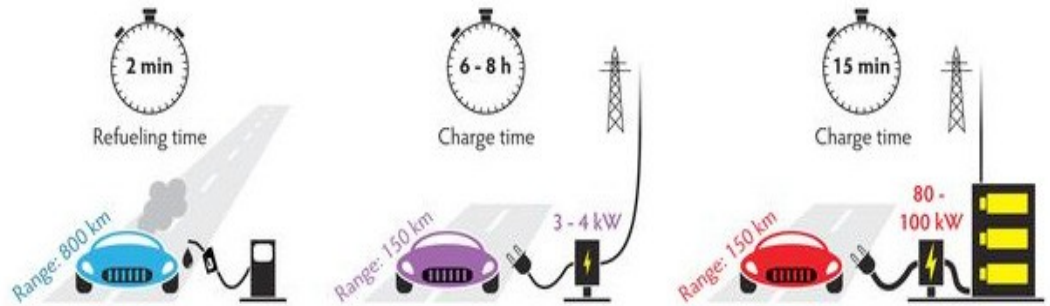
As a result of these changes, new development should consider exceeding the minimum requirements for EV charging spaces including additional chargers, a central ultra-fast EV charging station (similar to a gas station), oversized electrical infrastructure and more. Technologies and design options to consider which will position a development for an electric vehicle fleet include the following:

A LOOK AHEAD

- **Ultra High Speed Charging**
- **Parking Management Systems**
- **Photo-Voltaic Roads**
- **Inductive Charging (In-Road or Parking Structure)**

Charge your electric car in 15 minutes

EPFL researchers propose to store energy from the power grid in a buffer to allow ultrafast charging of hundreds of electric cars with grid overload protection.



Gasoline and diesel

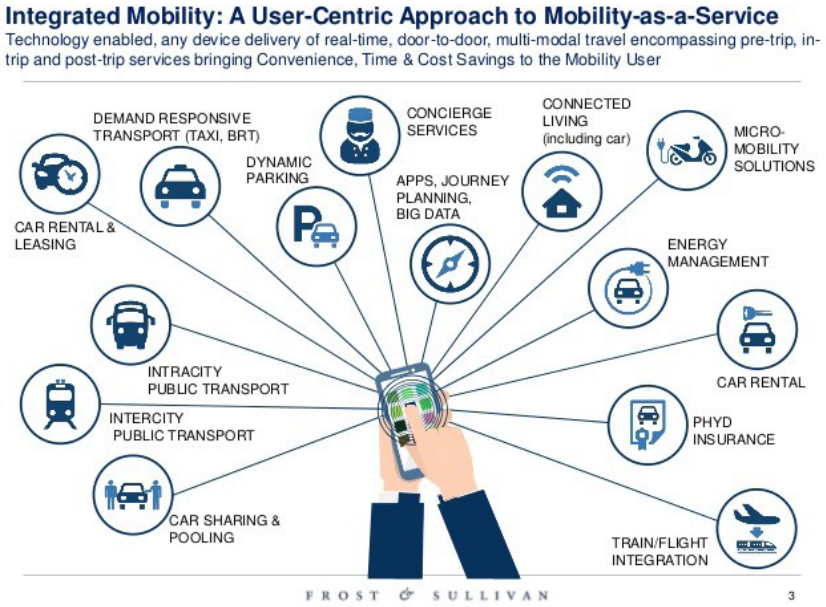
96% of today's cars. Rapid refueling and long range, but harmful for the environment.

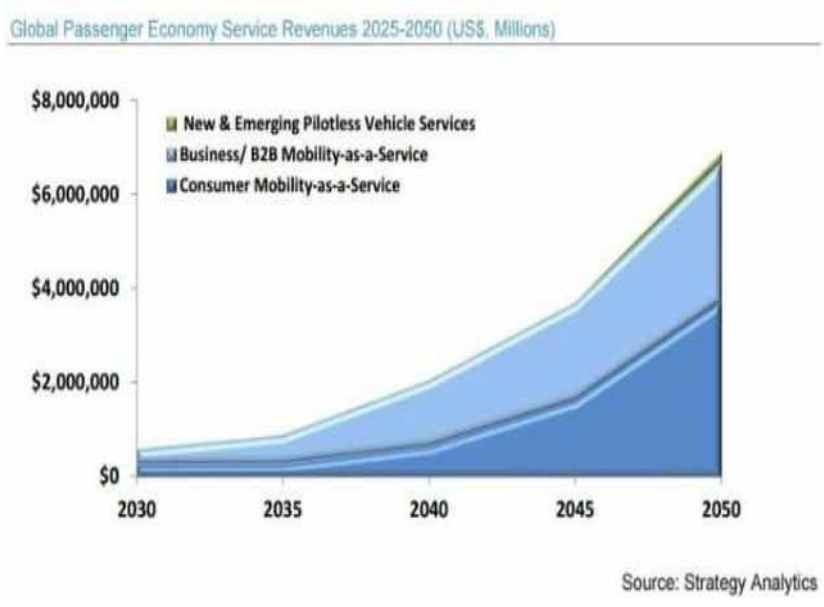
Electricity, home charging

Most common charging method for today's electric cars. Growing risk of overloading the electric grid due to increasing popularity and power requirements.

Electricity, ultrafast charging

Buffering allows for rapid charging of hundreds of cars without overloading the electric grid.





3 Shared Use Economy (Mobility-as-a-Service)

The shared use economy is a trend which will be particularly important over time. Services such as UberPool, Bikeshare, Vanpool and others have taken off in recent years as there is an acknowledgment that significant economies can be achieved. It is believed that a significant share of the vehicle market in the future will be shared vehicles leading to challenges and opportunities. One challenge which may be encountered is unique to secured parking facilities. If a facility is secured, shared use vehicles cannot be parked there. However, one of the greatest opportunities of shared use is the ability to eliminate private ownership and the associated cost and space.

If more residents look at mobility as a service, their commute options are increased as they have no vested ownership interest tying them to a single mode of transportation. Additionally, fewer parking spaces must be reserved for residents and employees. An additional revenue opportunity could be created with space devoted to mobility operators necessary to store, maintain and operate vehicle, bike and delivery fleets. As the Shared Use Economy accelerates in the future, existing development patterns will either have to be adapted to fit the lifestyle or costly retrofits may be necessary.

A LOOK AHEAD

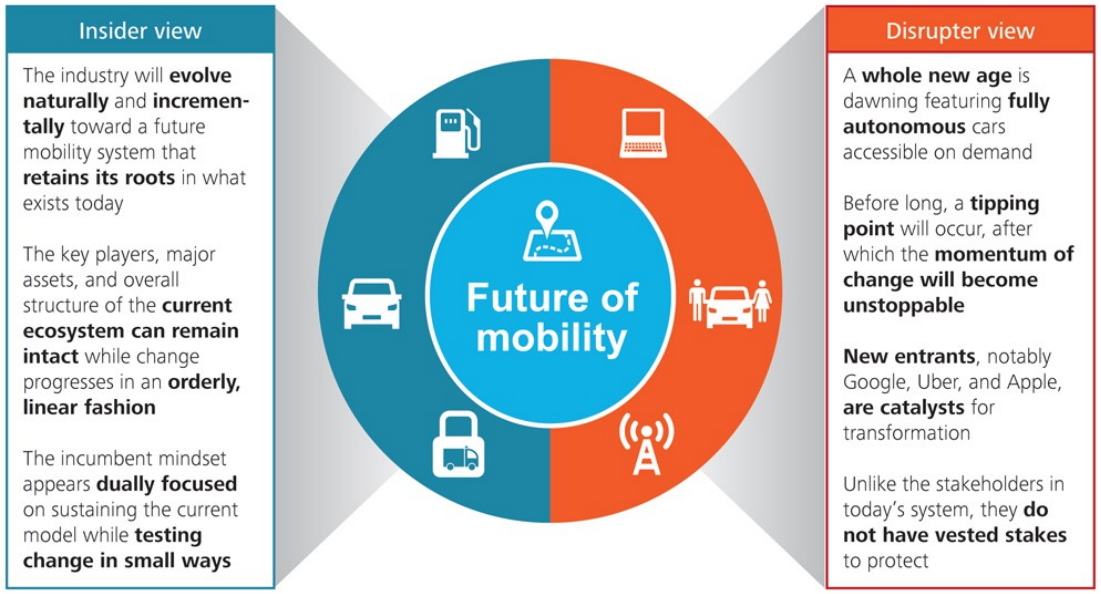
- **Mobility Hub**
- **Rideshare**
- **Pickup/Drop-off**
- **Bikeshare**
- **Parking Management System**
- **EV Charging**
- **Connected Vehicles**
- **Mobility Apps**

4 Efficient Multimodal Network

One of the most visible current mandates from a planning perspective is variously called “Complete Streets”, “Active Transportation” and “Multi-modal Transportation”. The overall concept is to provide for all roadway users and not just vehicular needs. This includes, pedestrians, bicyclists, transit and other users. There is ample design guidance available on this subject. However, the concept of an *Efficient Multi-Modal Network* becomes significantly more important when combined with other trends such as the Shared Use Economy. Without private vehicle ownership, road users are further incentivized to explore other modes of transportation such as walking, public transit or riding a bike. It therefore becomes significantly more important to provide for these needs and de-prioritize the automobile to the extent feasible.

Effective multi-modal design includes safe and convenient facilities for the other modes and includes active options such as the ability to re-use and shift the priority to other modes of transportation. Examples of this include the creation of parklets and conversion of on-street parking, non-contiguous sidewalks with an active streetscape, cycle tracks or modern bike lane designs, safe and efficient pedestrian crossings, pavement treatments, transit priority and more.

Figure 3. "Insider" and "disrupter" views of the future of mobility



Source: Deloitte analysis, based on publicly available information and company websites.

Graphic: Deloitte University Press | DUPress.com

A LOOK AHEAD

- **Mobility Hub**
- **Bikeshare**
- **Cycle Tracks**
- **Mobility Apps**
- **Transit Signal Priority**
- **Holographic Signage**

Images
https://static1.squarespace.com/static/54d12125e4b0553df7774232/t/5672f0c-42c34856d6e548956/1450379482558/Pic4.jpg

5 Home Delivery

Home Delivery services are one of the most significant and underrated trends in the market today. Services such as Uber Eats, Grubhub, Amazon Prime Now and others are experiencing exponential growth. Particular challenges include creating sufficient pickup/drop-off zones, providing secured delivery locations so drivers don't have to park and navigate a complex, providing aerial drop-off locations and more.

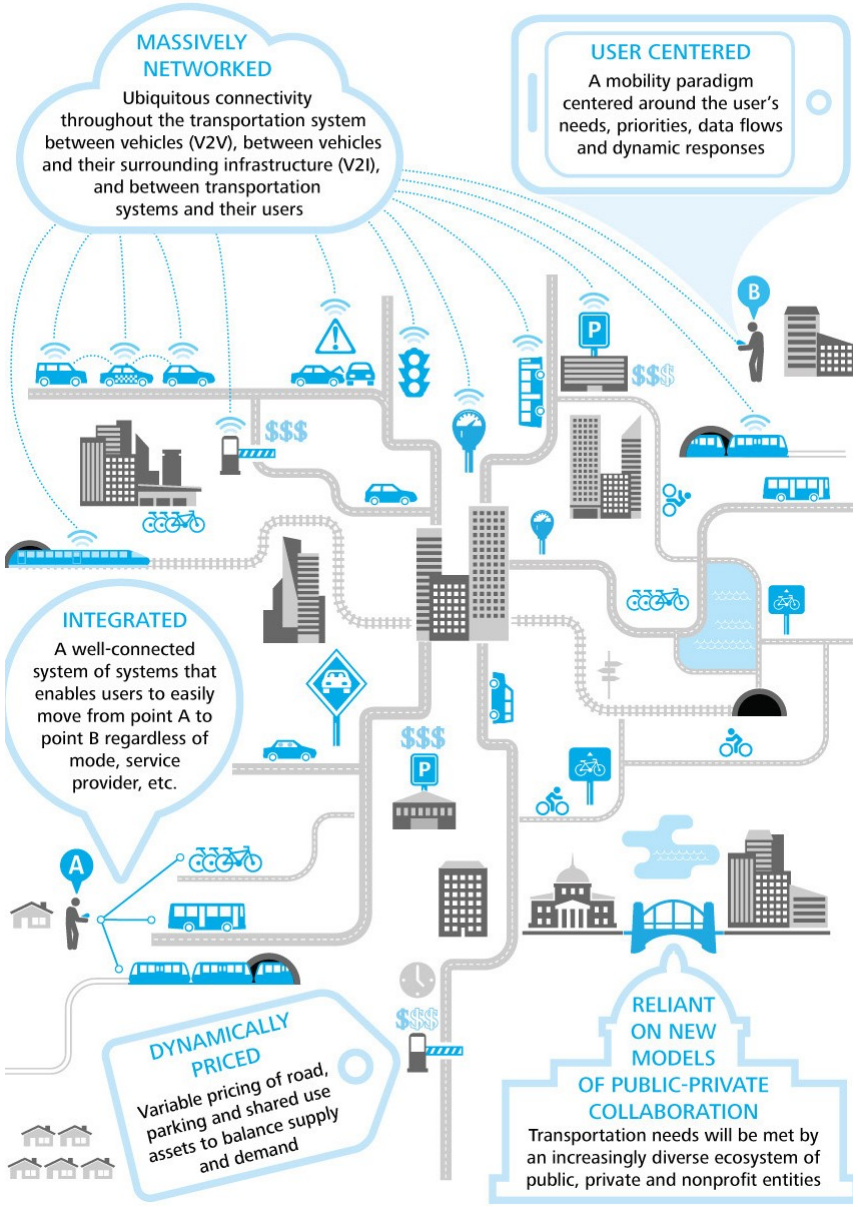
The benefit of this trend is the reduction of overall cars on the road and vehicle miles traveled as a delivery driver typically uses route optimization techniques to visit multiple locations along a route. Even more important is the potential for aerial drone delivery which will remove cars from the road entirely. It is likely that the resident or business of the future will rely in some part and make significant use of home delivery services. Locations and management techniques for secure storage and delivery of these items may be critical in the future.

A LOOK AHEAD

- **Pickup/Drop-off**
- **Drone Delivery**

Image(s)
https://marketrealist.imgix.net/uploads/2014/10/e-commerce-same-day-delivery-market.png?w=660&fit=max&auto=format, https://images-na.ssl-images-amazon.com/images/G/01//112715/image-1._CR0,8,1340,762_.jpg
http://cerasis.com/wp-content/uploads/2015/01/future-of-logis-tics-drone-deliver.jpg

igure 4. Key features of digital-age transportation systems



6 Connectivity

With the advent of the Internet of Things (IoT), there is a significant trend towards greater connectivity. This is simply an extension of the internet revolution. Every Smart City is quickly moving towards an IoT model with connected street lights, traffic signals and more. This trend will lead to significant innovation as connected vehicles and people can make more intelligent transportation decisions. This is also critical to ensuring the safety of the commute. From a Multi-Modal Network standpoint, connectivity will provide greater warning and safety for pedestrians, bicyclists and transit vehicles. From a Shared Use Economy perspective, connectivity is an enabling technology. In order to create a responsive, robust and efficient network, early attention should be given to building in key communication and connectivity technologies. These will increase convenience, performance and safety. Examples include Direct Short Range Communications (DSRC), Small Cell/5G and more.

A LOOK AHEAD

- **Connected Vehicle**
- **Small Cell**
- **DSRC**
- **Mobility Apps**
- **Autonomous Vehicle**

Images
use key-features-future-urban-transportation-systems (deloitte), DUP401-Figure-3 (deloitte), 5g-data-transfer-speed-graphic

FAST – Fixing Angelenos Stuck in Traffic

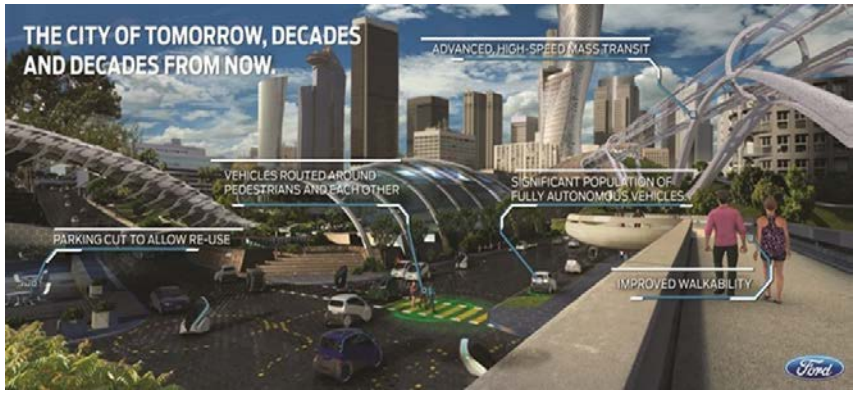
Mobility Hub Modules

Design Concept – Adaptable and Green

- Reflects the community
- Solar Panels
- Natural /LED lighting
- EV Charging Station
- Work resources
- Integrated bike services
- Accessible
- Platform structure can be placed almost anywhere (non-permanent)

Metro acire avis budget group bikeconnect LADOT

15



MULTIMODAL

Transportation Center “Mobility Hub”

Definition
Combining innovative design and functionality with the more grounded needs of the moment is essential in meeting the needs of the public both in the present and future. Two of the above photos depict modern-day examples of a transit center built for the moment with light rail, buses, shuttles, and bike areas.

