https://www.aerospacearizona.org/summit2018

The Autonomous Transportation Revolution on the Ground and in the Air

Thursday, November 8, 2018 at ASU Polytechnic

Presented by

Mark Goldstein, International Research Center

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Presentation Available at http://www.slideshare.net/markgirc

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International Research Center
Your Research Edge

Today, We See Two Transformations In The Mobility Space

1 ..... GAS-POWERED ➡ ELECTRIC

2 ..... HUMAN-DRIVEN ➡ AUTONOMOUS

Autonomous platforms, or Mobility-as-a-Service (MaaS), will come in many different forms, including:

Source: ARK Invest 2018

Safety by the Numbers (U.S.)

- An estimated **39,141** people lost their lives on all modes of our transportation system in 2017. The vast majority—37,133 deaths—were from motor vehicle crashes[A,B]

- *Driver Factors:* Of all serious motor vehicle crashes, **94 percent** involve driver-related factors, such as impaired driving, distraction, and speeding or illegal maneuvers.

  In 2017:

  - Nearly **11,000** fatalities involved drinking and driving.[B]
  - Speeding was a factor in nearly **10,000** highway fatalities.[B]
  - Nearly **3,500** fatal crashes* involved distracted drivers.[B]

- *Commercial Vehicles:* **13 percent** of annual roadway fatalities occur in crashes involving large trucks.[B]

- In 2017, **82 percent** of victims in fatal large truck crashes were road users who were not an occupant of the truck(s) involved.[B]

- *Professional Drivers:* Professional drivers are **ten times** more likely to be killed on the job, and nearly nine times more likely to be injured on the job compared to the average worker.[C]

- *Pedestrians:* **5,977** pedestrians were killed by motor vehicles in 2017, representing 16 percent of all motor vehicle fatalities.[B]

- *Highway-Rail Grade Crossings:* Over the past decade, highway rail grade crossing fatalities averaged **253** per year, representing about one-third of total railroad-related fatalities.[A]

Sources:

A U.S. Department of Transportation, Bureau of Transportation Statistics, special tabulation, September 8, 2018

B NHTSA 2017 Fatal Motor Vehicle Crashes: Overview (DOT HS 812 603)

C Beede, David, Regina Powers, and Cassandra Ingram, *The Employment Impact of Autonomous Vehicles*, U.S. Department of Commerce, Washington, DC: http://www.esa.doc.gov/sites/default/files/Employment%20Impact%20Autonomous%20Vehicles_0.pdf

* *This number is likely underreported.*

Source: U.S. DOT 2018 (https://www.transportation.gov/av/3)

Autonomous Vehicles (AV)

AV WILL CHANGE THE WORLD

Customer Experience	Broader Disruption	Business Opportunity
Saves lives	Resets physical landscape	Biggest business opportunity since the creation of the internet
Creates time and freedom	Reshapes entire industries	Multi-trillion dollar Total Addressable Market (TAM)
Saves money		Very significant moats
Changes everyday life		

Source: General Motors 2017

The auto industry faces never-before seen change

Technological

Autonomous driving

Electrification

Connectivity

Social

Urbanization

New way of working

Sharing

Regulatory

City regulation

Emission standards

Integrated view necessary to assess implications

Source: The Boston Consulting Group 2018

National Highway Traffic Safety Administration (NHTSA) Automated Vehicles for Safety

The Road to Full Automation

Fully autonomous cars and trucks that drive us instead of us driving them will become a reality. These self-driving vehicles ultimately will integrate onto U.S. roadways by progressing through six levels of driver assistance technology advancements in the coming years. This includes everything from no automation (where a fully engaged driver is required at all times), to full autonomy (where an automated vehicle operates independently, without a human driver)..

https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

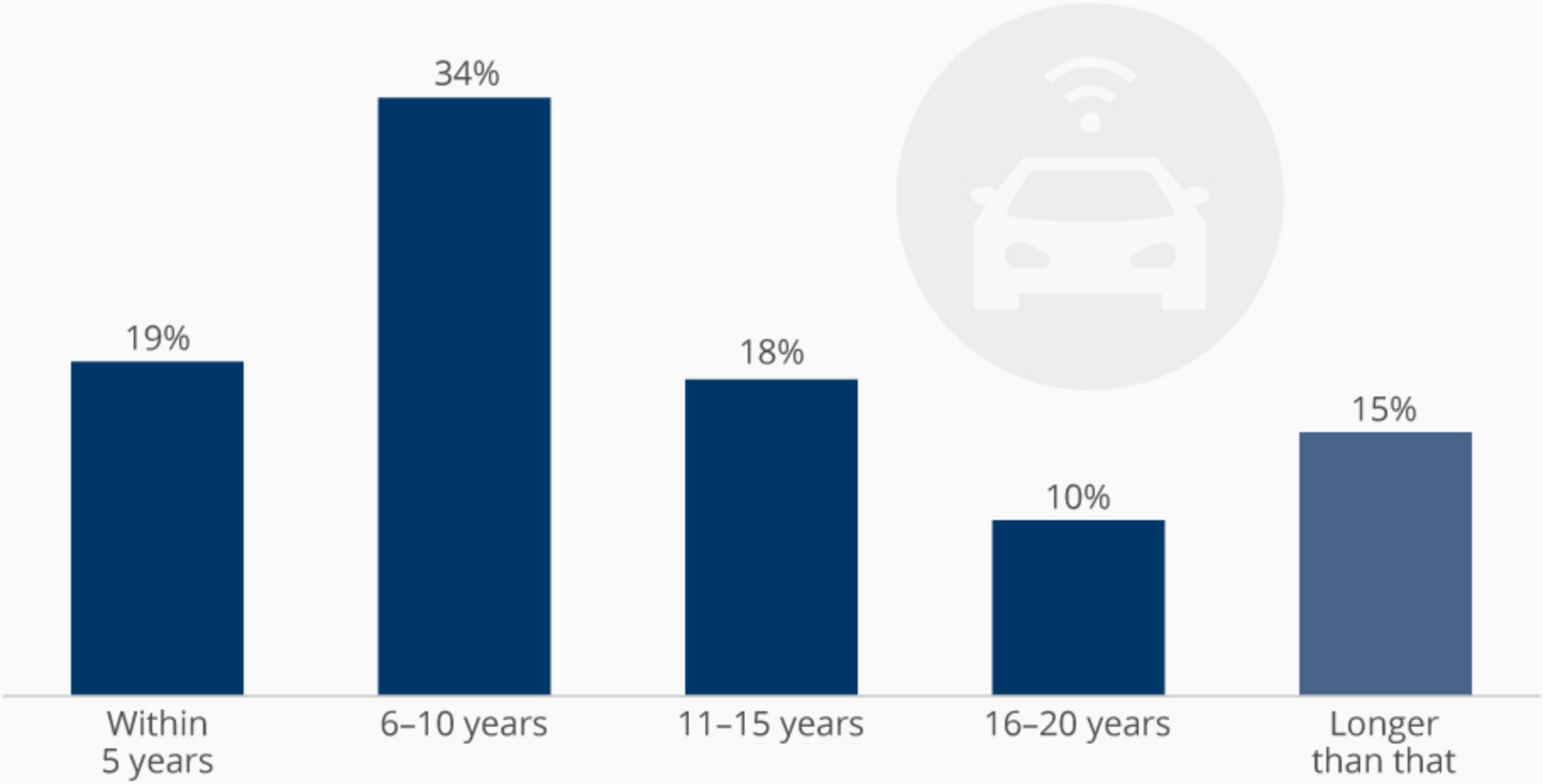
SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) AUTOMATION LEVELS

Full Automation

0	1	2	3	4	5
No Automation	**Driver Assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Zero autonomy; the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

Americans Expect Driverless Cars to Be Common in 10 Years

"How soon do you think driverless cars will be commonly used in the U.S.?"