Objective
Depending on the type of transportation an individual utilizes, their endpoint destination may not be reached with a single mode of transportation. Multi-modal mobility hubs offer alternative transportation methods to connect people to their destinations. These may include bikeshare, public transit, private circulator, pedestrian connections, rideshare options and more. Commute options and information is often provided and convenient lockers, showers, EV charging, pick-up/drop-off waiting areas, convenience services (i.e. coffee and snacks) and more are often components.

Advantages
Centralized location for all of the publics transit needs including solving the “last mile” problem that transit has had for many years.

Challenges
Maintenance, upkeep, location and space.

Images (Clockwise from Main Image):
Examples of Future Mobility Hub
http://la.streetsblog.org/wp-content/uploads/sites/2/2014/07/mobilityhub.png
Example of Current Mobility Hub
http://www.archdaily.com/424032/haluchere-mobility-hub-aup
https://www.fhwa.dot.gov/eihd/images/30.jpg
Ford Motor Future Mobility Hub Vision http://www.autorentalnews.com/channel/rental-operations/article/story/2017/02/mobility- 2050-a-path-for-car-rental.aspx
Fort Lauderdale Example
https://www.fortlauderdaledaily.com/features/future-fort-lauderdale-heres-what-our-city-might-look-2050

Cost: $$$$$

Feasibility:

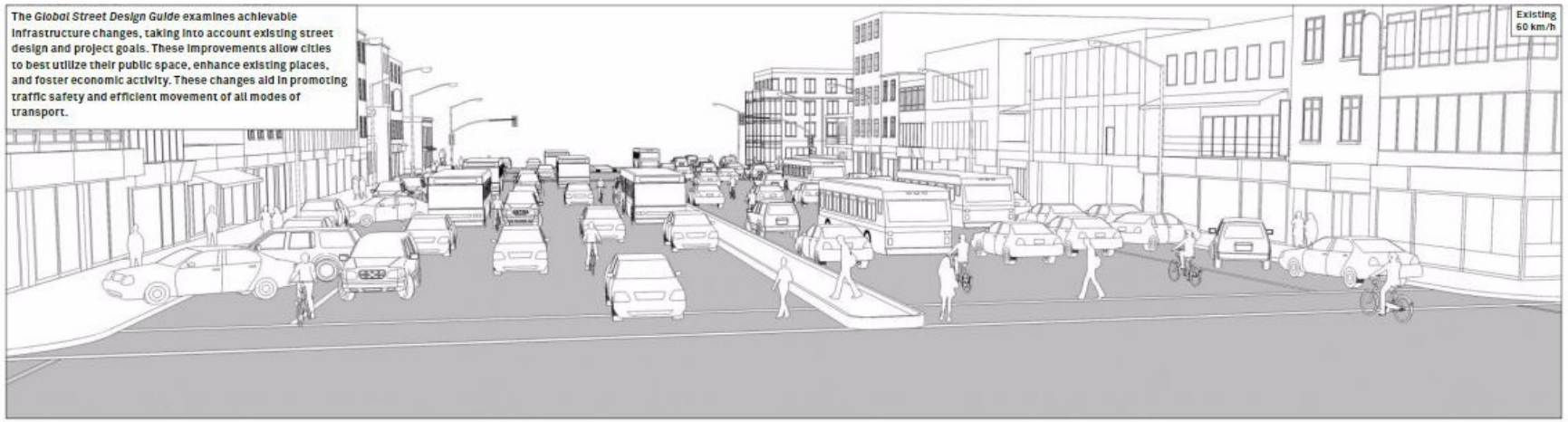
Level of Maturity:

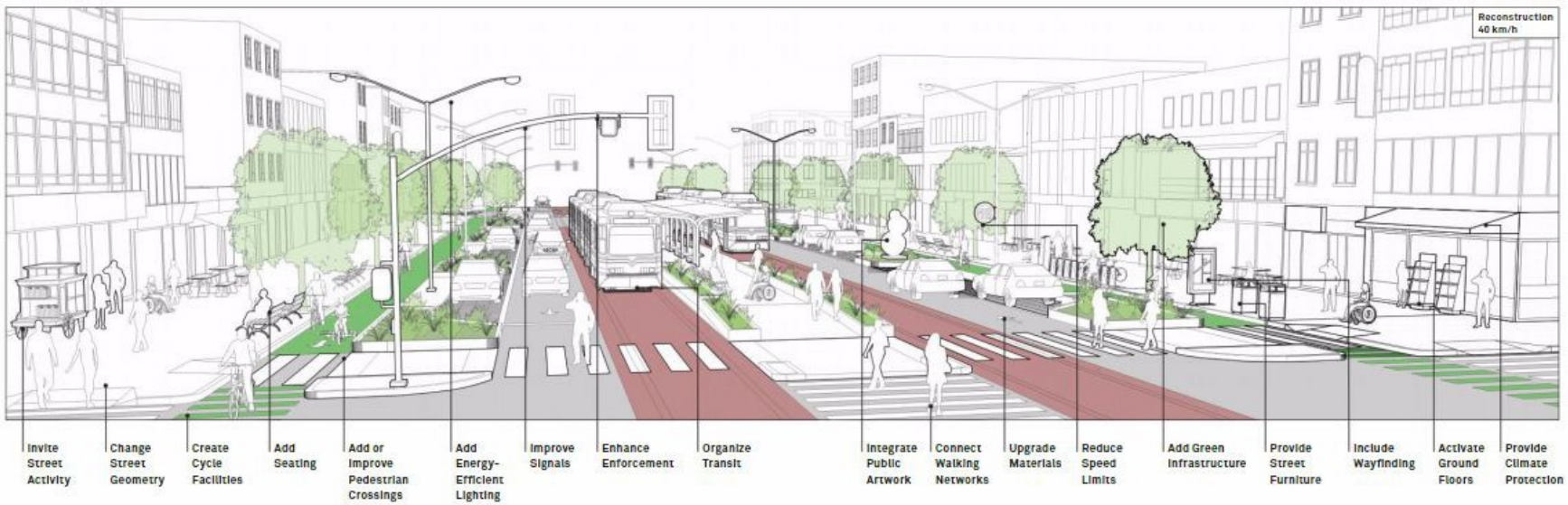
Level of Acceptance:

Defining Streets
What is Possible

1.8 | What is Possible

The *Global Street Design Guide* examines achievable infrastructure changes, taking into account existing street design and project goals. These improvements allow cities to best utilize their public space, enhance existing places, and foster economic activity. These changes aid in promoting traffic safety and efficient movement of all modes of transport.





Complete Streets

Definition

Complete Streets are streets that create safe use and access for anyone; drivers, transit riders, cyclists and pedestrians alike. Whether you are crossing the street to catch the trolley or driving through a neighborhood, the overall Complete Street design concept and considerations create an ease of use for all users regardless of age or ability.

Objective

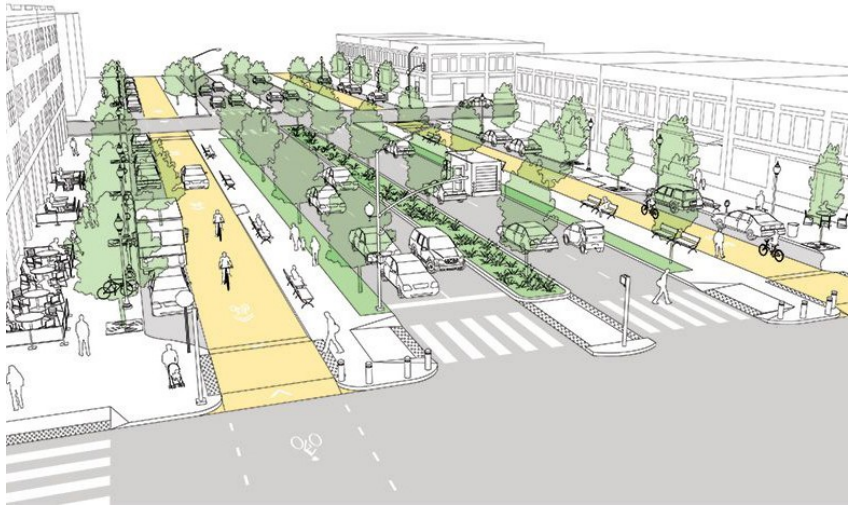
Creating street segments that are safer for all users. Moving away from the automobile centric design, and toward streets that are as much for pedestrians and cyclists as they are for drivers and transit riders.

Advantages

Complete Streets help facilitate community resource access to all users, including children, people with disabilities, and older adults, can move about within and seek multimodal solutions to their transportation needs. In doing so, communities with Complete Street designs have experienced overall improved health and safety by users.

Challenges

Making the time to understanding the needs of local stakeholders, and projection of their expected uses is necessary. Increasing walk-ability/bike-ability while maintaining a level of service for drivers is a balance.



Resources
https://smartgrowthamerica.org/program/national-complete-streets-coalition/what-are-complete-streets/
https://www.planning.org/research/streets/
https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of acceptance:


Corporate Coach
760


STOP


DIVINO
OPEN
FOOD
TWO BUCKS

On-Street Parking Conversion

Over time, as the project matures, if parking demand decreases, an option should be explored for conversion of parking areas to parks, patio areas and meeting areas.

Definition

On-street parking can be converted into other uses to benefit the surrounding area and local visitors.

Objective

On-street parking will be converted into other uses such as establishing a new bicycle lane or widening the sidewalk. Many major cities such as New York City, San Francisco, Los Angeles, and Toronto have conducted studies on business which had their on-street parking converted. What they found out was that businesses were hardly impacted or even increased revenue.

Advantages

Converting on-street parking into bicycle lanes or patio areas can increase trips to local businesses and even increase revenue as shown in studies. Streets that face lower volumes can have their on-street parking converted into bike lanes.

Challenges

Local business owners who face their on-street parking to conversion may resist the change.

References

http://www.peopleforbikes.org/blog/entry/10-ways-cities-can-win-the-fight-to-upgrade-parking-spaces-to-bike-lanes

https://www.citylab.com/solutions/2015/03/the-complete-business-case-for-converting-street-parking-into-bike-lanes/387595/

Image 1

http://zeleneet.com/media/2015/07/san-frantisko_zamenyaet_parkingi_parkletami_2.jpg

Image 2

http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2015/09/outerlands-parklet-800x610.jpg

Image 3

https://s-media-cache-ak0.pinimg.com/originals/8c/61/b0/8c61b0d-9663b0e00abcac9730db3da64.jpg

Image 4

http://media.jrn.com/images/b9982256z.1_20130823205329_000_g1i25k7d.1-1.jpg

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of acceptance:


CAR FREE ZONE

Car Free Zones

City centers, neighborhood corridors, and even some parks have transitioned to “pedestrianization” zones, or car free zones. With increased safety concerns, cities in mostly metropolitan areas have converted certain areas to car free zones.

Definition

Area of public space such as a roadway corridor, city center or park that previously had allowable automobile use that converts “traditional” automobile routes to pedestrian use only. These space conversions often include a bicycle use component as well.

Objective

The re-purposing of traditional automobile use zones to car free zones to create new open space for the community.

Advantages

Increased safety and reduced greenhouse gas emissions by limiting car use in specific areas, while providing increased open space for pedestrians, cyclists, and business owners.

Challenges

Some people enjoy the drive or “cruising” through areas available to automobiles for generations. Before suggesting a change of use, understanding the desire of community members is vital to success. Reconfiguring adjacent areas to service the increase parking demands may be a challenge, requiring viable solutions to the movement from parking garages to the area. Circulators (eventually autonomous circulators) and bike share options are safe and simple solutions to increase movement to and from these car free zones.

References/Images
http://gas2.org/2014/10/18/nyc-ban-cars-central-park-loop-2015/
http://www.scmp.com/news/hong-kong/education-community/article/2022012/hong-kong-street-go-car-free-weekend-citys
http://www.sandiegouniontribune.com/opinion/commentary/sdut-balboa-park-plaza-support-2016jul22-htmlstory.html
http://media.jrn.com/images/b9982256z.1_20130823205329_000_g1i25k7d.1-1.jpg

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of acceptance:

General Electric's Beijing Technology Park recently completed construction in 2016, and was designed with the future in mind. Limited on-site parking and available entrance points around the entirety of the building promote ridesharing and carpooling services for its 3,000+ employees.

Meridian Building in San Diego - Architects created a drive-thru drop off/pick up zone.

Drop Off and Pick Up Zones

Definition

Specialized drop off zones will be established to accommodate emerging transportation options such as ride-sharing services like Uber, and autonomous vehicles. A fast and safe drop off and pickup zone will allow businesses and riders to operate in a much more efficient manner.

Objective

With ride sharing and delivery services becoming more mainstream every day, access to pick up and drop off zones has become more important than ever in minimizing traffic delays around our cities and urban environments. We have seen how Uber and Lyft have revolutionized the taxicab industry, making it not only easier but faster to get a ride around town. With other delivery services such as UberEats, DoorDash, and GrubHub becoming mainstream alongside traditional delivery companies such as FedEx, UPS, and USPS, the need for having accessible pick-up and drop-off zones has never been greater. Incorporating multiple zones around the building of interest will facilitate smoother interactions between delivery vehicles and the roads around them.

Advantages

Minimize traffic in crowded city streets. Creating a safer environment by implementing designated drop-off zones, eliminating 4-way-hazard traffic stops and parking in bike lanes.

Challenges

Designing buildings with emphasis on wraparound access. Accommodating delivery vehicles while minimizing the traffic impact around the building. Another challenge is providing convenient access and clear direction to pickup and drop off areas.

Cost: $$$$$

Feasibility:

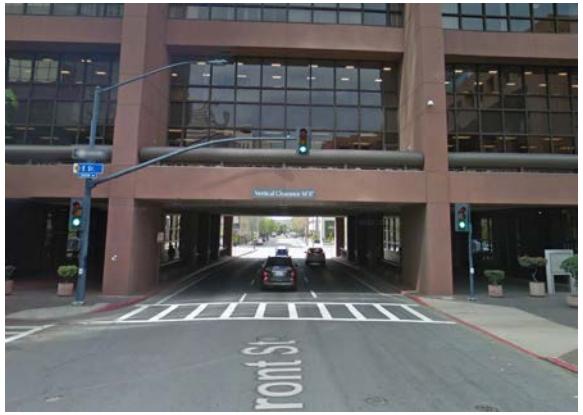
Level of Maturity:

Level of acceptance:

Traffic Calming

Turbo Roundabout

A turbo roundabout is newer form of roundabout that induces a spiraling flow of traffic and forces drivers to decide which exit they are taking before entering. This variation can potentially be more efficient than a standard roundabout. Due to its unique and innovative design, if a turbo roundabout were installed it would be one of the first in North America.



Innovative Intersection and Roadway Design

As society transitions from vehicles driven by humans to a fully autonomous system at some point in the future, the appearance and function of intersections will transition as well. At the University of Texas at Austin researchers have created an Autonomous Intersection Management (AIM) program to better understand how an autonomous system would operate.

Rethinking how buildings and roadways interact provides solutions and innovative design opportunities, for example, Front St. through the IRS building in San Diego.