@StatistaCharts

n=1,503 adults, aged 18+

Source: Gallup

statista

Consumer Concerns About Self-Driving Cars

% of respondents naming the following reasons for their reluctance to use self-driving cars

Base: 1,260 consumers from 10 countries who say they are unlikely/very unlikely to take a ride in a self-driving car

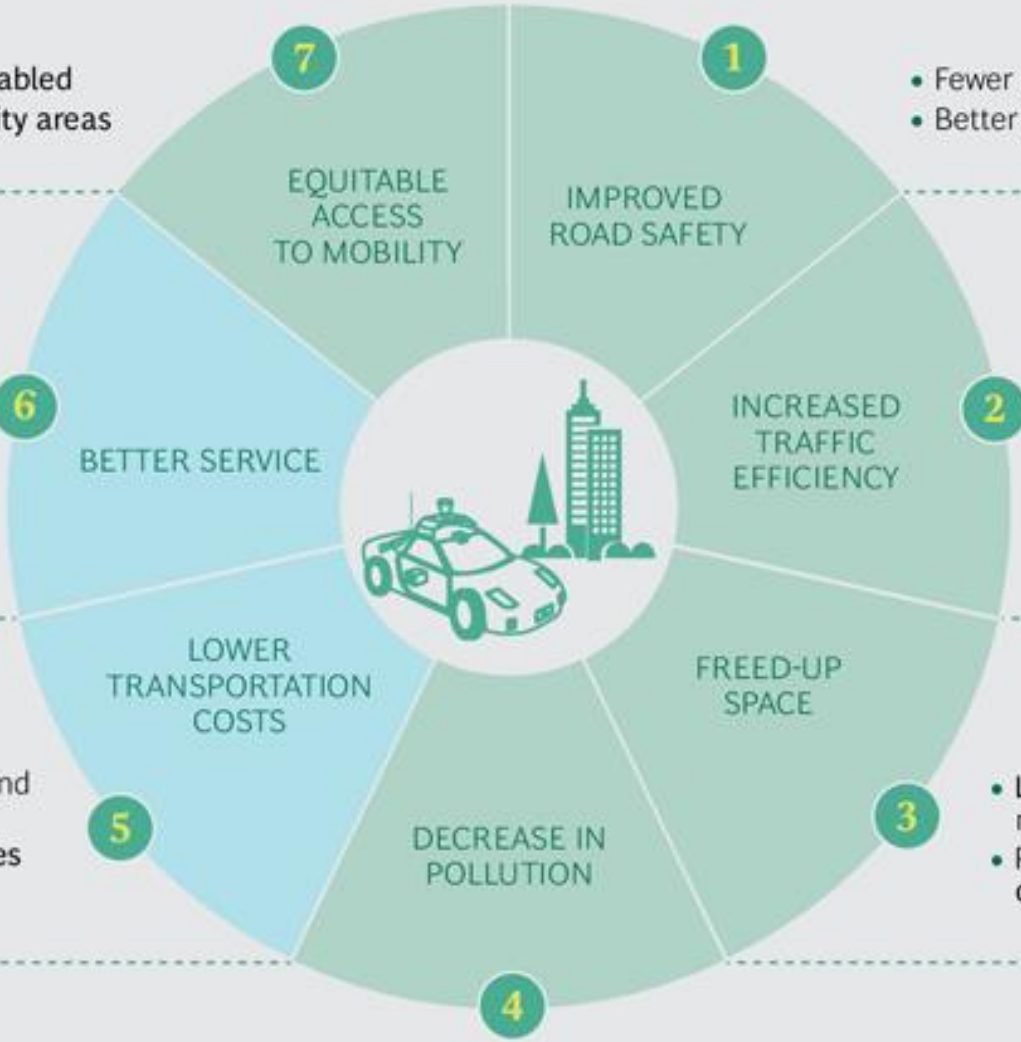
Sources: BCG, World Economic Forum

@StatistaCharts

statista

https://www.statista.com/chart/5950/concerns-about-self-driving-cars/

EXHIBIT 9 | Policymakers See Widespread SDV Benefits for Both Individuals and Society



- Access for **elderly and disabled**
- Better access in **low-density areas**

- Fewer **accidents**
- Better safety for **all road users**

- Increased **convenience**
- More and better mobility **choices**

- No need to add new **car-focused capacity**
- **Less congestion**, better flow

- **Cheaper mobility** for the end consumer
- Lower cost of travel for **cities and consumers**

- **Less space for parking** needed in city centers
- Possibility for **new type of city planning**

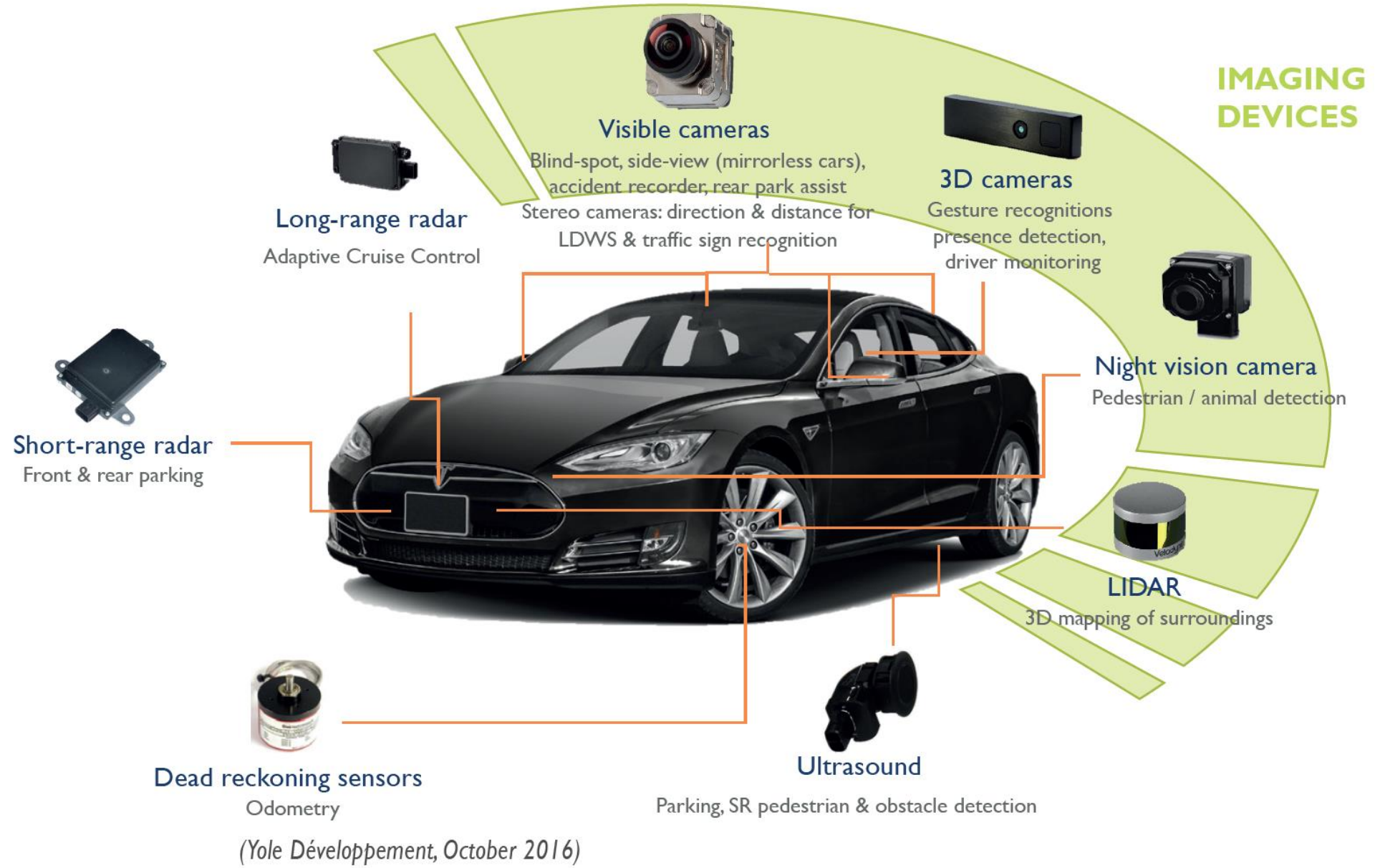
- **Less car travel** at low occupancy
- **Fewer cars** on the streets

Society benefits Individual benefits

Sources: City interviews, Q3 2015; World Economic Forum; BCG analysis.

Imaging Technologies for Automotive

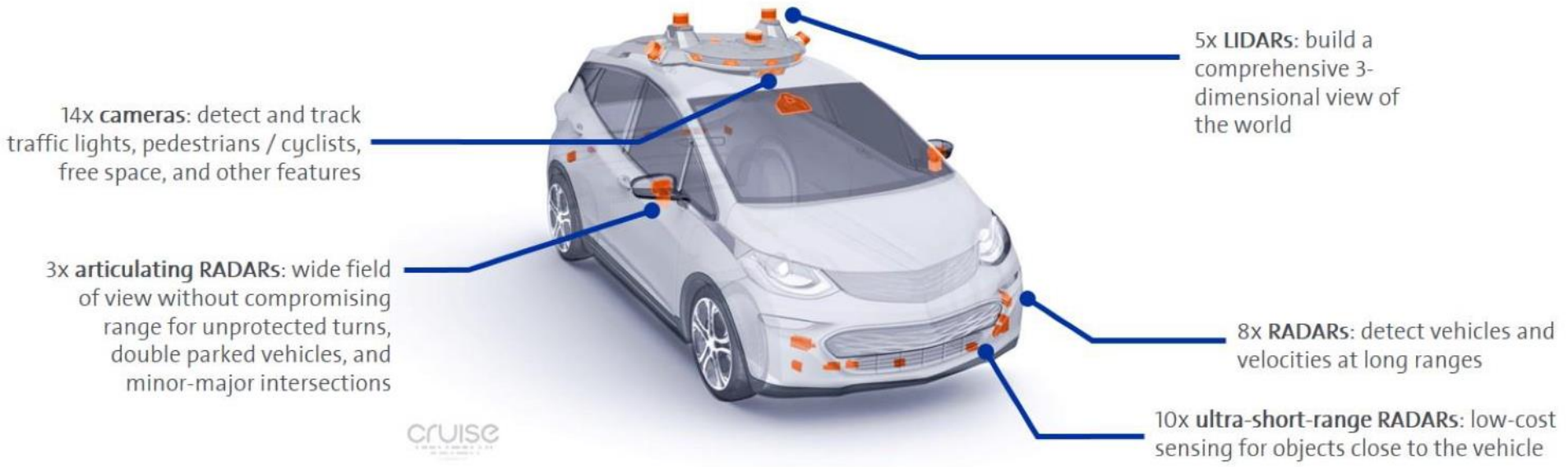
From applications to devices



(Yole Développement, October 2016)

Autonomous Vehicles (AV)

AV SPECIFIC REDUNDANT HARDWARE SYSTEMS

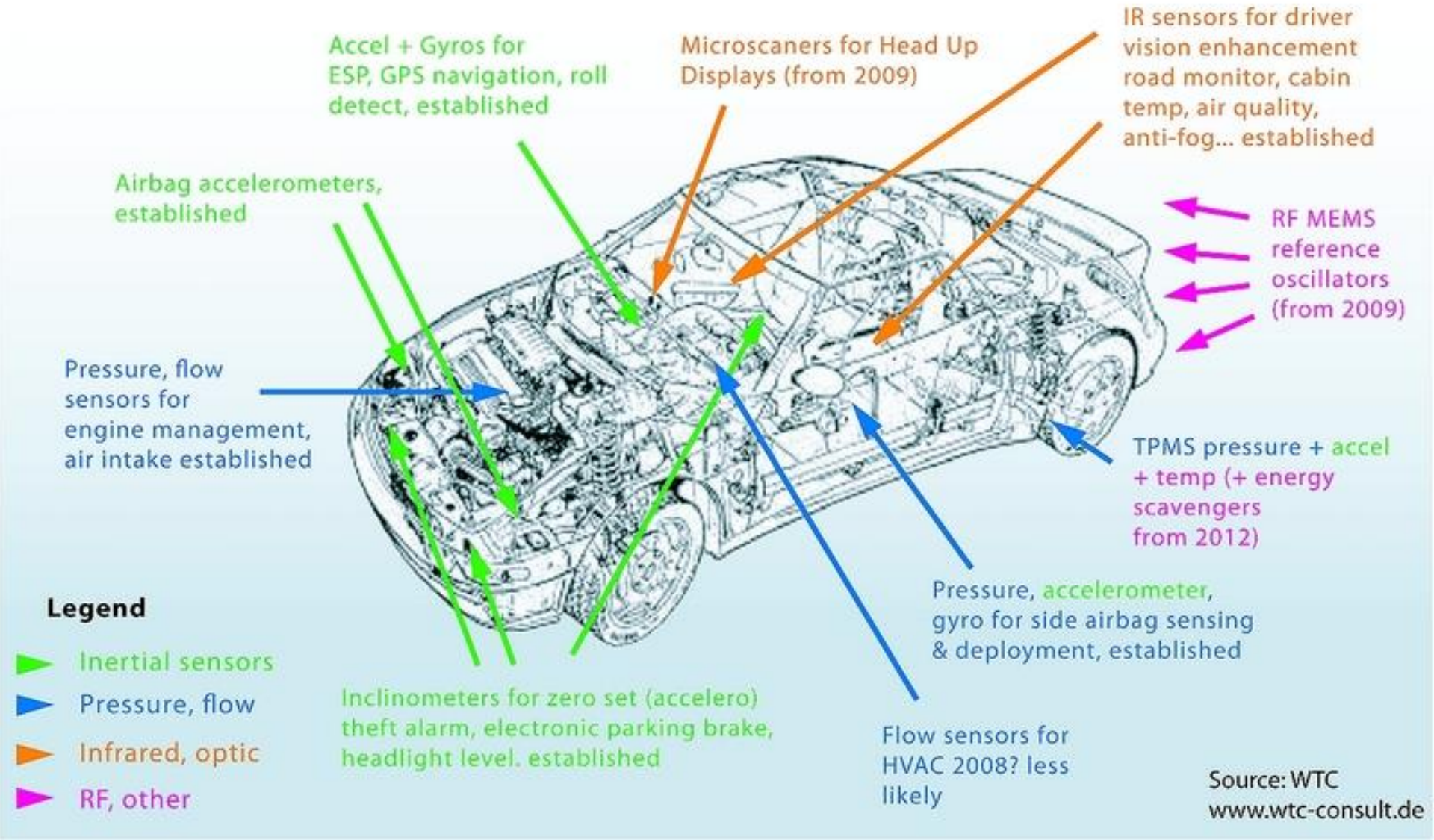


Proprietary LIDAR Cost & Size Reduction

Currently Available LIDAR	• Effective range: 1x • Cost: ~$20,000 • Quality Issues
Next Gen LIDAR	• Expected effective range: ~1.25x • Cost: ~$10,000
Strobe + GM + Cruise	• Expected effective range: ~2.5x • Cost: ~$300