Images (Opposite Page then Top to Bottom)
"Johnson Controls Helps Create a Green and Energy Efficient Campus for GE." Johnson Controls Helps Create a Green and Energy Efficient Campus for GE | Johnson Controls. N.p., n.d. Web. 10 July 2017. <http://www.johnsoncontrols.com/insights/2017/buildings/features/johnson-controls-helps-create-a-green-and-energy-efficient-campus-for-ge>.
http://www.turboroundabout.com/uploads/2/3/5/9/23597294/1413460372.png
https://www.youtube.com/watch?v=r7_lwq3BfkY

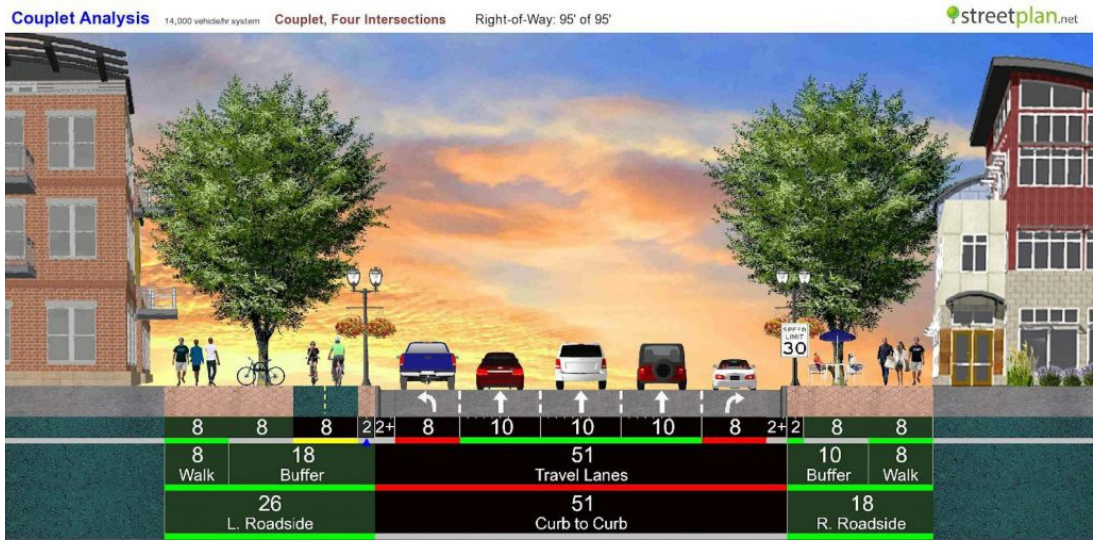
Resources
"What Is a Turbo Roundabout ?" Turbo Roundabouts. Transoft Solutions, n.d. Web. 10 July 2017. <http://www.turboroundabout.com/turbo-roundabout.html>.
Dresner, Kurt. AIM: Autonomous Intersection Management. Cs.utexas.edu. N.p., 2006. Web. 14 July 2017.

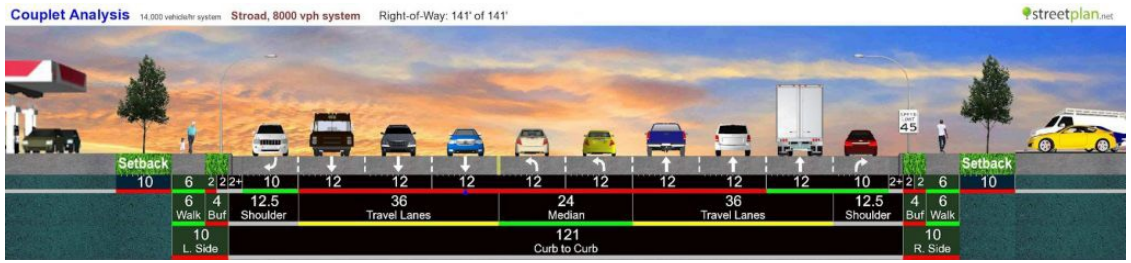
Cost: $$$$$

Feasibility:

Level of Maturity:

Level of acceptance:





Reasons for 2-way streets

- Slower traffic speeds.
- Decrease “Vehicle Miles Traveled” by eliminating indirect routes (driving around the block to get to your destination).
- Increased access to businesses.
- Conversion is very costly.

Resource
https://richmondva.wordpress.com/2007/07/29/one-way-vs-two-way-streets-let-the-debate-begin/

Reasons for one-way coupletstreets

- 1- way streets allow for more cars, thereby decreasing congestion.
- Easier than 2-way streets to time stoplights (timed lights improve traffic flow and decrease idling (& therefore pollution)).
- Fewer turn prohibitions.
- More on-street parking.
- Possibly: safer for pedestrians.

Resources
Analytics, Metro. "Top Ten Advantages of One-Way Couplets." (n.d.): n. pag. Web. 24 July 2017. <http://www.metroanalytics.com/_Downloads/_Top_10_Lists/Top%2010%20Advantages%20of%20Oneway%20Couplets.pdf>.

Analytics, Metro. "Addressing Ten Arguments Against One- Way Couplets." (n.d.): n. pag. Web. 24 July 2017. <http://www.metroanalytics.com/_Downloads/_Top_10_Lists/Top%2010%20Arguments%20Against%20One-Way%20Couplets,%20Addressed.pdf>.

[Couplet 1] http://innovativeintersections.org/place-making-innovative-intersections/town-center-intersections/

[Couplet 2] http://innovativeintersections.org/place-making-innovative-intersections/coupletexamples/

[Couplet 3] http://innovativeintersections.org/place-making-innovative-intersections/coupletexamples/

One-Way Couplet

One way couplets are a relatively new method for adding capacity to roadways without having to widen them. They have enormous potential to reduce congestion while freeing up space for other modes of transportation. This sort of design also improves safety through significant reductions in conflicting movements at intersections.

Definition

One Way Couplets work by changing multiple two-way streets into a single one-way loop. This allows for an increase in traffic capacity without adding lanes. These couplets also allow for fewer turning movements as there are only left turns allowed intersections at major crossings.

Objective

Intended to reduce congestion by raising capacity and reducing the number of four-way intersections along the length of the couplet.

Advantages

Modern examples already exist in Portland, Denver, Boulder, Palm Springs, and New Orleans. Couplets free up right of way by eliminating left turn lanes. They also allow for increased visibility of downtown areas by increasing the range of areas drivers are exposed to.

Challenges

While there are examples they are not widespread and driver unfamiliarity may cause problems in the short term. Couplets also have the potential to increase out-of-direction travel.

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:

Bicycle Sharing

Bicycle sharing is another solution to the “first and last mile” transportation issue, while providing additional transportation opportunities within the community.

Definition

Access to bike sharing stations and services can greatly increase the interconnectedness between public transit, while inviting individuals to a healthier and environmentally sustaining lifestyle. Typically, bike sharing services are IT-automated and station based; users pay a fee to access the bicycle, and then can drop the bicycle off at any nearby docking station (bicycle hub) within the allotted rental time-frame.

Objective

There are many instances where cities have partnered with various private companies to offer maintenance and pickup of bicycles at various locations around the city, including bicycle racks that are independent of the cities dedicated bicycle hubs within a certain geographical area. Projects such as the Caltrans Adams Ave/ Mission Valley bike path opening up in early September 2017 are further expanding the ability of San Diego residents and tourists to utilize alternative modes of transportation.

Advantages

Some of the way bicycle sharing programs improve quality of life for local residents include:

- Enhance first-last mile connectivity of public transportation
- Improved air quality and traffic congestion through reduced vehicle usage
- Convenience for both local residents and tourists alike improves access to jobs, education, and amenities
- Reduces accidents and increases awareness as bicycle programs become more accepted into our daily lives

Challenges

Facility planning and community acceptance.

Images (Top to Bottom):
Sources: wiftmile pilot smart bike-sharing in Santa Clara
http://www.computerworld.com/article/3143132/internet-of-things/verizon-iot-swiftmile-pilot-smart-bike-sharing-in-santa-clara.html
http://www.boettcher-henssler-kayser.de/work/ibsplus
Image (Opposite Page Left to Right)
Source: Pedal Corvallis
http://transportation.oregonstate.edu/sites/fa.oregonstate.edu/files/zagster_101_training_4.5.17_-_pedal_corvallis-page-016_1.jpg

Resources
Radin, Danielle. "New Bikeway to Mission Valley Set To Open." NBC 7 San Diego. NBC 7 San Diego, 7 July 2017. Web. 13 July 2017. <http://www.nbcsandiego.com/news/local/New-Bikeway-to-Mission-Valley-Set-To-Open--433203043.html>.
Zagster. Zagster, n.d. Web. 10 July 2017. <https://www.zagster.com/>.

Example – Zagster Bike Sharing Model

Objective

Companies such as Zagster have revolutionized the bike share model to cut costs and enhance ease of usability with a redesigned bicycle rental system.

Advantages

Convenience is a major factor impacting bikeshare systems. Companies such as Zagster embrace the "Mobility-as-a-Service" model by providing scalable, turn-key solutions for public and private enterprise. The model includes management through a semi-customizable phone app which allows users to rent a bike for a certain period of time and identify other stations where a bike can be dropped off. For those without a smartphone device, the bikes can be rented and unlocked using a one-time pin obtained from a Zagster bike station.

A bluetooth locking mechanism built into the frame of the Zagster bicycle provides security. A unique Zagster bike lock uses retractable docking cables with no detachable pieces to be misplaced or misused allowing users to attach their bicycle to any fixed object or traditional bike rack during a trip. Without being limited to stopping at designated bike stations, users can feel assured that their rental will be secure while locked up, all while alleviating the need to keep track of loose locks and keys.

Challenges

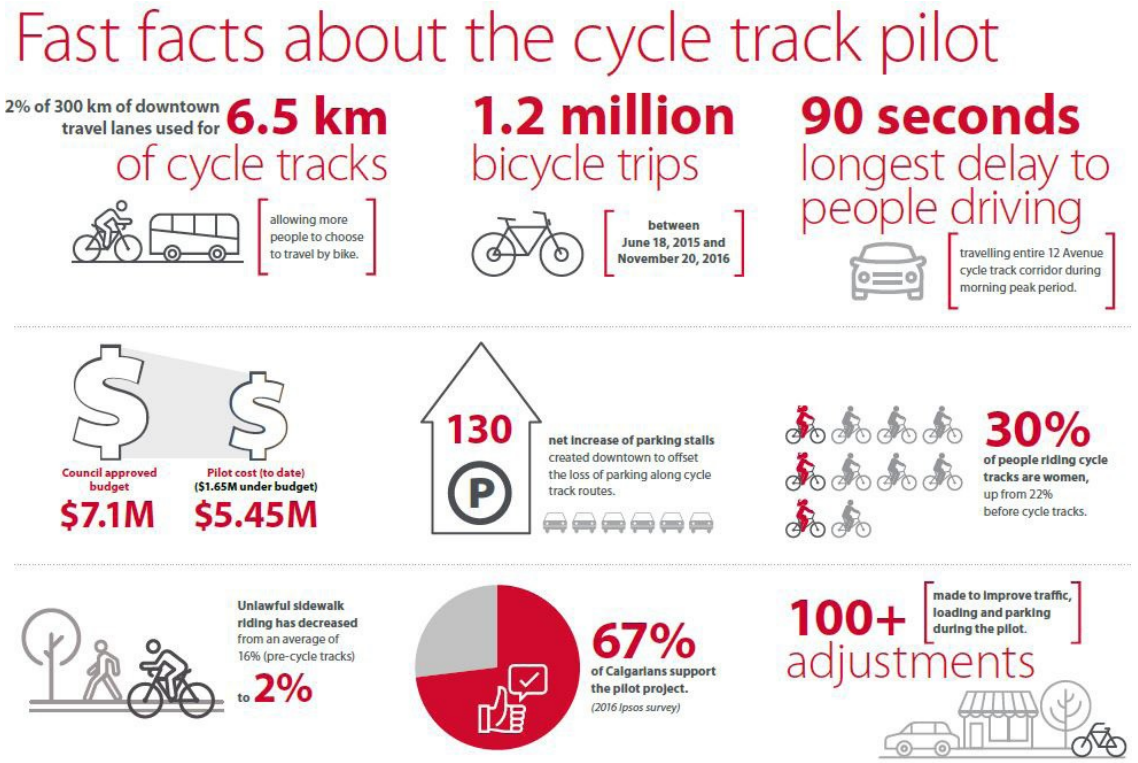
Location, visibility and promotion.

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of acceptance:



References:
http://www.cnn.com/2015/03/04/tech/city-cycle-super-highways/index.html
http://www.calgary.ca/Transportation/TP/Pages/Cycling/Cycling-Route-Improvements/Downtown-cycle-track-pilot-project.aspx
http://www.bikingbis.com/2014/04/16/more-cycle-tracks-and-greenways-in-seattles-bicycling-future/
http://sdotblog.seattle.gov/2013/07/31/17399/
https://www.sandiego.gov/sites/default/files/legacy/planning/programs/transportation/mobility/pdf/bicycle_master_plan_final_dec_2013.pdf
http://bloustein.rutgers.edu/wp-content/uploads/2014/10/Pucher_BikeUrbanism_SeattleUW_18June.pdf
Images https://pbs.twimg.com/media/BKf16EKCAAAUaba.jpg
http://www.sandiegomagazine.com/images/2015/april/trails/silver-strand-coronado.jpg
http://chi.streetsblog.org/2013/05/21/nacto-workshop-visits-indianapolis-to-help-it-become-a-better-cycling-city/
http://www.calgary.ca/Transportation/TP/Pages/Cycling/Cycling-Route-Improvements/Downtown-cycle-track-pilot-project.aspx

Cycle Track

Cycle tracks are cycle-only facilities that aim to provide cyclists with a safe transportation network for commutes and recreational activities involving cycling as a transportation alternative. These cycle tracks require a step further in the investment of cycling facilities since the nature of the facilities is to provide separation by physical means from roadways and sidewalks to minimize potential interaction with vehicles and pedestrians.

Definition

Cycle tracks are cycle-only facilities that are physically separated from other transportation facilities (sidewalks and roadways) by means of a physical barrier or grade. These facilities provide adequate space for cyclists to travel safely with minimal conflicts with vehicles and pedestrians.

Objective

In the U.S., 41% of daily trips made are less than 3 miles. This distance could be traveled in approximately 18 minutes at a speed of 10 miles per hour making bicycle travel feasible. The active inclusion of cycle tracks could make the activity more appealing for people to jump onto a bicycle and commute to work or other destinations providing cyclists with a series of benefits that span from increased physical performance, improved health, and other wellness benefits. Additionally, bicycling is often a lest costly form of transportation.

Advantages

Cycling is an environmentally friendly transportation alternative that incurs a low economic investment for individuals who seek it as their transportation method of choice, and has a reduced environmental footprint when compared to roadways. The needs for vehicle parking stalls could be reduced in favor for less spacious and less expensive bicycle stalls. Construction costs of cycle tracks can be 10 times less expensive than roadway construction costs. Economic benefits of cycle tracks can exceed costs by a ratio of 3:1.

Challenges

The main challenge of cycle tracks is to make them appealing for public usage. The public has to feel that the facility will serve their essential transportation demands. Additionally, for cycle track success, an extensive transportation network for cycling has to be constructed to reinforce cycling as a real alternative for transportation. Furthermore, cycle tracks are the most expensive cycling facilities when compared to bike lanes and bike routes.

Cost: 

Feasibility: 

Level of Maturity: 

Level of Acceptance: 

PARKING

Car Park Management Systems

Definition
Car Park Management involves creating an efficient and easy to use system for drivers to locate their parking spots and for the parking facility to account for available parking spots. Features such as ultrasonic detectors will transmit data to the central station on whether a spot is occupied or not. A guidance system will also be in place to guide drivers to their respective spots with LEDs and arrows. To prevent drivers from occupying spots that are not assigned to them, a system can be used to assign vehicles with QR codes or license plate reading technology to match the vehicle to their spot and enforce a fine if a violation were to occur.

Objective
To create a parking management system that reduces time, fuel, and congestion due to vehicles that are circling around looking for parking.

Advantage
The system will provide a direct and easy to use service to find parking. Drivers will be able to reserve parking spots and pay in advance through a smartphone app. There will be a reduction in time spent searching for parking, lower vehicle emissions, and lower congestions within parking facility.

Challenge
Systems are often costlier than traditional parking facilities due to additional infrastructure and technology costs. Additionally, people often require education on the system. In the future, a majority of vehicles on the road are anticipated to be autonomous. Parking structures without parking management technology have fewer options in accomplishing this transition effectively. To this end, the goal would be to design a system that functions when vehicles have drivers but could be easily adapted to autonomous operation.

Images (Main to Top to Bottom):
Source: Autostadt
http://jalopnik.com/vws-200-foot-tower-of-cars-must-be-seen-to-be-believed-1691271455
https://www.autostadt.de/documents/20182/55363/AutoT%C3%BCrme%20(Copy).jpg/d2893540-532c-420f-91d7-b644bd065863
http://www.newlaunches.com/wp-content/uploads/2013/02/autoparkit-5-590x390.jpg
http://businessjournaldaily.com/auto-parkit-la-site-opens-warren-next/

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:

Fully Automated Parking Structures

Automated parking will provide drivers and even autonomous vehicles a fast and efficient method of parking. Automated parking can work by simply leaving your vehicle at a drop off point for pickup where it will be transported to an assigned stall. The actual transferring of the vehicle or smart valet can be done in various ways.

AutoParkit

Located in Los Angeles, California, the AutoParkit facility is a fully automated valet service. Patrons simply leave their vehicles in the loading bay and the vehicle is transported to one of the stalls. “Cars are retrieved by a fob swipe in 40 to 120 seconds, delivered nose-out for ease of exit.”.

Images (Left to Right)
Ihttp://autoparkit.com/wp-content/uploads/2017/02/Capture-2.jpg
http://parkplusinc.com/wp-content/uploads/2016/12/PARK-PLUS-Automated-Parking.jpg
https://www.digitaltrends.com/cars/volkswagen-autostadt-car-towers/
http://twistedsifter.com/2012/01/volkswagen-car-towers-in-germany/
http://www.reuters.com/video/2012/04/04/worlds-biggest-car-delivery-center?videoId=232867514
http://www.designboom.com/technology/volkswagen-parking-lot-towers-at-autostadt

ParkPlus

In Boulder, Colorado, ParkPlus has created a fully autonomous parking structure. The ParkPlus system works by using lasers to scan incoming vehicles and a robotic valet to park the cars. The vehicles are then put into place by a robotic dolly that lifts the vehicles to a storage rack. “Using this system, up to 4 times as many cars can be parked in the same amount of space as a traditional garage” (Forbes). When the time comes to depart from the structure, the robotic valet has an average retrieval time of 3-5 minutes. The smart valet service is able to accommodate 60 of the 300 available parking spaces for the facility. Due to the nature of this particular style of parking service, it is the first of its kind with a time frame to widespread acceptance expected to be 20 years plus.

AutoTürme

Located in Wolfsburg, Germany, this parking facility was constructed between 1998 and 2000. The facility is the final stage of Volkswagen’s production line at Wolfsburg, where vehicles are stored prior to being delivered to the customers who desire to pick their brand new vehicles at this facility. A robotic pallet system mounted on each lift is positioned underneath the vehicle in question and lifts the vehicle which is then transported (to the facility’s entrance or available parking space depending on the need) at an average rate of 1.5 meters per second.

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of acceptance:

Electric Vehicle Support

The rise of Electric Vehicles (EVs) is well documented, every year the technology becomes more efficient allowing for longer ranges and lower price tags. As the usefulness and affordability of EVs continues to drop they will become even more prevalent. As such, any parking system will need to take a greater percentage of EVs into account.

Image
http://insideevs.com/elon-musk-tesla-supercharger-v3-coming-output-350-kw/

Resources
https://www.tesla.com/supercharger
https://electrek.co/2017/02/27/high-power-fast-charging-station-150-350-kw-evgo-abb-tesla/
https://electrek.co/2016/11/29/ultra-fast-charging-electric-car-network-bmw-mercedes-ford-vw/
https://electrek.co/2017/01/05/chargepoint-400-kw-charing-electric-vehicle-range
https://www.greenbiz.com/blog/2014/05/07/rmi-whats-true-cost-ev-charging-stations
http://insideevs.com/new-ev-trend-fast-tracking-ultra-fast-dc-fast-chargers/
http://www.plugincars.com/quick-guide-buying-your-first-home-ev-charger-126875.html
http://www.fleetcarma.com/electric-vehicle-charging-guide/
http://www.plugincars.com/electric-car-quick-charging-guide.html

High Speed EV Charging

Definition

Companies such as Ford, VW, BMW, Audi, Porsche, Mercedes-Benz, Chargepoint, EVgo, ABB, Tesla, among others, are researching on the future implementation of “ultra-fast” DC charging stations with a capacity in excess of 350 kW. Existing top of the line DC chargers provide outputs between 120 kW - 150 kW.

Objective

With charging stations having outputs in the proximity of 350 kW, fully charging an EV with an empty battery can take noticeable less time than current expected charging times. Direct current (DC) electric-vehicle charging technology allows for vehicles to be charged from an empty battery to a full charge in approximately 1.25 hours (according to Tesla’s website simulation on the Model S charging time) to 1.33 hours (according to Tesla’s website simulation on the Model S charging time). These rates are based on current charging capacity that Tesla’s superchargers can provide with up to 145 kW of power. Ultra fast charging rates can allow a vehicle to charge sufficient for 190 mile range in as little as 20 minutes. At 350 kW, charging times are significantly reduced and parking space turnover is more important.

Advantages

Charging an EV with an empty battery can take noticeable less time than current expected charging times; particularly when charging past 80% battery capacity.

Challenges

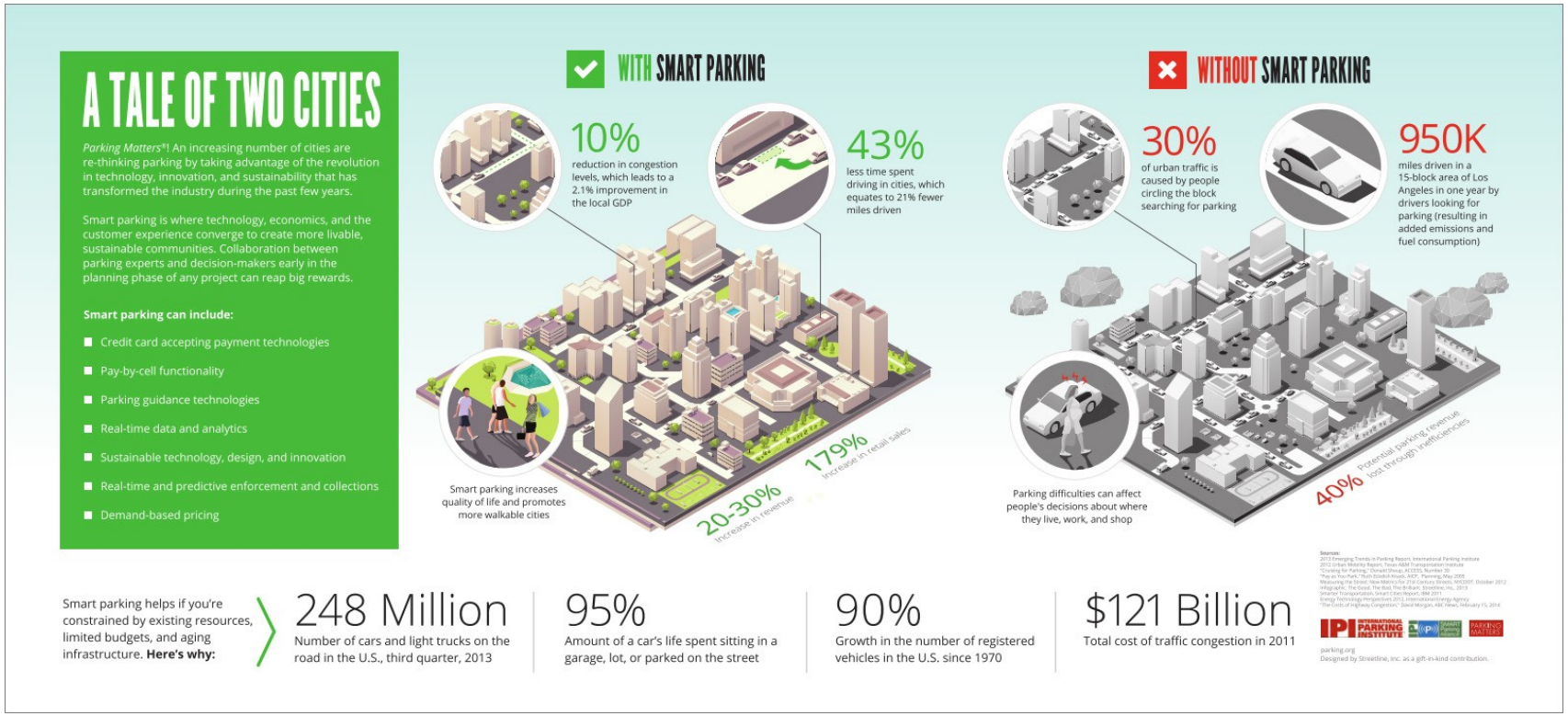
High cost of high speed DC charging stations means that ultra-fast charging stations incur a higher cost.. Retrofitting for those vehicles may be required from the automotive manufacturers; potentially expensive. Installing the power infrastructure and service points should be considered early to reduce future retrofit costs.

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of acceptance:


A TALE OF TWO CITIES
Parking Matters®! An increasing number of cities are re-thinking parking by taking advantage of the revolution in technology, innovation, and sustainability that has transformed the industry during the past few years.
Smart parking is where technology, economics, and the customer experience converge to create more livable, sustainable communities. Collaboration between parking experts and decision-makers early in the planning phase of any project can reap big rewards.
Smart parking can include:
Credit card accepting payment technologies
Pay-by-cell functionality
Parking guidance technologies
Real-time data and analytics
Sustainable technology, design, and innovation
Real-time and predictive enforcement and collections
Demand-based pricing
WITH SMART PARKING
10%
reduction in congestion levels, which leads to a 2.1% improvement in the local GDP
43%
less time spent driving in cities, which equates to 21% fewer miles driven
Smart parking increases quality of life and promotes more walkable cities
20-30%
increase in revenue
179%
increase in retail sales
WITHOUT SMART PARKING
30%
of urban traffic is caused by people circling the block searching for parking
950K
miles driven in a 15-block area of Los Angeles in one year by drivers looking for parking (resulting in added emissions and fuel consumption)
Parking difficulties can affect people's decisions about where they live, work, and shop
40%
Potential parking revenue lost through inefficiencies
Smart parking helps if you're constrained by existing resources, limited budgets, and aging infrastructure. Here's why:
248 Million
Number of cars and light trucks on the road in the U.S., third quarter, 2013
95%
Amount of a car's life spent sitting in a garage, lot, or parked on the street
90%
Growth in the number of registered vehicles in the U.S. since 1970
$121 Billion
Total cost of traffic congestion in 2011
IPI INTERNATIONAL PARKING INSTITUTE
parking.org
Designed by Streetline, Inc. as a gift-in-kind contribution.


OP 12345
OP 12345


IN
PARKING
OUT
7/F PARKING
SPACE AVAILABLE
Available Lots
RFID Reader
Barrier Gate
Ticket Dispenser
Guiding Display
Ultrasonic Sensor
RFID Reader
Barrier Gate
Exit T
Veri

Autopay/Auto-tolling

Automatic parking payment is nothing new, these systems have been in place for years, but there are still ways for this technology to be implemented in innovative ways.

Definition

Autopay works by using automated pay stations and exit lanes in parking structures to eliminate the human element of paying for parking. These methods allow drivers to enter, pay, and exit the parking structure in a more efficient manner.

Objective

Using tolling machines on the various levels of parking structures or even allowing drivers to pay for parking ahead of time using apps such as ParkWhiz to reserve spaces in advance.

Advantages

These measure allow for optimization of structures entrances and exits so people are not stuck in long lines waiting for human parking attendants. In the event of individuals paying ahead of time this method will allow for even shorter lines as these people do not need to receive tickets at the entrance.

Challenges

Maintenance of these systems can be pricey and if the system for any reason goes down for any significant length of time the structure will be severely impacted.

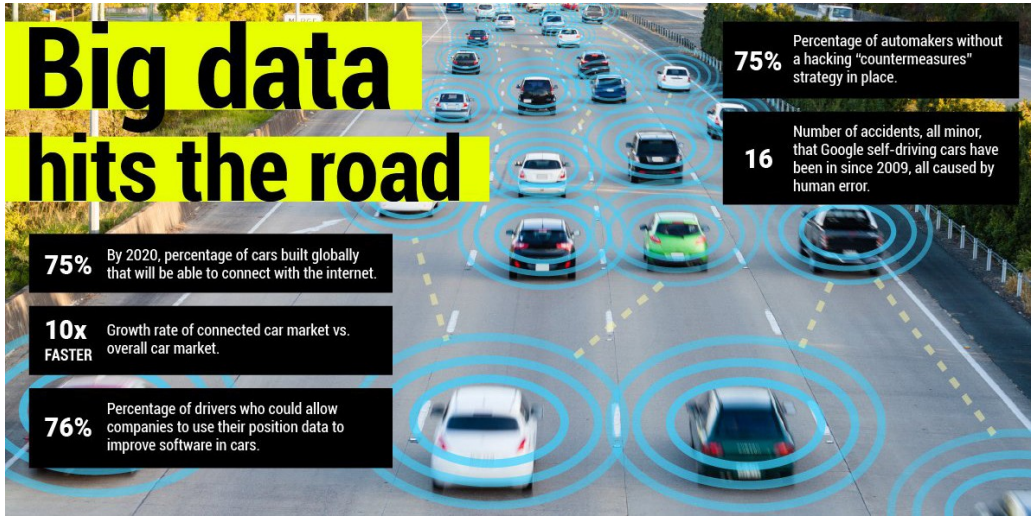
Resources
"Guaranteed Parking | Find and Book Parking Anywhere." ParkWhiz. N.p., n.d. Web. 24 July 2017. <https://www.parkwhiz.com/>.
https://www.youtube.com/watch?v=mhqgoGlmQXY
Image 1
https://www.alibaba.com/product-detail/On-street-Parking-Cash-Charge-Card_60472732401.html
Image 2
https://www.alibaba.com/product-detail/Parking-Card-Vending-Machine-Autopay-Station_60306808022.html
Infographic
http://www.parking.org/wp-content/uploads/2015/12/Tale-of-Two-Cities-Smart-Parking-Infographic.png

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:



Images (Clockwise from Top Left)
https://www.ericsson.com/en/publications/ericsson-technology-review/archive/2016/ludanek-on-ict-and-intelligent-transportation-systems
http://www.montana.edu/news/16120/msu-researchers-to-collabo- rate-on-automated-and-connected-vehicle-research-opportunities
Resource
http://www.businessinsider.com/connected-cars-2015-9

CONNECTED VEHICLES

Vehicle to Vehicle (V2V) - Vehicle to Infrastructure(V2I) - Vehicle to Everything (V2X)

Definition

What are connected vehicles? The concept at its most basic can be explained as vehicles communicating both with each other and with the environment around it. Connected vehicles are the future of motoring in the developed world and the United States Department of Transportation (USDOT) is already taking steps to provide guidelines for the devices that will eventually be installed in vehicles.

The National Highway Traffic Safety Administration (NHTSA) has estimated that the cost of vehicle-to-vehicle equipment (V2V) and support would cost in the range of $350 by the year 2020.

Advantages

Connected vehicles will drastically improve safety for both drivers and cyclists/ pedestrians. “NHTSA preliminary estimates of safety benefits show that two safety applications—Left Turn Assist (LTA) and Intersection Movement Assist (IMA)—could prevent up to 592,000 crashes and save 1,083 lives saved per year.” (USDOT). LTA would warn the driver not to enter the intersection if there is another driver going straight in the opposite direction while IMA would be responsible for warning against entering an unsafe intersection. Additional connected vehicle applications involve wayfinding, safety, speed data and more. Some examples are noted below.

Mobile Accessible Pedestrian Signal System (PED-SIG): An application that allows for an automated call from the smart phone of a visually impaired pedestrian to the traffic signal, as well as audio cues to safely navigate the crosswalk.

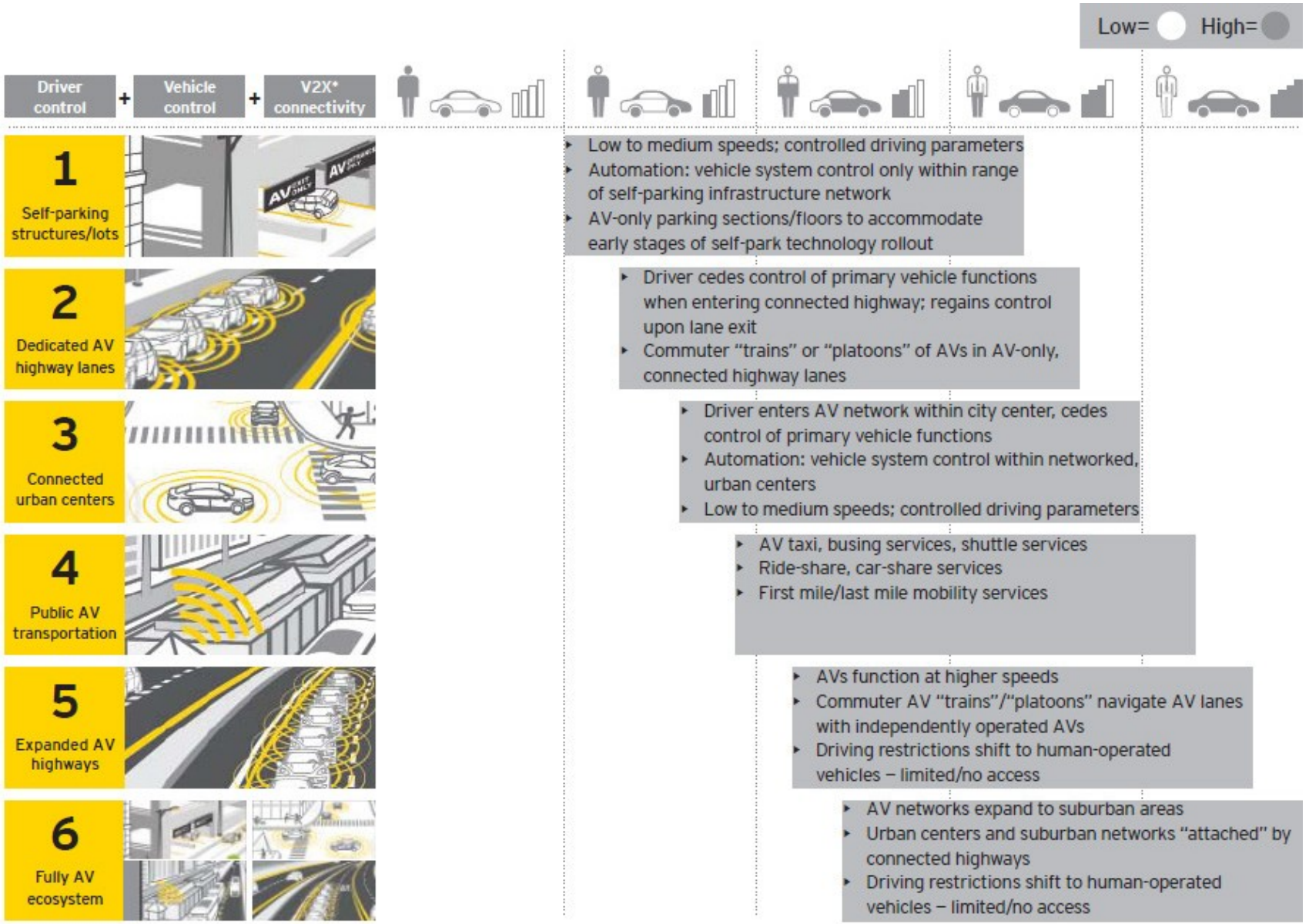
Transit Bus Stop Pedestrian Warning: An application that alerts transit bus drivers and pedestrians at major bus stops when passengers are in harm’s way as buses pull into and out of a bus stop.