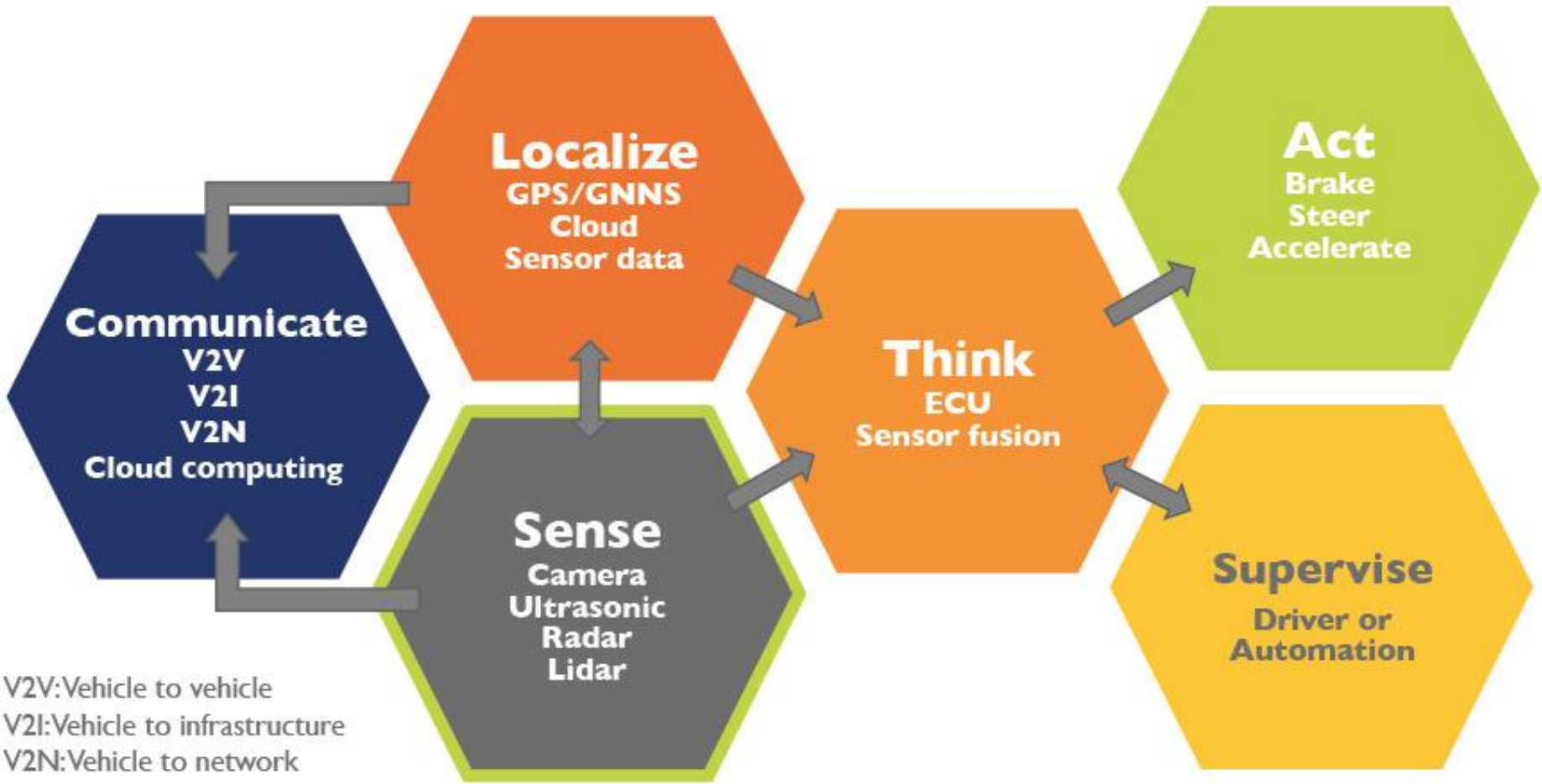
Source: General Motors 2017

Applications for MEMS in automobiles



Vehicle automation process

(Source: Radar Technologies for Automotive 2018, Yole Développement, November 2017)



V2V: Vehicle to vehicle
V2I: Vehicle to infrastructure
V2N: Vehicle to network

Autonomous Vehicles (AV)

Minimum Viable Product (MVP)

DEVELOPING THE MVP

Self-driving software "brain"	Deep simulation capability	HD Mapping and Routing	Proprietary AV sensors	AV-specific redundant hardware systems
Core EV platform	Automotive safety and durability validation	Cyber-security and electrical architecture	Vehicle connectivity and data collection	AV-specific vehicle design
Operations infrastructure	Large scale production readiness	UX interfaces (in car & app)	Customer support & remote assistance (OnStar)	Total cost optimization

ALL COMPONENTS NEED TO BE DEVELOPED FOR A SUCCESSFUL LAUNCH

Source: General Motors 2017

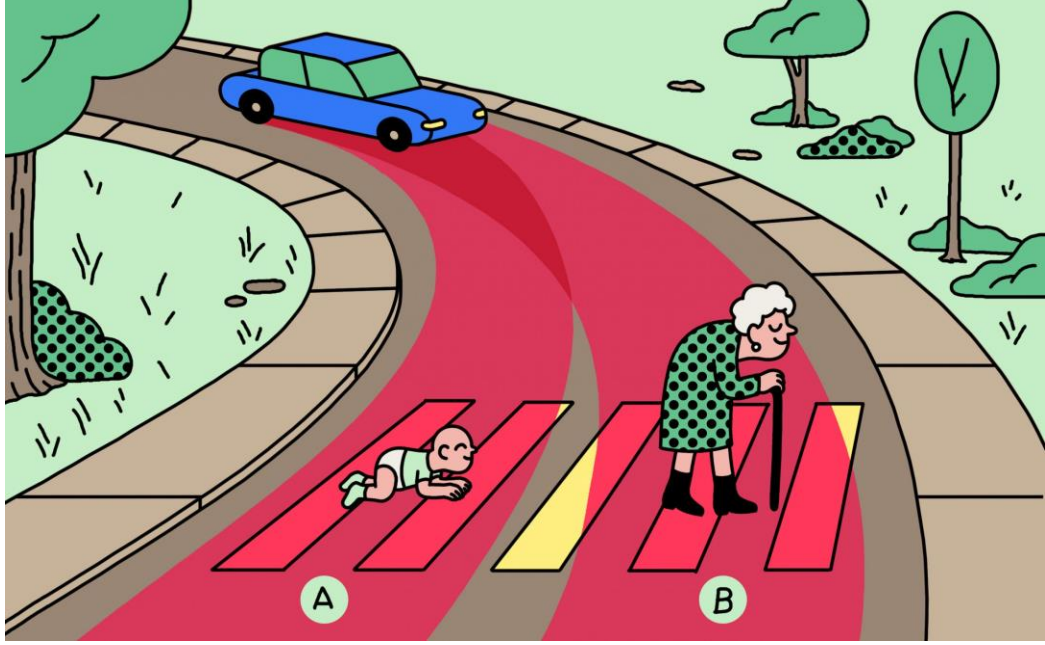
Should a self-driving car kill the baby or the grandma? Depends on where you're from

MIT Technology Review

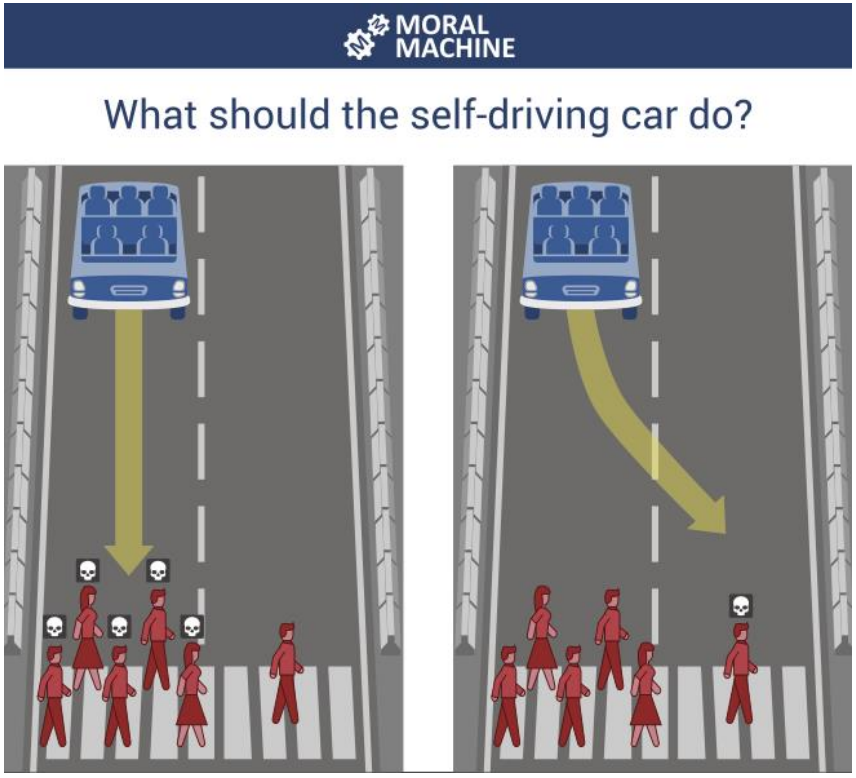
The infamous "trolley problem" was put to millions of people in a global study, revealing how much ethics diverge across cultures.

by Karen Hao October 24, 2018

https://www.technologyreview.com/s/612341/a-global-ethics-study-aims-to-help-ai-solve-the-self-driving-trolley-problem/



In 2014 researchers at the MIT Media Lab designed an experiment called Moral Machine. The idea was to create a game-like platform that would crowdsource people's decisions on how self-driving cars should prioritize lives in different variations of the "trolley problem." In the process, the data generated would provide insight into the collective ethical priorities of different cultures.