Even though improving mobility and efficiency are not the main goals of connected vehicles, the technology will allow for improvements in these areas. One advantage is the ability to detect and warn drivers of upcoming queues to reduce heavy last-second braking. Another is an application called Dynamic Speed Harmonization which can recommend target speeds as a result of congestion or nearby incidents. Not just individual vehicles will be positively impacted, transit will be improved by the implementation of Transit Signal Priority.

The best that current technology is capable of doing is using a variety of cameras and sensors to attempt to warn the driver should an accident be incoming on the present course. Connected vehicle technology will vastly increase the range at which drivers can be warned about upcoming dangers. If vehicles are communicating with each other, then problems ahead can be detected without needing to have a direct line of sight such as over a hill or around a blind bend in the road.

Challenges

The primary challenges present with current Connected Vehicle technology involve data security, precise positioning and widespread adoption. It is likely that Connected Vehicle technology will be mandated by government agencies which could lead to rapid and costly retrofits if not planned in advance.


Low=
High=
Driver control
+
Vehicle control
+
V2X* connectivity
1
Self-parking structures/lots
Low to medium speeds; controlled driving parameters
Automation: vehicle system control only within range of self-parking infrastructure network
AV-only parking sections/floors to accommodate early stages of self-park technology rollout
2
Dedicated AV highway lanes
Driver cedes control of primary vehicle functions when entering connected highway; regains control upon lane exit
Commuter "trains" or "platoons" of AVs in AV-only, connected highway lanes
3
Connected urban centers
Driver enters AV network within city center, cedes control of primary vehicle functions
Automation: vehicle system control within networked, urban centers
Low to medium speeds; controlled driving parameters
4
Public AV transportation
AV taxi, busing services, shuttle services
Ride-share, car-share services
First mile/last mile mobility services
5
Expanded AV highways
AVs function at higher speeds
Commuter AV "trains"/"platoons" navigate AV lanes with independently operated AVs
Driving restrictions shift to human-operated vehicles – limited/no access
6
Fully AV ecosystem
AV networks expand to suburban areas
Urban centers and suburban networks "attached" by connected highways
Driving restrictions shift to human-operated vehicles – limited/no access

Small Cell/5G

Definition

Connected vehicles are expected to be an important feature in future transportation. One must accommodate the increase in mobile devices and other everyday objects that will send and receive data on the same network. In order to support future conditions and the anticipated increase in load that will strain the network, small cells will be installed on infrastructure such as traffic lights and utility poles to increase network capabilities. A large enough number of small cell nodes will need to be installed to support future connectivity needs and serve as a redundant pathway for information. This effort could be coordinated with and largely funded by cellular providers.

Objective

Install a large enough number of small cells to accommodate the future load the wireless network will experience and provide convenience and redundancy for the Internet of Things and connected world.

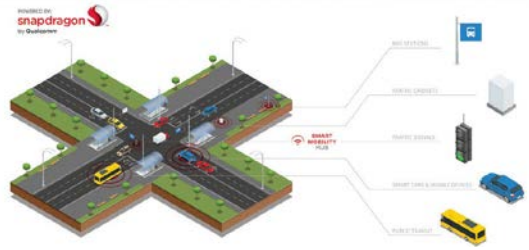
Advantages

A network that will be able to handle a connected world which will provide drivers important information as they are traveling. The network also provides convenience for those traveling in autonomous vehicles. Small Cell technology may be a selling point if consumers are concerned with the latest technology and fastest connection speeds. It is also a revenue opportunity.

Challenges

Seamlessly integrating small cell technology without creating unnecessary clutter or costly retrofits.

Image (opposite page to clockwise from left)
http://www.ey.com/Media/vwLUExtFile/The-case-for-autonomous-vehicles/$FILE/ey-the-case-for-autonomous-vehicles_890x640.jpg
https://www.nash-innovations.com/thinking-ahead/vehicular-small-cells-automotive/
https://www.mobileworldlive.com/featured-content/top-three/small-cell-forum-outlines-plan-for-5g-future/
Qualcomm

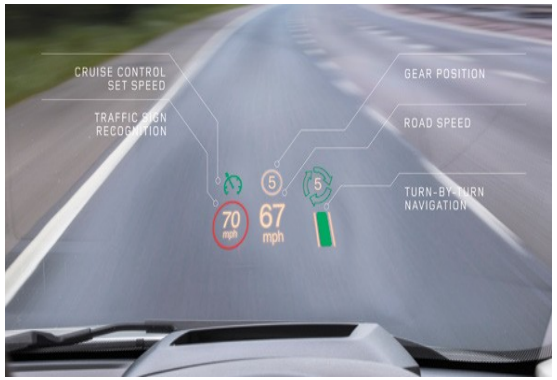


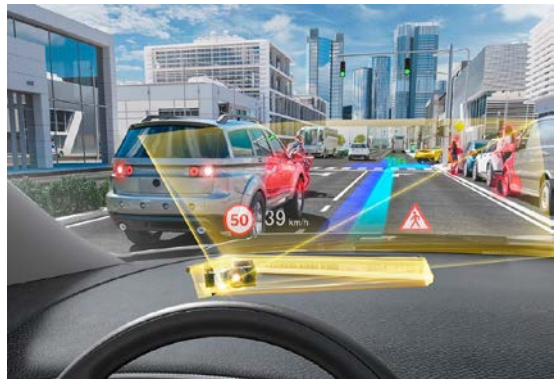
Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:





DSRC

Definition

Dedicated Short Range Communications (DSRC) is a wireless communication that is two way and has a range of short to medium for data transmission. DSRC wireless communications between future connected vehicles will ensure safety and traffic efficiency.

Objective

To set up DSRC network to support future vehicle to vehicle and vehicle to infrastructure.

Advantages

Can reduce collisions by alerting drivers to possible dangers ahead such as a halted vehicle or sharp road curve. Will be able to allow toll payments and additional convenience to drivers.

Challenges

DSRC technology is not yet widespread. Although it is beginning to be included as standard equipment on newer model vehicles, it requires a Roadside Unit (RSU) on the infrastructure side to operate at full capability.

SPaT/HUD

Definition

Heads Up Display (HUD) within vehicles will be able to display data in relation to Signal Phasing and Timing (SPaT) or directional information. SPaT data includes information on the status of an intersection (green/yellow/red) and timing until a lite changes. SPaT information is able to be broadcast and may interact with connected vehicles via vehicle to infrastructure (V2I).

Objective

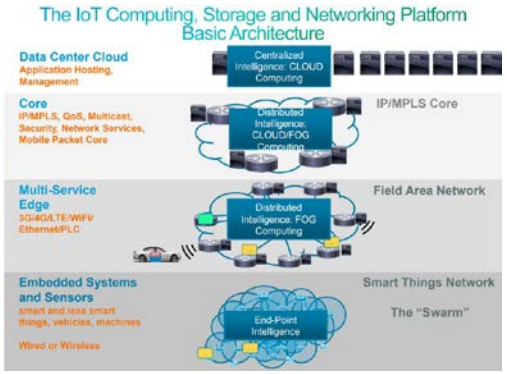
To integrate V2I for connected vehicles and provide additional commute and safety information.

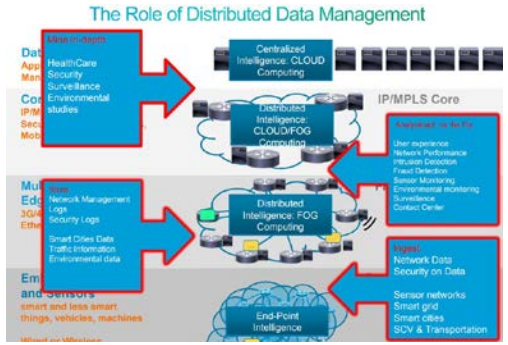
Advantages

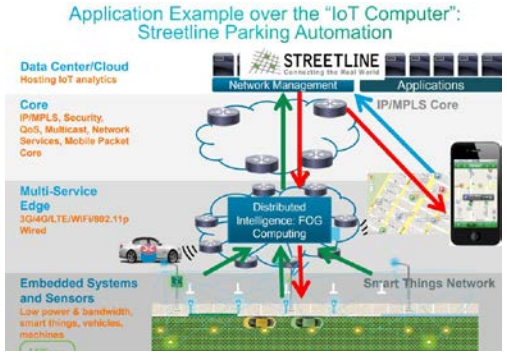
Companies such as Audi are implementing SPaT/ HUD with their vehicles. Drivers will have access to traffic light information and will even have a countdown timer to green. Most automakers have HUD systems within their future development plans.

Challenges

Development of technology that synchronizes HUD and SPaT is still in its early stages. System will need a centrally managed traffic signal system database obtained from public agencies to properly operate.







Edge Node

As everyday objects such as vehicles start to fall under the emerging concept of The Internet of Things (IoT), increased traffic, latency and bandwidth limitations mean that mobility management systems need to operate on multiple layers. Although the traditional City Hall server approach is still common, cloud based computing is making such systems obsolete. Additionally with the significant increase in data handling and management necessary with Connected Vehicles and Autonomous Vehicles, additional computing power is necessary at the local level to authenticate messages, pass information, store data and process time critical applications. As a result, an Edge Node computer is necessary to ensure proper functioning of a true IoT ecosystem.

Definition

An Edge Node computer is seamlessly integrated into local infrastructure and street furniture such as traffic signal cabinets or parking garages to process data needs in the IoT ecosystem.

Objective

Establishing Edge to support an infrastructure for the Internet of Things.

Advantages

A stable network that can handle the load imposed by all interconnected objects will provide the advantages that come with the objects.

Challenges

These devices are still in the design and testing phase. Early examples exist but are not fully optimized for the IoT environment. Additional development is necessary for implementation.

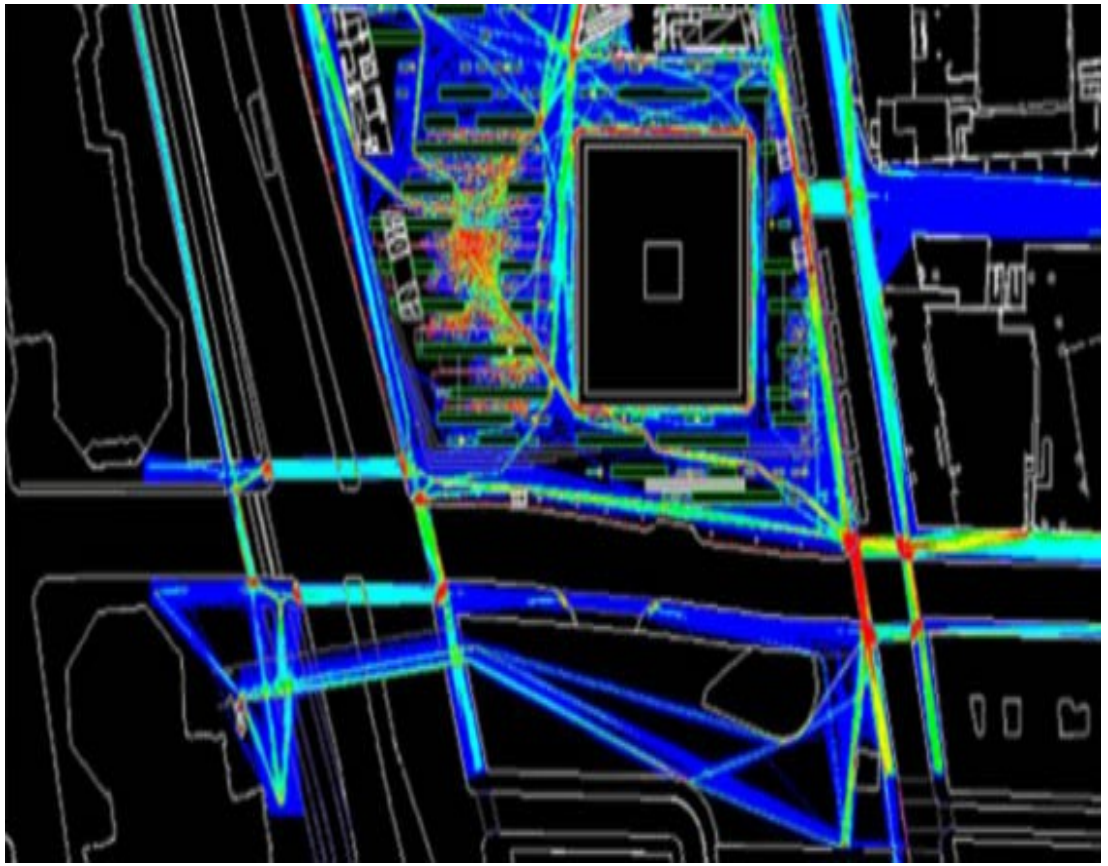
Cost: $$$$$

Feasibility:

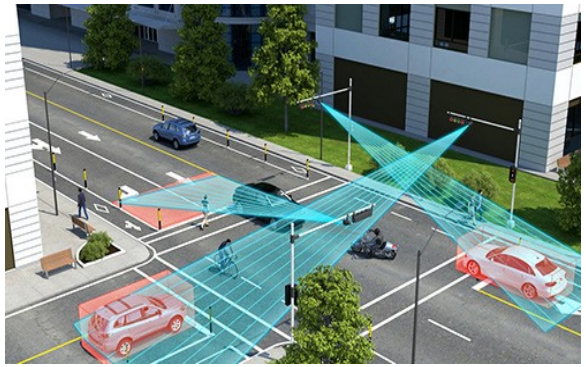
Level of Maturity:

Level of acceptance:

Images (Opposite Page)
https://www.extremetech.com/extreme/240264-hands-audis-exciting-no-really-traffic-light-count-down-timer
Reference:
http://tf.nist.gov/seminars/WSTS/PDFs/1-0_Cisco_FBonomi_ConnectedVehicles.pdf




17.6% FEWER ACCIDENTS.
ENOUGH SAID.
RHYTHM




ENTRANCE
RAMP SIGNAL
LEFT LANE
CARPOOLS
2 OR MORE ONLY
BUSES OK
A series of 12 smart lights on Rosecrans St. from Hancock St. to Nimitz Blvd, has shrunk travel time by 25%

INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

Adaptive Traffic Control Systems

Unpredictable traffic patterns often surpass an agency's ability to update signal timing. This inability prevents intersections from operating efficiently and can cause congestion and delay to all forms of mobility. Conventional signal systems have inherent limitations to a traffic system's ability to perform at peak optimization because they are preprogrammed; their preprogrammed nature limits them to perform based on assumptions made about peak hour traffic patterns. Adaptive signal systems are able to accommodate current traffic patterns by adjusting signal timing settings automatically while monitoring system performance.

Definition

Adaptive Traffic Control (ATC) works by processing data that is received from sensors strategically placed in the roadway system. This information is processed through the adaptive algorithm and is used to determine how to optimize signal timing settings in real-time. Adjustments are made to traffic signal timing settings on a continuous basis—settings such as how long lights should be green to which phase is going to be served next.

Images
http://blog.mordorintelligence.com/framework-of-the-intelligent-transportation-system-its/
http://www.sandiegouniontribune.com/news/politics/sd-me-smart-stoplights-20170309-story.html
http://leddartech.com/intelligent-transportation-systems/
http://rhythmtraffic.com/blog/adaptive-traffic-control/
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https://www.fhwa.dot.gov/innovation/everydaycounts/edc-1/asct.cfm
https://www.fhwa.dot.gov/innovation/everydaycounts/edc-1/asct-faqs.cfm#t1_what
https://www.fhwa.dot.gov/innovation/everydaycounts/edc-1/pdf/asct_brochure.pdf

Objective

ATC aims to provide improvements to roadway conditions by reacting to unexpected traffic conditions and adapting to the needs of the current traffic. By adjusting traffic signal timing on a real-time basis, a more efficient system is provided to all roadway users.