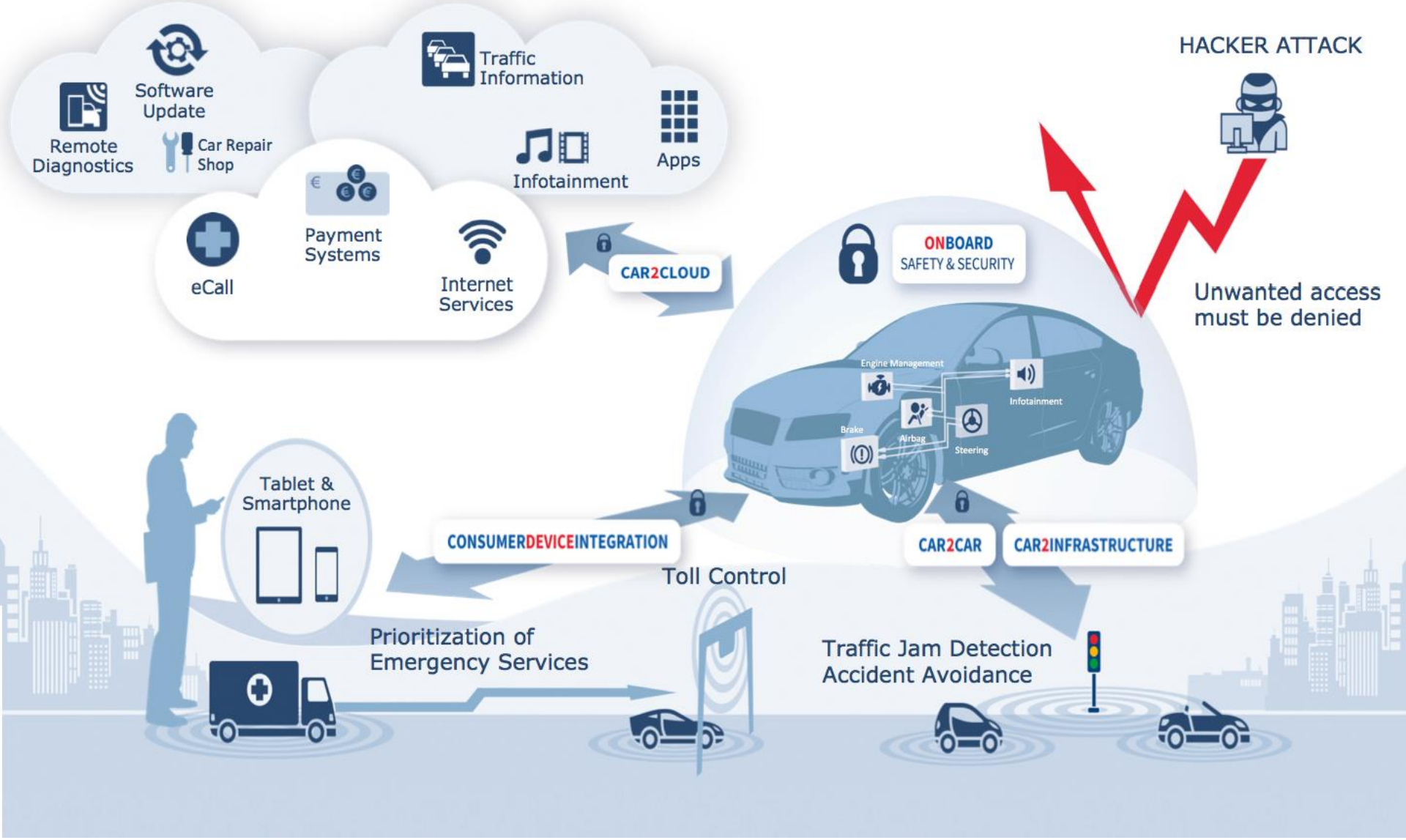


The researchers never predicted the experiment's viral reception. Four years after the platform went live, millions of people in 233 countries and territories have logged 40 million decisions, making it one of the largest studies ever done on global moral preferences.

A new paper published in *Nature* presents the analysis of that data and reveals how much cross-cultural ethics diverge on the basis of culture, economics, and geographic location.

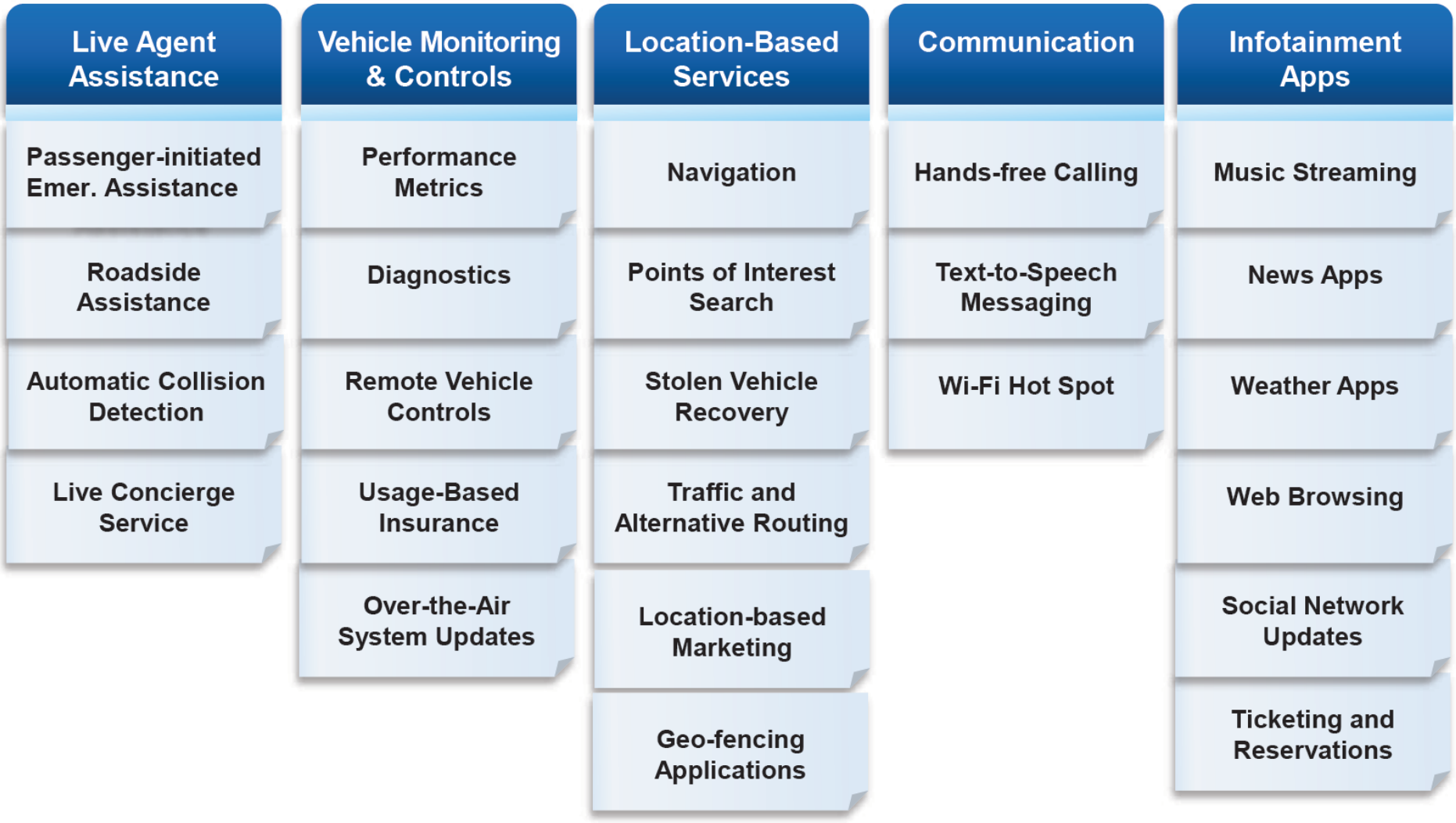
The classic trolley problem goes like this: You see a runaway trolley speeding down the tracks, about to hit and kill five people. You have access to a lever that could switch the trolley to a different track, where a

Connected Cars On Board Safety & Security Features



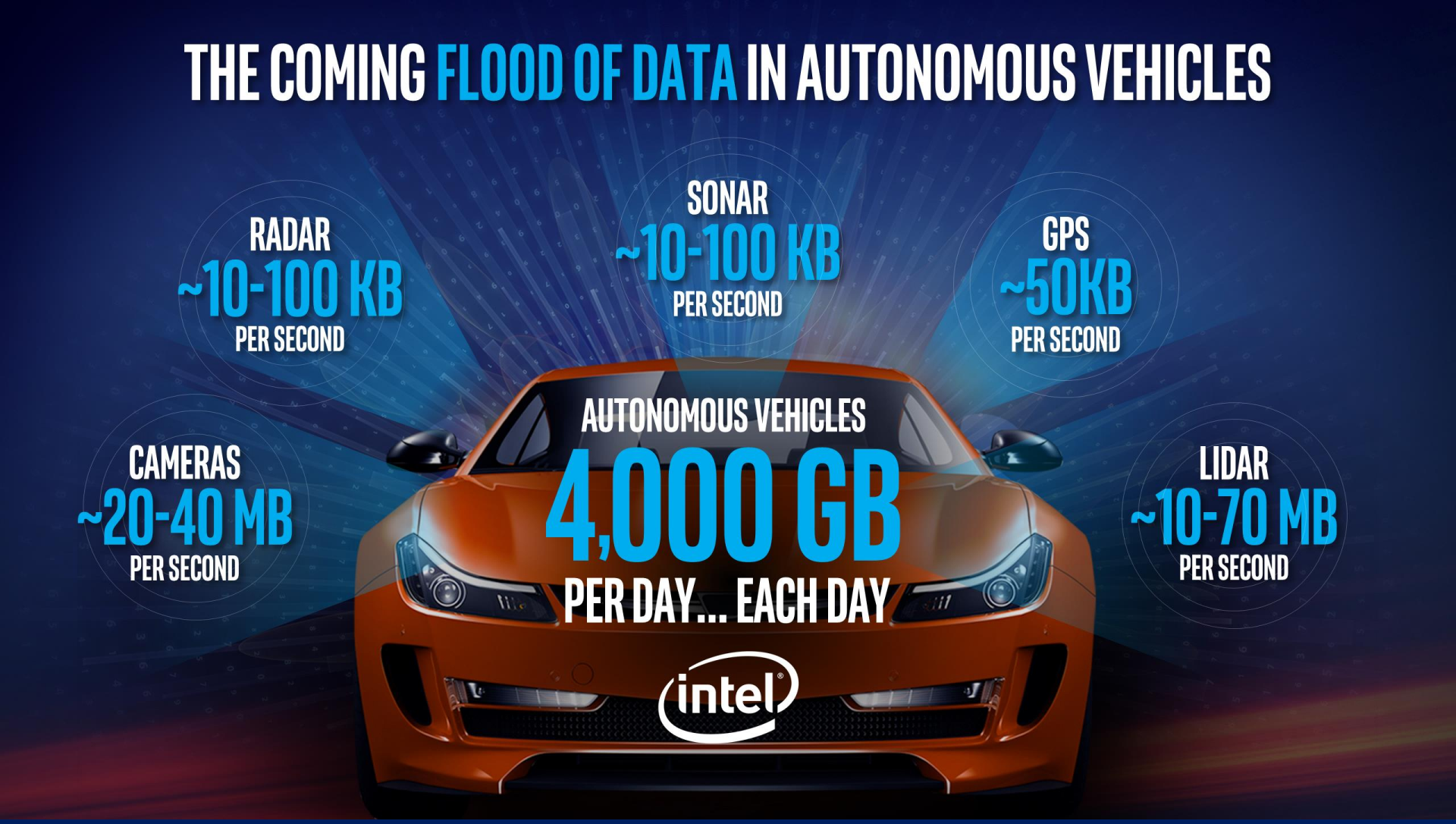
Source: Infineon Technologies AG

Connected Car Services

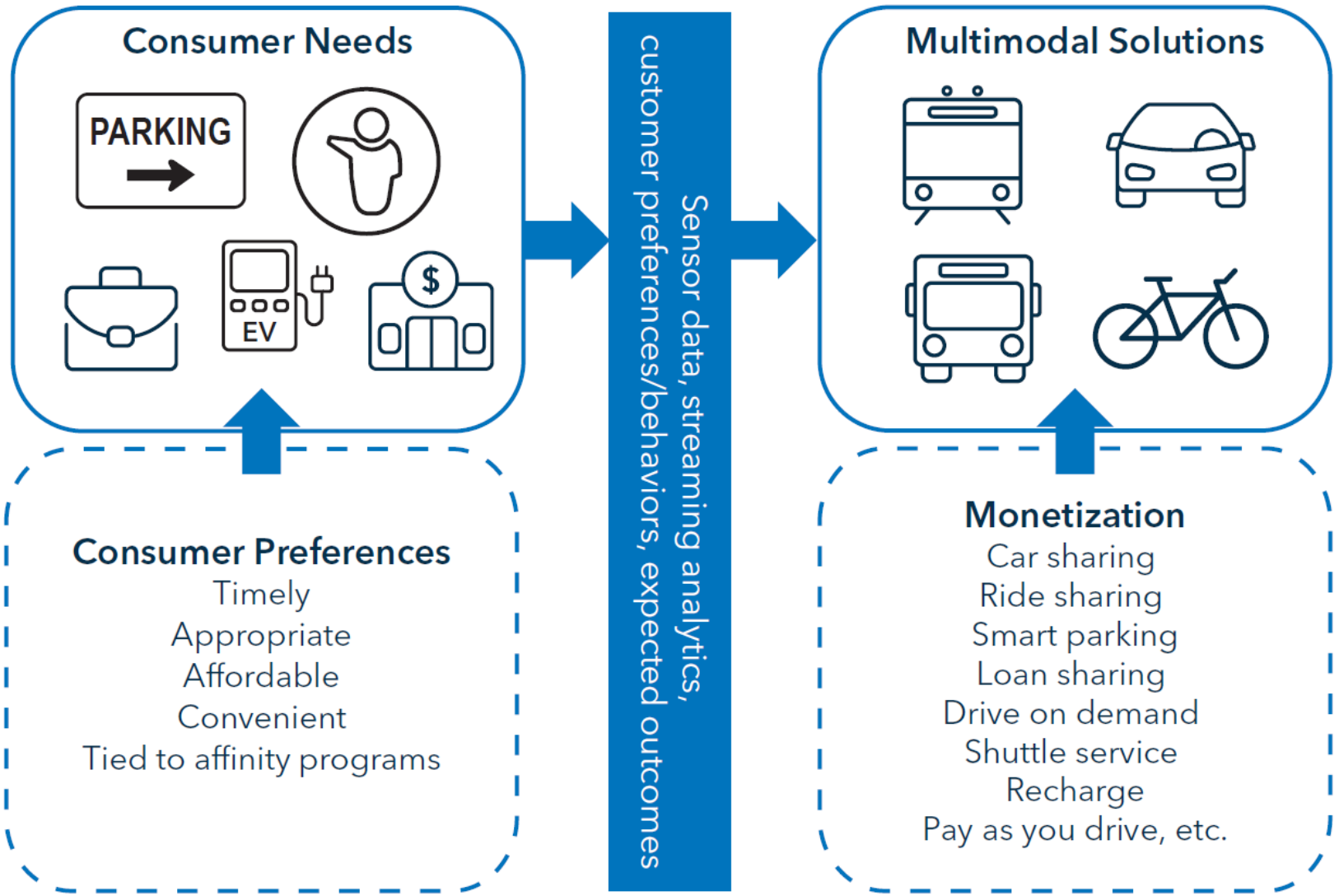


Source: Parks Associates

THE COMING FLOOD OF DATA IN AUTONOMOUS VEHICLES



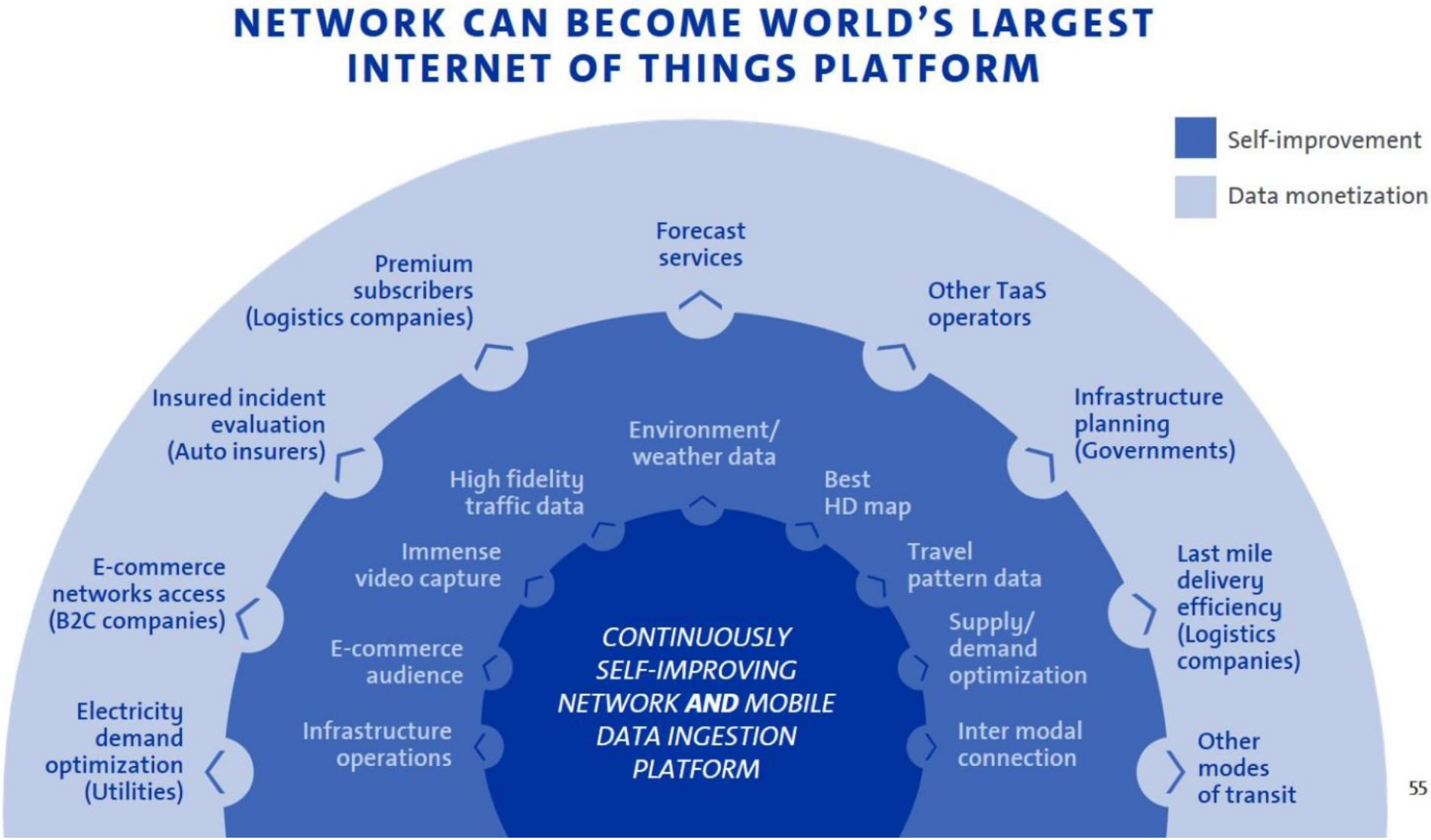
Monetizing Mobility Services



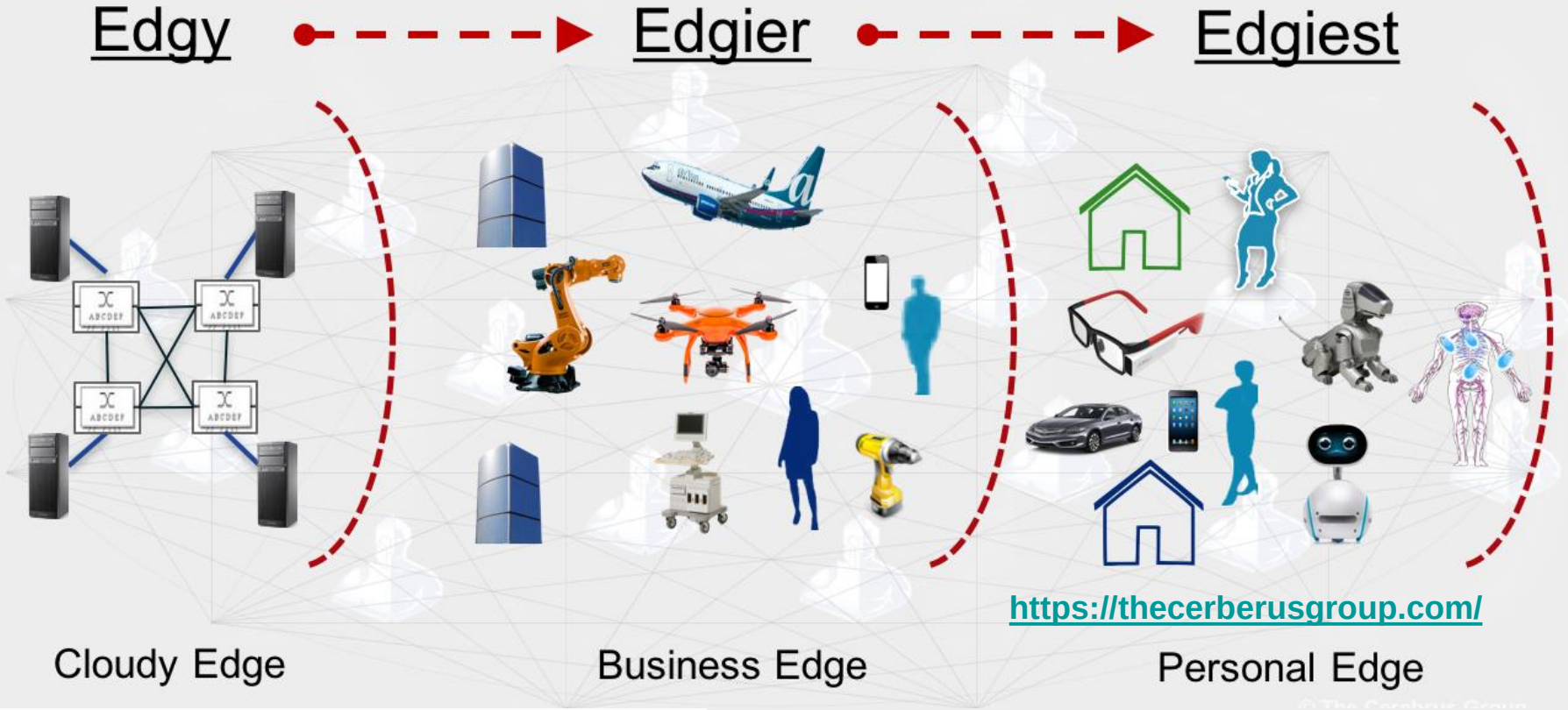
Source: SAS 2017

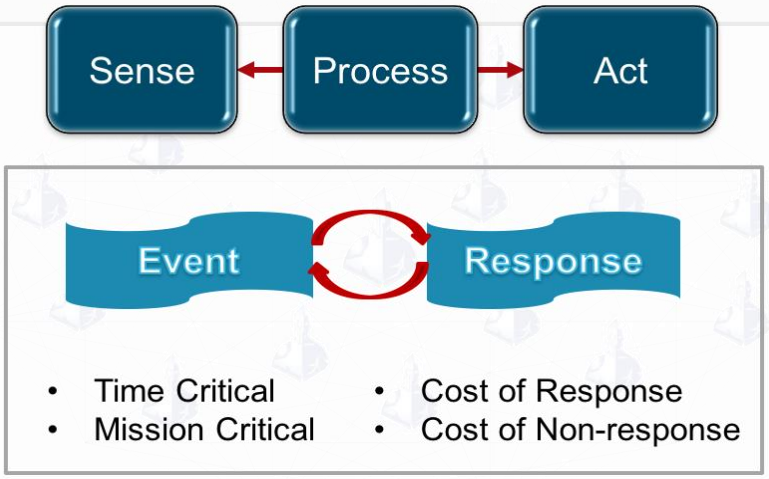
Figure 2: Relying on sensor data, streaming technology and customers' likelihood to react in a certain manner, mobility providers can make optimal, real-time decisions about which services to offer consumers in various transportation scenarios – and when to do it.

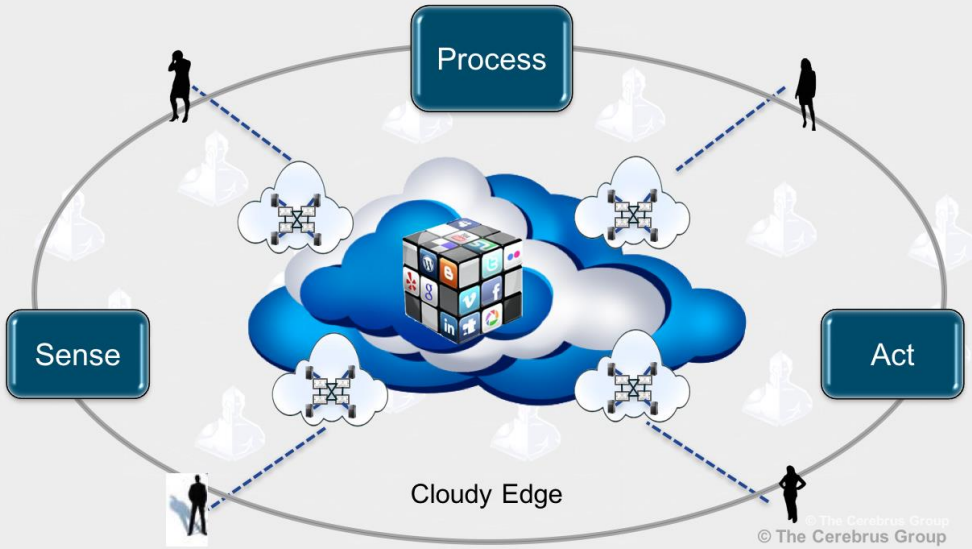
Autonomous Vehicles (AV)



Source: General Motors 2017


Edgy
Edgier
Edgiest
https://thecerberusgroup.com/
Cloudy Edge
Business Edge
Personal Edge


Sense
Process
Act
Event
Response
• Time Critical
• Mission Critical