Advantages

This fluidity promotes a smooth flow of traffic and eases congestion for all forms of transportation. This real-time signal timing adaptation caters to unexpected changes traffic conditions and reduces travel time, congestion, and fuel consumption while enhancing the effectiveness of the traffic system.

Challenges

Implementing and adaptive system can be relatively costly, but can save money over time by reducing the frequency of having to manually re-time signals. Improvements to roadway conditions—such as congestion and reduced delay—can also yield direct benefits by providing a less-costly alternative to major roadway improvements.

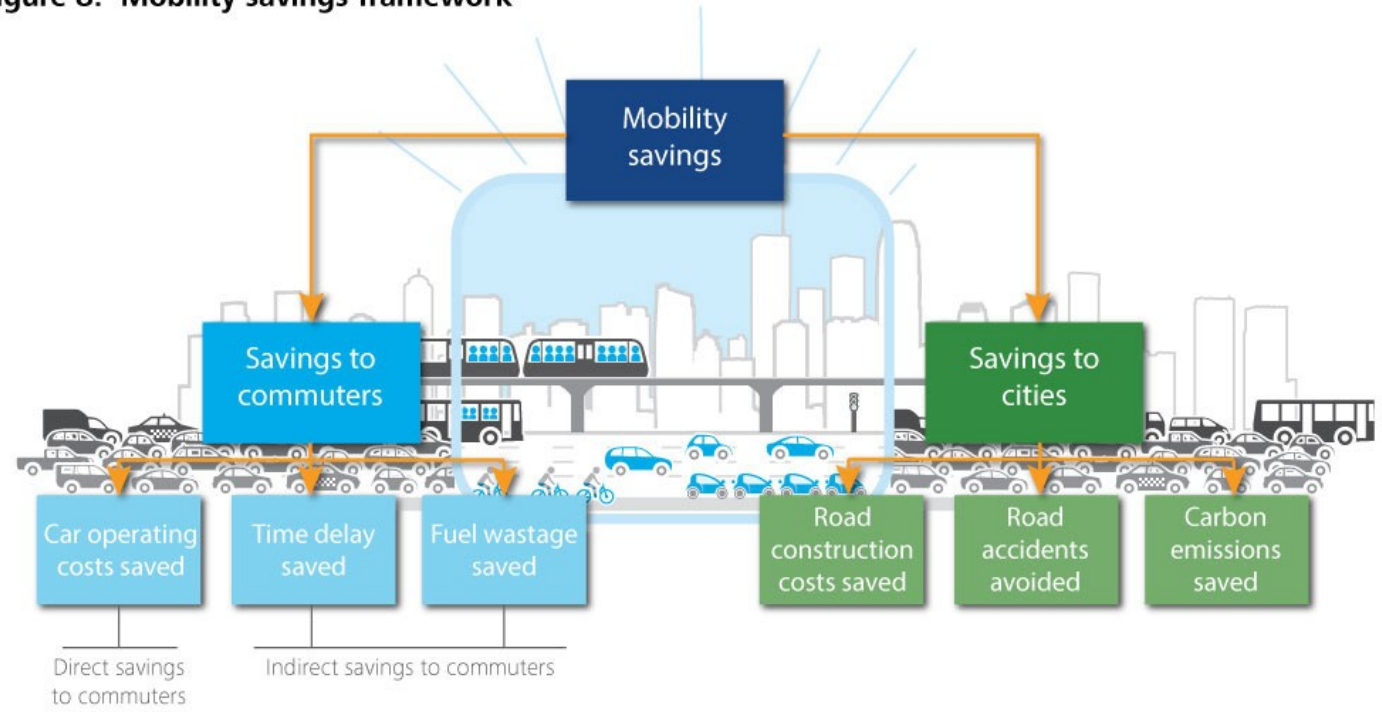
Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:

Figure 8. Mobility savings framework



Graphic: Deloitte University Press | DUPress.com

Digital Infrastructure

Digital Infrastructure is the framework that allows data consumption and data sharing to take place. With everything from cell phones and computers, to appliances and smart mirrors being part of the IOT (Internet of things), the need to facilitate data transfer and utilize big data has grown exponentially. Creating horizontal networks and developing solutions to ease communications from one device to the next all contributes to an internet driven society where evaluation of our data can be utilized to benefit our lives.

Moblie Apps/User Interface

Definition

Integrating apps and technology to facilitate utility while promoting mobility.

Objective

Provide a platform for people to automate their daily tasks, giving them more freedom to focus their attention on what is important to them. The platform could be accessed through stationary kiosks installed at key mobility locations around town, or through one's smartphone device, further connecting the individual to their environment.

Image Opposite Page
https://dupress.deloitte.com/dup-us-en/industry/public-sector/smart-mobility-trends.html
Images/Resources
http://xpressewallet.com/wp-content/uploads/2015/01/sfms-ewallet-1.jpg
Corwin, Scott, Nick Jameson, Derek M. Pankratz, and Phillip Willigmann. "The Future of Mobility: What's Next?" DU Press. N.p., 14 Sept. 2016. Web. 18 July 2017. <https://dupress.deloitte.com/dup-us-en/focus/future-of-mobility/roadmap-for-future-of-urban-mobility.html>.

Some of the ways in which the platform could enhance user experience include:

- Plan a route using various modes of transportation suited to the individual's preferences, financial considerations, and time. Currently, app based ridesharing services have created the first level of automation and accessibility we expect to see in an interconnected future. Uber offers various categories of ridesharing options, including economy, premium, accessibility, and carpool; each category is tailored to a certain experience and function. These options could expand to include autonomous vehicles, pods, rail lines, and bikesharing services among other future methods of transportation.
- Automate repeatable tasks such as reordering supplies and groceries, as well as purchasing transportation fares. The ability to automate these menial tasks ultimately frees up valuable time that can be spent on higher priority duties. We have seen many business models bloom under this key principle, including UberEats, DoorDash, and Amazon Prime services.
- Integrating digital profiles into our live experiences. As autonomous services help liberate our attention from tasks such as driving, companies have begun building on the idea of custom user experiences. In the car scene, designers have begun renovating vehicle interiors that fundamentally change the way we think about commuting, giving passengers the ability to engage in other activities traditionally left outside of the vehicle.
- With integrated services being offered through a mobility platform, further automation can be achieved in many aspects of our daily lives. E-wallets have begun to replace our physical wallets, with users choosing to pay through app based gateways such as Apple Pay at Starbucks and other business'. Expanding the E-wallet to auto-purchase subway and bus fares as you enter the door, or auto-pay for a bike sharing bicycle as you hop on, can further streamline these experiences on a daily basis.

Challenges

Big business working together to facilitate an interconnected future. Many of these concepts are in the early stages of development and implementation, but through their continued collaboration we will see these types of integrated solutions become an essential part of our daily lives.

Transportation Itinerary Kiosk

Definition

Real-time information of various transit traffic delays and costs can be utilized to determine the best possible itinerary plan per-case basis. Now, instead of traveling to your destination solely by bus, the kiosk may recommend an Uber to the nearest drop off location to your destination, potentially saving valuable time in a congested city environment. Alternatively, money might be a factor to consider, and the kiosk may recommend a bike sharing hub followed by a short walk to reach your destination. The Itinerary Kiosk in combination with mobile applications supports concepts such as Mobility-as-a-Service.

Objective

As transportation options become more abundant, deciding how you get from point A to point B can become a problem of efficiency. Next generation transportation kiosks can help alleviate the uncertainty by detailing an optimized route utilizing multiple modes of transportation.

Advantages

Allows individuals to personalize transit plans for wherever they plan on going whenever they plan on going there. These kiosks often support Transportation Demand Management (TDM) programs and are an important element of Mobility Hubs.

Challenges

Consolidating information from several different companies / agencies. Providing visibility and a usable interface for patrons.

Cost: $$$$$

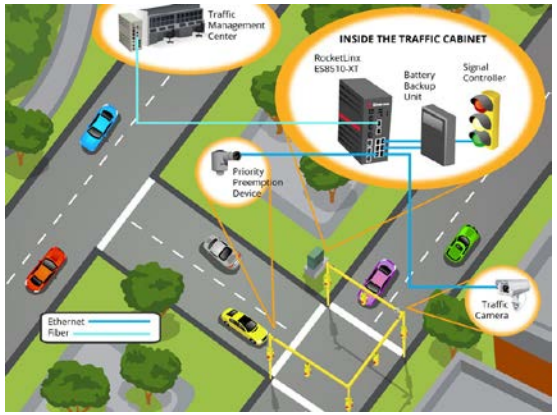
Feasibility:

Level of Maturity:

Level of Acceptance:

Image (Opposite Page to Right)
http://www.digitalavmagazine.com/en/2014/06/24/el-centro-de-transporte-union-depot-se-sumerge-en-la-senal-izacion-digital-sin-perder-su-estilo-neoclasico/
http://appinfoinc.com/solutions/preemption-priority/

Resource
http://eviewsinc.com/wp-content/uploads/2016/10/09.jpg
Lloyd, Randy. Pardon Our Interruption. Next-Generation Preemption System Clears the Way for Harris County, Texas, First Responders, n.d. Web. 11 July 2017.



Traffic Signal Communications

Traffic signal communications technology is allowing the traffic signal industry to finally catch up to the internet age. A networked traffic signal system is critical to achieving full efficiency of the signal network. It is a bedrock technology on which many other Smart Mobility initiatives rely. Previously private municipal networks are giving way to shared networks which further leverage real estate and investments.

Definition

At its core, traffic signal communications is the networking of traffic signals in order to share information and management commands throughout an area.

Objective

Many municipalities have been working to complete their signal networks for several decades. However, in many places, the equivalent of dial-up modems is common and the networks are slow or non-existent. Installing and maintaining high-speed fiber optic lines only for traffic signal communications is a costly and disruptive option for many agencies. However, completing a traffic signal network is critical to maximizing the efficiency of the roadway system. As technology and business models have evolved, new options are available making effective signal communications possible.

Advantages

Significantly greater efficiency in a transportation network. This technology is also an enabling or bedrock technology for many other technologies.

Challenges

Retrofitting older areas can be costly and difficult.

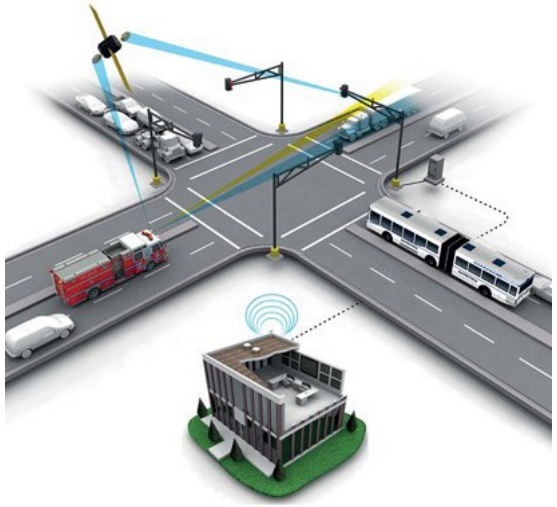
Cost: $$$$$

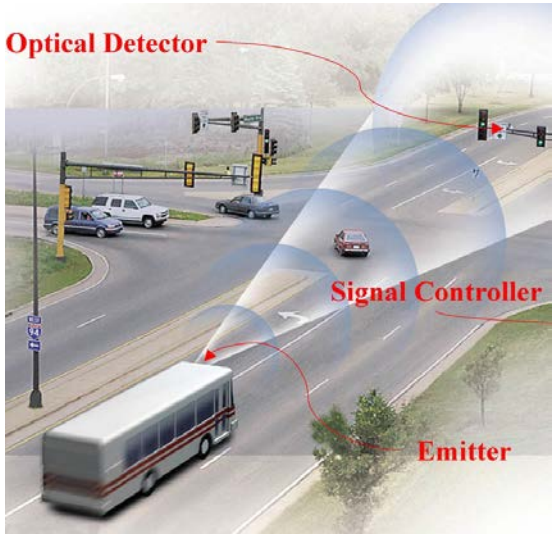
Feasibility:

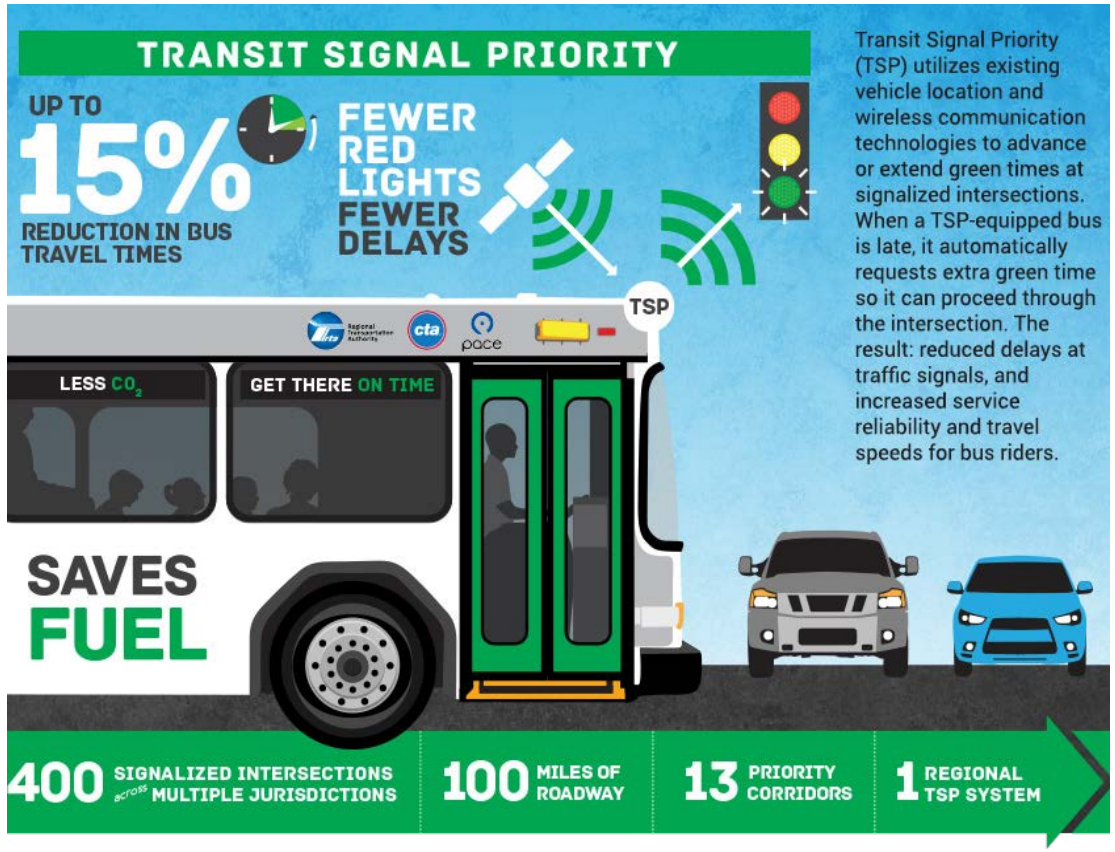
Level of Maturity:

Level of Acceptance:

Images
http://cms.ukintpress.com/UserFiles/Image/TTT%20images/2016/07%20July/3_%20Austin%20ATD%20Transportation_Management_Center.jpg
http://blog.comtrol.com/wp-content/uploads/2015/05/IowaDOT.jpg
https://static1.squarespace.com/static/56ca7c77859fd07d71bf2961/587a2a1403596eda8ab28ebd/587a2a1529687f8f4b9cea28/1484401197564/Picture3.png?format=500w




Optical Detector
Signal Controller
Emitter


TRANSIT SIGNAL PRIORITY
UP TO
15%
REDUCTION IN BUS TRAVEL TIMES
FEWER RED LIGHTS FEWER DELAYS
Transit Signal Priority (TSP) utilizes existing vehicle location and wireless communication technologies to advance or extend green times at signalized intersections. When a TSP-equipped bus is late, it automatically requests extra green time so it can proceed through the intersection. The result: reduced delays at traffic signals, and increased service reliability and travel speeds for bus riders.
TSP
cta
pace
LESS CO_2
GET THERE ON TIME
SAVES FUEL
400 SIGNALIZED INTERSECTIONS across MULTIPLE JURISDICTIONS
100 MILES OF ROADWAY
13 PRIORITY CORRIDORS
1 REGIONAL TSP SYSTEM

Traffic Signal Priority

Traffic Signal Priority has been in place for many years. The concept is to allow a local municipality to determine the priority which should be given to each mode of transportation at different times of day. For example, during rush hour priority might be given to transit followed by vehicles and then pedestrians.

Definition

Also known as preemption, Emergency Vehicle Preemption (EVP), Transit Signal Priority (TSP) and more, this idea allows a priority vehicle to place a “priority call” on a traffic signal and get a green light faster.

Objective

The objective is to allow an agency to provide varying degrees of priority for different modes of transportation and roadway users. Emergency vehicles typically get absolute priority where the light always is green for an emergency situation. Transit vehicles typically get a lower priority than emergency vehicles but more than ordinary traffic so they can keep to their published schedule. Some agencies are now providing priority to bicycles and pedestrians over ordinary vehicle traffic at certain times of day. Together, this concept can provide significant benefits and flexibility in managing traffic flow for all modes.

Advantages

Greater flexibility in traffic management and enhanced safety for emergency vehicles. Additional advantages are provided through information feedback to transportation managers who are able to track and identify different vehicles through the system. This is especially useful to provide up to date transit information at “check-in” points as the vehicles pass signals on the route. It also provides assurance that transit vehicles and circulators will follow a more predictable schedule.

Challenges

Older forms of prioritization are based on line-of-sight communication from the emergency or transit vehicle. This is often blocked depending on roadway geometry and other vehicles who may be blocking the emitter. A robust communications infrastructure must be in place to provide effective operation.

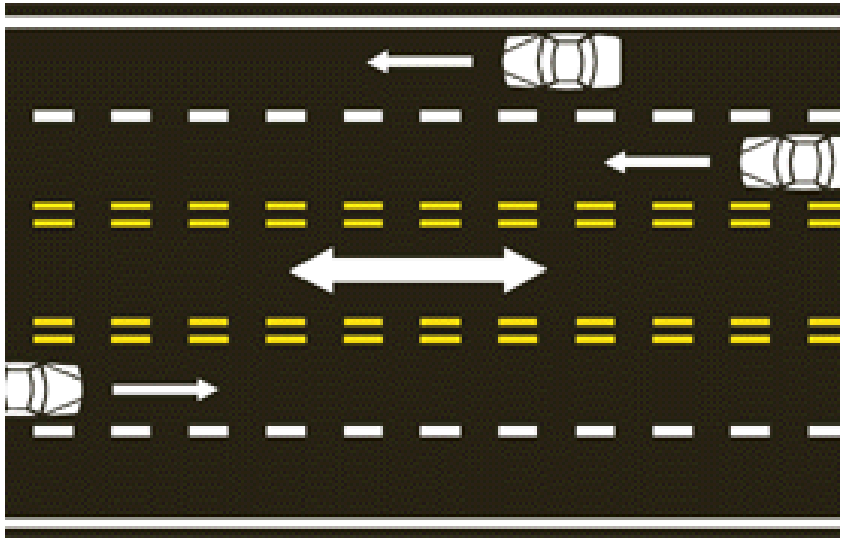
Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:

Images
http://www.itsinternational.com/EasysiteWeb/getresource.axd?AssetID=113311&type=custom&service-type=Inline&customSizeId=18
http://www.rtachicago.org/files/content/TSP/bus-graphic.png
https://publicpolicyforum.org/sites/default/files/blog-images/transit-0109c.jpg
http://www.temple-inc.com/images/Temple-Inc-Emergency-Vehicle-Preemption-priority-control.jpg



Reversible Traffic Lanes

Definition

Reversible Traffic lanes allow capacity to be taken from one underutilized direction and give the capacity to the over-taxed opposite direction.

Objective

To reduce peak hour or special event congestion by opening up additional lanes without having to widen any arterials.

Advantages

Being able to lower queues and wait times without costly construction.

Challenges

Changing roadways has potential to confuse drivers unless there are adequate signs and sufficient warning of lane widening/ dropping.

Images (left to right)
http://www.123driving.com/flhandbook/flhb-pavement-markings.shtml
"Reversible traffic lanes add peak-direction capacity to a two-way road and decrease congestion by borrowing available lane capacity from the other (off-peak) direction" (Mobility TAMU) By borrowing from underutilized directions of traffic additional capacity can be added without the heavy cost of widening roads.
Images/Resources (Opposite Page)
[Videotec ULISSE] http://www.videotec.com/dep/ekr/assets/Marketing/ULISSE_RADICAL_18x_trans.jpg CCTV PRODUCTS FOR TRAFFIC & HIGHWAYS CONTROL. Rep. N.p.: n.p., n.d. Web. 11 July 2017. <https://www.anixter.com/content/dam/Suppliers/VideoTec/Brochures/Traffic%20and%20Transportation.pdf>.
http://www.tatpl-traffic.com/

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:

PTZ Cameras

Definition

Cameras placed at major intersections have been a common sight for years now despite their flaws. Issues with glare, weather, and poor quality at night have held back cameras from being more widely used. European based tech manufacturer Videotec is one of the companies making strides in the area of advanced, durable cameras that can function in the ever-evolving world of transportation. Other manufacturers and vendors have been adding advanced features such as license plate recognition and more.

Objective

To improve upon current generations of traffic cameras and their limitations in terms of maintenance and useful operating hours.

Advantages

PTZ cameras provide significantly greater visibility of roadway operations allowing transportation managers to improve the flow of roadways during challenging times. The cameras also enhance safety by providing more eyes on the street and can improve maintenance efficiency through providing a remote view of potential problem areas.

Challenges

Public perception and cost for retrofit are major challenges facing PTZ installations.

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:

Variable Speed Signs Variable Speed

Variable Speed Signs or Variable Speed Limits (VSLs) aim to warn traffic about potential roadway inclemencies ahead. These systems are intended to function much like roadway sensors who collect live traffic data and can provide a real-time posted speed limit with respect to the collected data. This data can include current traffic volume, work zones, and unsafe weather conditions that require reduced speeds.

Definition

Variable Speed Signs or Variable Speed Limits (VSL) are real-time systems of roadway signs that are used to warn traffic of reductions in speed ahead of time so that they take preemptive action and reduce their speed. These speed reductions can be related to roadway congestion, work zones, or inclement weather.

Objective

Intended to provide traffic with information regarding the most adequate speed ahead of their position, VSLs aim to reduce roadway congestion, stop and go traffic, queuing, and roadway accidents.

Advantages

This technology has been used in Europe since the 1960s with significant success in countries such as United Kingdom, Netherlands, and Germany. VSLs have proven effective in the reduction of roadway accidents, the reduction of traffic speed through the areas of speed reduction, and as law enforcement tools for posted speed limits. With the advent of signal synchronization and adaptive signal control VSLs have more potential application than ever before.

Challenges

Compliance from the drivers is the main concern for public agencies and law enforcement. If the public goes into a speed reduction area and the roadway segment is empty, they may tend to increase their speed above the speed limit and disregard the posted speed limit. Additionally, some systems have been tested in the U.S. and found to have difficulty displaying the proper speed limit. Furthermore, there are challenges that relate to the time appropriateness of reverting the speed limit on the sign to the standard posted speed limit.

Images (Left to Right Start on Opposite Page)
https://www.sabre-roads.org.uk/wiki/images/c/ce/Variable_speed-limit_sign,_Belfast_-_Geograph_-_2081010.jpg
http://www.skylineproducts.com/vsl-2/
http://monitor-electronics.gr/wp-content/uploads/081.jpg
http://www.govtech.com/transportation/Variable-Speed-Signs-Keep-Roads-Safer.html

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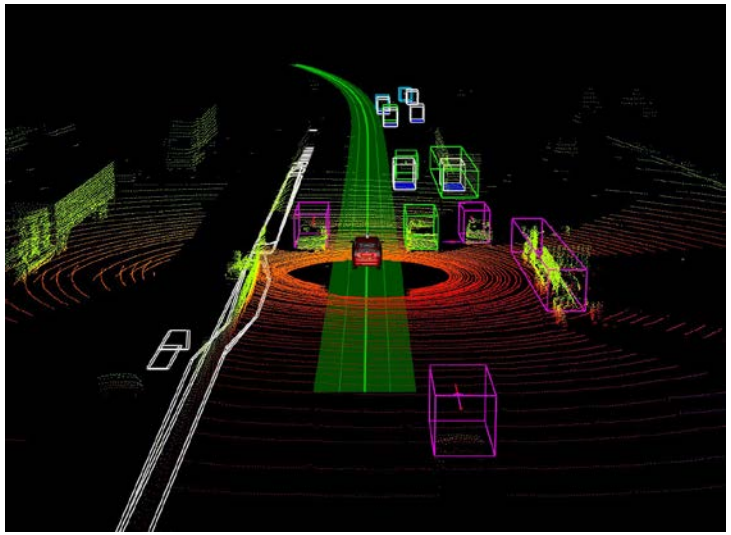
http://www.wsdot.wa.gov/smarterhighways/vsl.htm
http://www.skylineproducts.com/vsl-2/
https://safety.fhwa.dot.gov/speedmgt/vslimits/
https://ops.fhwa.dot.gov/publications/fhwahop17003/
http://www.govtech.com/transportation/Variable-Speed-Signs-Keep-RoadsSafer.html
http://www.itscosts.its.dot.gov/ITS/benecost.nsf/SummID/SC2016-00361?OpenDocument&Query=Home
https://safety.fhwa.dot.gov/speedmgt/vslimits/docs/michiganvsl.pdf

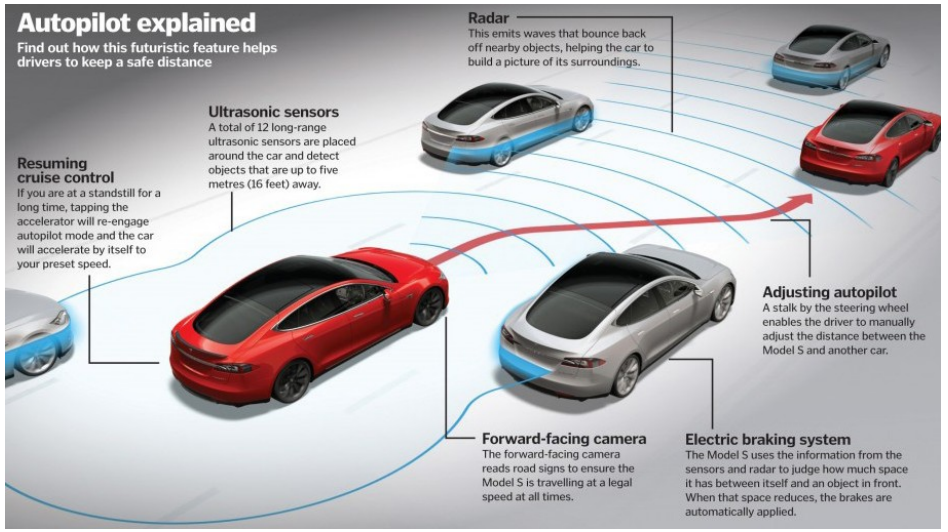
Cost: $$$$$

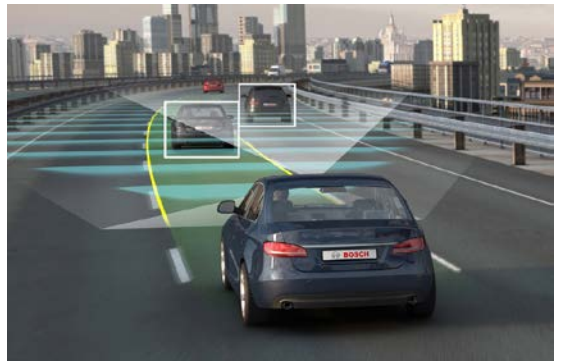
Feasibility:

Level of Maturity:

Level of Acceptance:







Traffic Ahead

Many carmakers are developing prototype vehicles that are capable of driving autonomously in certain situations. The technology is likely to hit the road around 2020.





	BMW	Mercedes-Benz	Nissan	Google	General Motors
VEHICLE	5 Series (modified)	S 500 Intelligent Drive Research Vehicle	Leaf EV (modified)	Prius and Lexus (modified)	Cadillac SRX (modified)

AUTONOMOUS VEHICLES

Technology

Definition:
Fully autonomous vehicles (AVs) are vehicles that require no direct input from individuals to be operated, and that can drive themselves along a route being completely aware of their surroundings and interacting in a safe manner according to the surroundings (signs, traffic signals, other vehicles, pedestrians).

Objective:
By the turn of the next decade, many manufacturers have the objective to provide a vehicle in their line-up with the ability to perform all safety and critical driving functions on top of monitoring roadway conditions for an entire trip. Elon Musk (Tesla's CEO) has promised to showcase the advancements of AVs with a fully autonomous road trip from Los Angeles to New York by the end of the year 2017.

Advantages:
Fully functional autonomous vehicles can potentially decrease the human error factor associated with many traffic accidents (90% of crashes involve human error according to the NHTSA).

Challenges:
For automakers to have virtually zero disengagements per driven mile so that potential clients embrace the idea of being driven by a self driving vehicle. Current LIDAR (Light Detection and Ranging) technology will need to become economically accessible since most automakers and AV developers rely on this technology. Similarly, technology involving radars and high speed processors and cameras (such as Tesla's) will need to become accessible.

Autonomous Vehicle Storage
Autonomous Vehicle (AV) storage units will need to be constructed for the purposes of containing the vehicles during off hours, maintenance, and recharging.

Resources
https://www.theverge.com/2017/7/4/15917180/self-driving-car-congress-bills-waymo-avis
https://www.bloomberg.com/news/articles/2017-02-01/tesla-is-testing-self-driving-cars-on-california-roads
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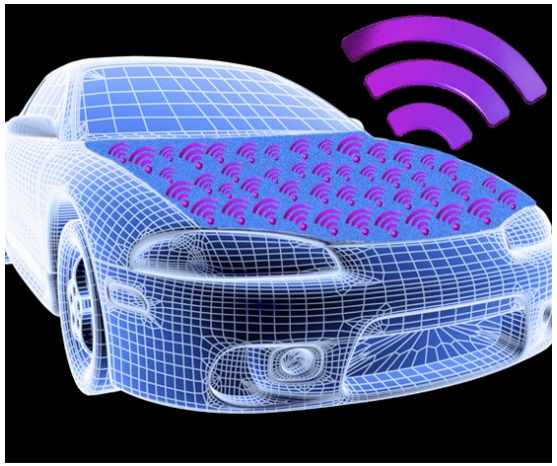
https://www.technologyreview.com/s/520431/driverless-cars-are-further-away-than-you-think/
http://www.driverless-future.com/?page_id=384

Cost: $$$$$

Feasibility:

Timeframe to Maturity:

Widespread acceptance:



Ultra-Wideband Positioning

Definition:

GPS services rely on triangulating a signal through multiple satellites to pinpoint a location in three dimensions. By mimicking the satellite triangulation technique on the ground through sensor networks installed on our existing infrastructure, various companies have achieved centimeter accuracy of their GPS devices for use in autonomous vehicles, among other potential applications.

Objective:

Provide an infrastructure of ultra-wideband positioning that is economic, precise, and easy to install for civilian purposes. Additionally the concept should be expanded upon the enhancement of forthcoming technology innovations such as autonomous vehicles, connected vehicles, and existing roadway network infrastructures such as traffic signals, signs, striping. etc. The accuracy yielded by the constellation sensor networks is what allows vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication to become a reality. These two types of communication will become an integral part of how autonomous networks pass critical information to each other in real time scenarios, ensuring a safe and efficient tomorrow.

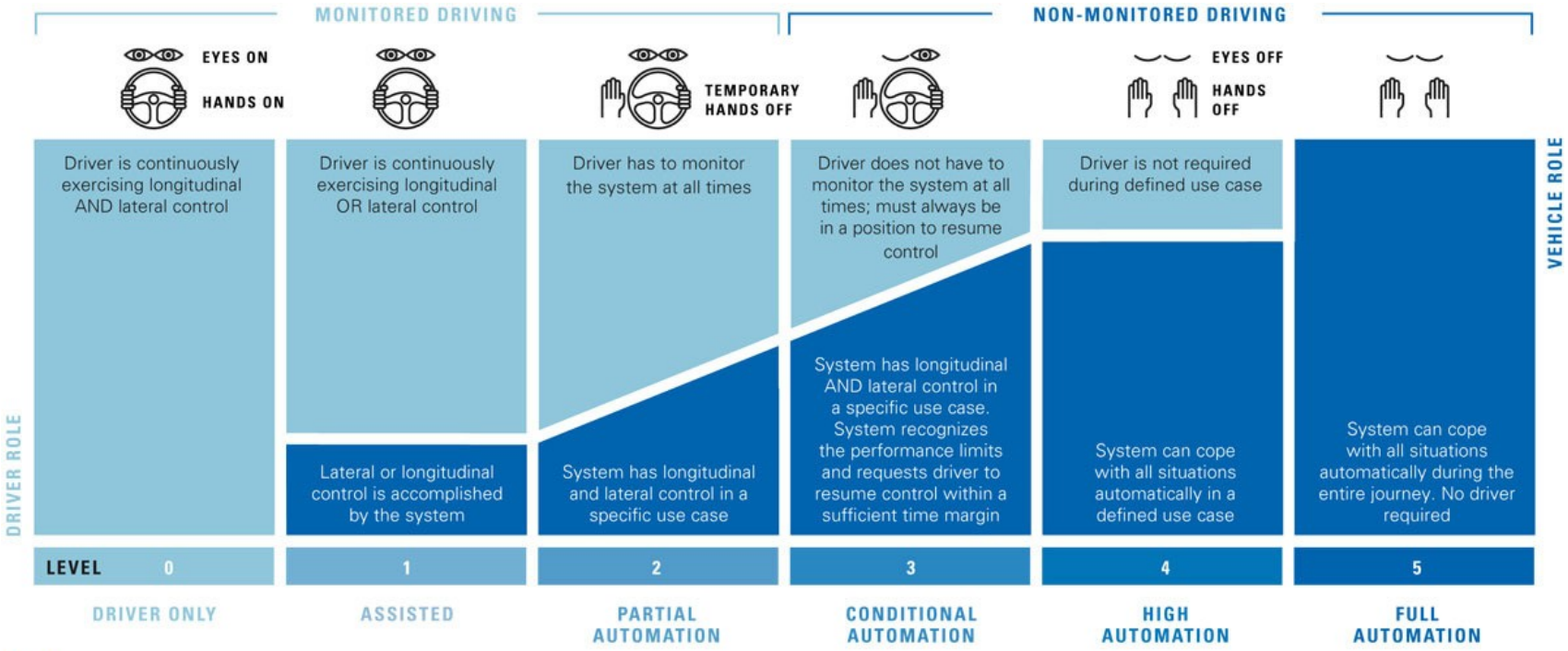
Advantage:

Navigation of AVs that perform mission-critical functions may potentially rely on the accuracy of this concept to operate safely and efficiently. This technology can easily be implemented today, and could potentially automate a whole field of transportation methods.

GPS services rely on triangulating a signal through multiple satellites to pinpoint a location in three dimensions. Traditionally, accuracy is less than ideal without investing a significant amount of resources into the hardware, so pinpointing a location would yield an approximate area instead of an exact location; by contrast, Ultra-Wideband positioning devices required a stationary position, so accuracy was unobtainable on the move in real time. Navigation of autonomous vehicles that perform mission-critical functions rely on this accuracy to operate safely and efficiently, but standard GPS technology lacks the precision to enable an automated future- and that's where the breakthroughs in constellation sensor networks come into play. By mimicking the satellite triangulation technique on the ground through sensor networks installed on our existing infrastructure, various companies have achieved centimeter accuracy of its GPS devices for use in autonomous vehicles, among other applications.

With constellation sensor networks being utilized today, companies such as 5D robotics have already begun designing and implementing autonomous solutions of the future. One of their first applications of the constellation sensor networks allows their virtual rail vehicles to precisely traverse a designated path. The user can easily create and modify paths to enable autonomous transportation. This behavior delivers the reliability and precision of a system on rails but with drastically reduced infrastructure capital expenditure, and no cost to reconfigure paths.

This technology can easily be implemented today, and could potentially automate a whole field of shuttle services and first-last-mile transportation methods.



Mike Lemanski

Challenge:

Establishing a virtual rail route would require sensors to be installed on existing infrastructure along the vehicle's path. This requires up-front investment. Widespread adoption is also a challenge. Although many companies recognize the need and have started moving towards this technology, without a specific application, such as a driverless circulator/shuttle, the cost may not be justified.

Cost: $$$$$

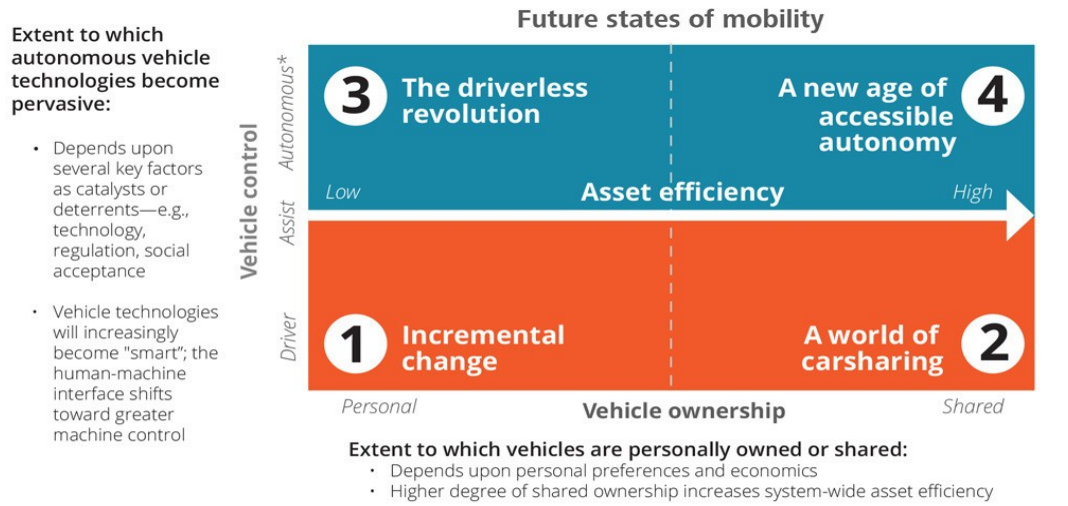
Feasibility:

Level of Maturity:

Level of Acceptance:

Images/Resources
http://www.birmingham.ac.uk/Images/News/AutomatedDriving-table-large.jpg

Figure 1. The future states of mobility



*Fully autonomous drive means that the vehicle's central processing unit has full responsibility for controlling its operation and is inherently different from the most advanced form of driver assist. It is demarcated in the figure above with a clear dividing line (an "equator").

Source: Deloitte analysis.

Graphic: Deloitte University Press | DUPress.com

Images (Left to Right, Top to Bottom Opposite Page)
https://dupress.deloitte.com/content/dam/dup-us-en/articles/3367_Fu- ture-of-mobility-whats-next/figures/Future-of-mobility-whats-next_Fig1.jpg
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Resources
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Autonomous Vehicle Circulator

Definition
A fleet of autonomous electric vehicles which travel on a fixed-route and schedule with additional vehicles available and stored until periods of peak demand.

Objective
To establish a network of driverless vehicles and provide an alternative method for travel to a set destination. AV shuttles will follow a preset route will be equipped with a LIDAR unit, ultrasonic sensors, and cameras to maximize safety for passengers and surrounding vehicles and pedestrians. This system is approaching maturity quickly and could solve last-mile travel problems and enable parking to be located in outlying or less desirable locations while ensuring convenient travel.

Advantage
AV shuttles will be able to carry 6 to 12 passengers, less vehicles on the road will reduce congestion, overall fuel consumption, and vehicle emissions. Additional advantages are the perceived "futuristic" nature which is a major selling point to decision makers, transit agencies and potential consumers/patrons.

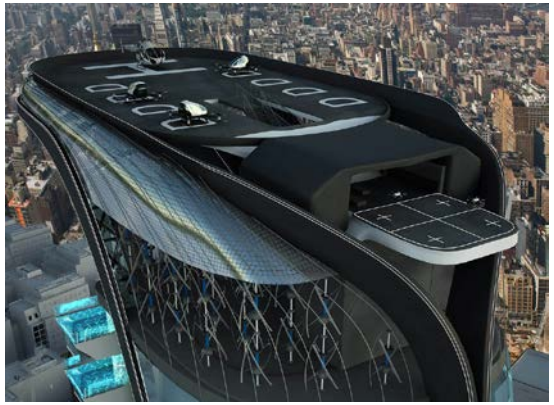
Challenge
The success of an autonomous vehicle circulation system is dependent on the reliability of autonomous vehicle themselves.

Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:



Drone Delivery

Definition

Many companies such as Amazon, UPS, and Google are beginning to implement drones to finalize deliveries to their customers. Currently drones are utilized by launching from delivery trucks that reach a region where multiple deliveries can be completed by a drone, the drone then completes the final one or two miles to the destination.

Objective

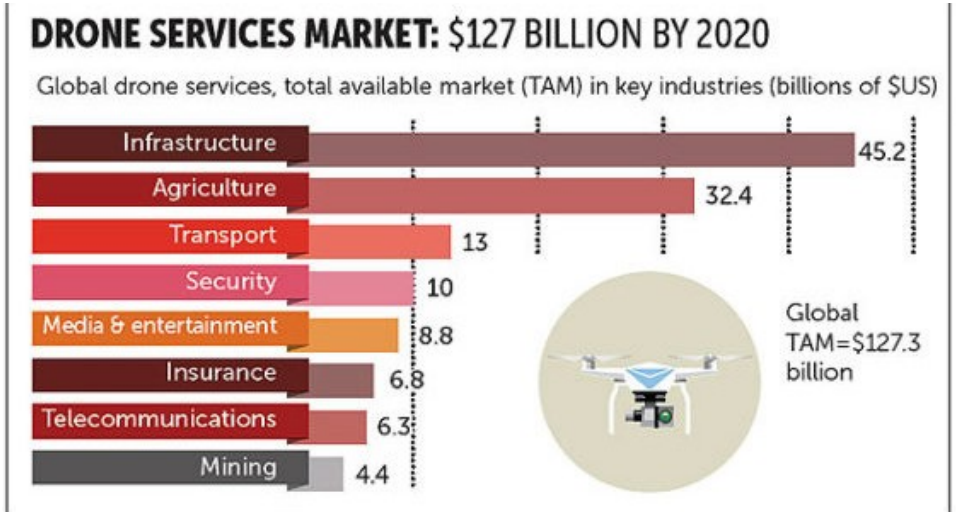
To establish a network of drone delivery and eventually autonomous drone delivery to reduce delivery drive time and increase delivery efficiency.

Advantage

Placing package drop off points on rooftops will be easily accessed by drones and a “Smart Locker” system which Amazon plans to implement, this will allow for security for packages and a structured system for customers to retrieve their packages.

Challenge

Currently as of 2017 the Federal Aviation Administration (FAA) regulations state that an unmanned aircraft is not to be operated beyond the visual line of sight which will hamper autonomous drone delivery. However, the idea of drone delivery in the U.S. remains a possible option as the FAA has stated that there is a plan to operate unmanned aircraft in the Arctic 24 hours a day for research purposes.

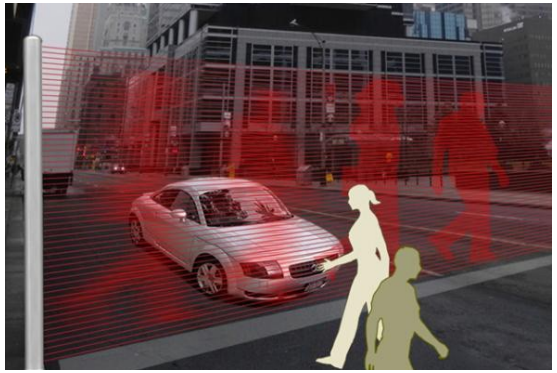


Cost: $$$$$

Feasibility:

Level of Maturity:

Level of Acceptance:



Images (Top Left Clockwise)
http://www.c-ville.com/News_and_ideas_for_sustainable_living/#.WXD8CYgrJaQ
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EMERGING TECHNOLOGY

There are several other emerging technologies which are not widely adopted or which may not provide the same utility or return on investment but which are nonetheless occasionally mentioned. Several of these are mentioned below. However, there are many more in development at various stages or which may have a particular application.

Pervious (Porous) Concrete

Definition

Traditional concrete has issues with heat retention and drainage that have been well documented for decades. Pervious concrete can be utilized in many of the ways traditional concrete has been implemented, including low volume streets, driveways, sidewalks, golf cart paths, retaining walls, slope prevention, and French drains.

Objective

Mimicking natural ground cover drainage has led to the development of open cell, porous materials for use in concrete construction. The natural drainage that is achieved with porous and pervious materials provide many benefits over traditional concrete.

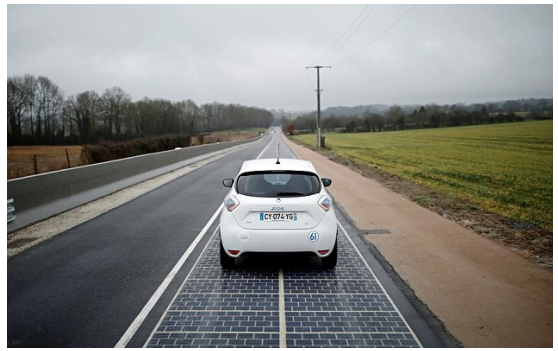
Advantages

- Reduces and cleans stormwater runoff
- Eliminates need for detention ponds and other costly storm water management practices
- Replenishes water tables and aquifers
- Allows for more efficient land development
- Minimizes flash flooding and standing water
- Prevents warm and polluted water entering our streams
- Open cell construction provides a medium for aerobic bacteria to break down harmful toxins, mitigating surface pollutants
- Improve root systems access to air and water, making for healthier, longer-living trees and foliage.
- Prevents water from pooling, eliminating standing puddles
- Helps alleviates the urban heat island effect by absorbing less heat during the day, and retaining more heat during the evening.

The best application of pervious concrete is within parking lots, where the porous material refrains from altering the hydrology of the land it sits upon.

Challenges

- Channeling water flow underneath the concrete.
- Implementing in areas with soil and foliage runoff that can clog the porous structure of the concrete, preventing draining. Intermittent pressure washing must be done in these types of settings to restore the concrete to like-new draining capacity.



Holographic signs

Definition

Holographic signs function by projecting a message to drivers using either a sheet of water or lasers projected between two emitters. “Traditional traffic lights are overshadowed by large electronic advertising signs, and the focus is lost at these intersections because the lights are less visible.” Holographic signs can provide a more direct view of signage with potential for safety enhancement. It should be noted that holographic signs are not currently recognized or approved in the MUTCD for public roadways.

Objective

Holographic signs attempt to fix the distraction problem by presenting the driver with a large message right in front of them that they are forced to react to.

Advantage

Provides an increase in safety for both the driver and for bicycles/ pedestrians.

Challenges

Water-based method requires additional storage and laser-based technology isn't ready yet.

Photo-Voltaic Roads

Definition

Photo-voltaic Pavements are roadways designed to collect solar energy through use of photo-voltaics or solar panels. The pavement generates electricity by collecting solar power through use of photo-voltaics which convert light into electricity by using semi conducting materials. The method of converting light into electricity is commonly used for basic solar panels.

Objective

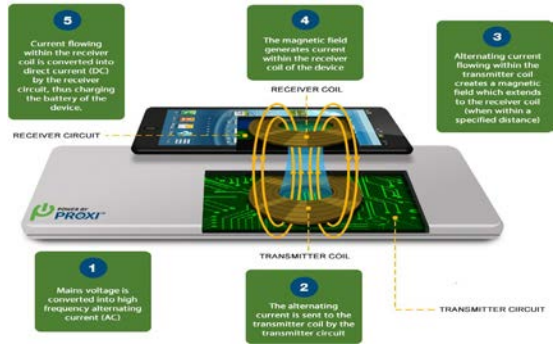
To use solar energy and convert it to electricity and provide a sustainable alternative power source for surrounding uses.

Advantage

Will be able to reuse solar energy for electricity to power equipment such as street lights and lower cost of using conventional energy means.

Challenge

The application is still fairly new and the existing photo-voltaic road in Normandy, France costs $5.2 million which is higher than a conventional pavement road.



Inductive Charging

Definition

Wireless charging uses electromagnetic fields to transfer power from transmitting devices to receiving ones.

Objective

In the future the technology will expand to stationary charging at intersections or parking spots and farther down the road potentially include segments of highways that charge your vehicle as you drive.

Advantages

One of the biggest advantages of inductive charging is that when the system is in place it allows for smaller and lighter batteries in cars because of the ability to charge while on the move.

Challenges

Cost will be extremely high, technology needs to develop.

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Musical Roads

Definition

Musical roads provide a fun incentive for drivers to obey the speed limit by playing an audible tone as their vehicle drives over grooves on the roadway.

Objective

Adding a unique and entertaining way to limit the speed of vehicles through sensitive areas such as a park or residential neighborhood.

Advantages

Musical roads can potentially increase safety by encouraging motorists to not speed or to limit distracted driving by giving the driver something to focus on.

Challenges

Time-consuming construction.

Images/Resources (Opposite Page start Left to Right)
Holographic: https://www.psfk.com/2013/05/light-projected-stop-sign.html Photovoltaic Roads Inductive Charging https://energy.gov/articles/five-things-you-didn-t-know-about-potential-wireless-vehicle-charging
https://powerbyproxi.com//wp-content/uploads/2013/08/how-wireless-charging-works-resonant.jpg Musical Roads: https://www.yelp.com/biz_photos/musical-road-lancaster?select=ci9NBXJVNdN6K- PENi5YQhQ