• Cost of Response
• Cost of Non-response
© The Cerebrus Group


Process
Sense
Act
Cloudy Edge
© The Cerebrus Group

C-V2X

Establishes the foundation for safety use cases and a continued 5G NR C-V2X evolution for future autonomous vehicles

- C-V2X Release 14 completed in 2017
- Broad industry support – 5GAA
- Global trials started in 2017
- Our 1st announced C-V2X product in September, 2017

Learn more at: https://www.qualcomm.com/c-v2x

Qualcomm

10

V2X - IEEE 802.11p

Uses unlicensed 5.9 GHz ITS frequencies for short-to-medium range vehicle safety & operations

ADAS
Advanced Driver Assistance Systems

Brain of the car to help automate the driving process by using:
- Immense compute resources
- Sensor fusion
- Machine learning
- Path planning

Next Generation Dedicated Short Range Communications (DSRC) for Intelligent Transportation Systems (ITS) vehicle safety & operations

Radar
Bad weather conditions
Long range
Low light situations

V2X wireless sensor
See-through, 360° non-line of sight sensing, extended range sensing

Camera
Interprets objects/signs
Practical cost and FOV

3D HD maps
HD live map update
Sub-meter level accuracy of landmarks

Lidar
Depth perception
Medium range

Precise positioning
GNSS positioning
Dead reckoning
VIO

Ultrasonic
Low cost
Short range

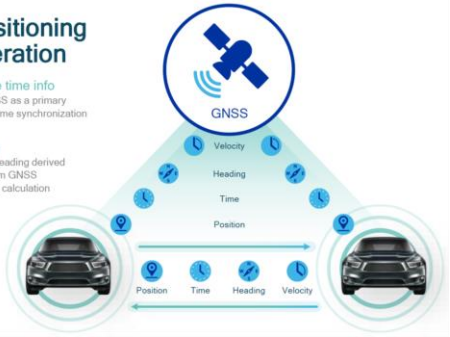
High precision positioning is key for V2X operation

Precise positioning
Use GNSS along with precise positioning services to get <1 meter accuracy

Accurate time info
Using GNSS as a primary source of time synchronization

Velocity
Accurate speed derived directly from GNSS positioning calculation

Heading
Accurate heading derived directly from GNSS positioning calculation



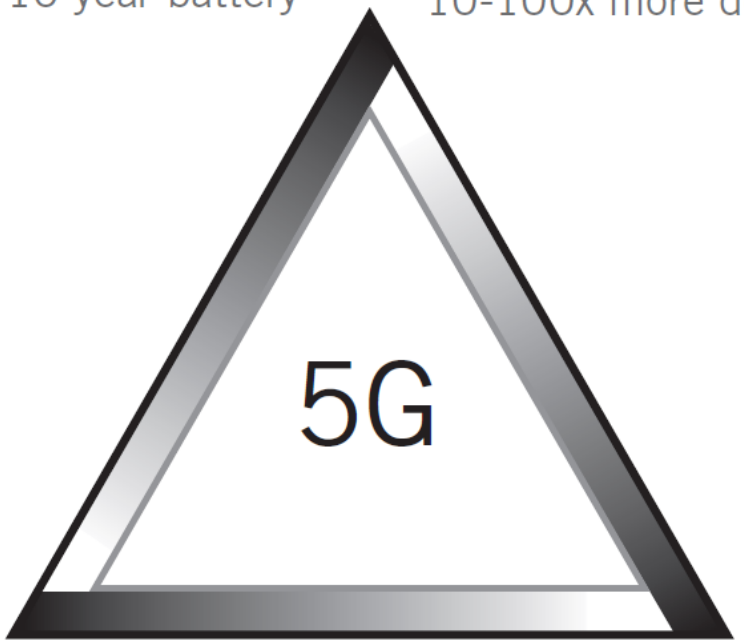
5G Use Cases

Massive IoT

Large Number of Connections
with Low Power, Low Cost

10 year battery

10-100x more devices



Enhanced Broadband

Throughput Capacity

100 Mbps reliably >10 Gbps peak

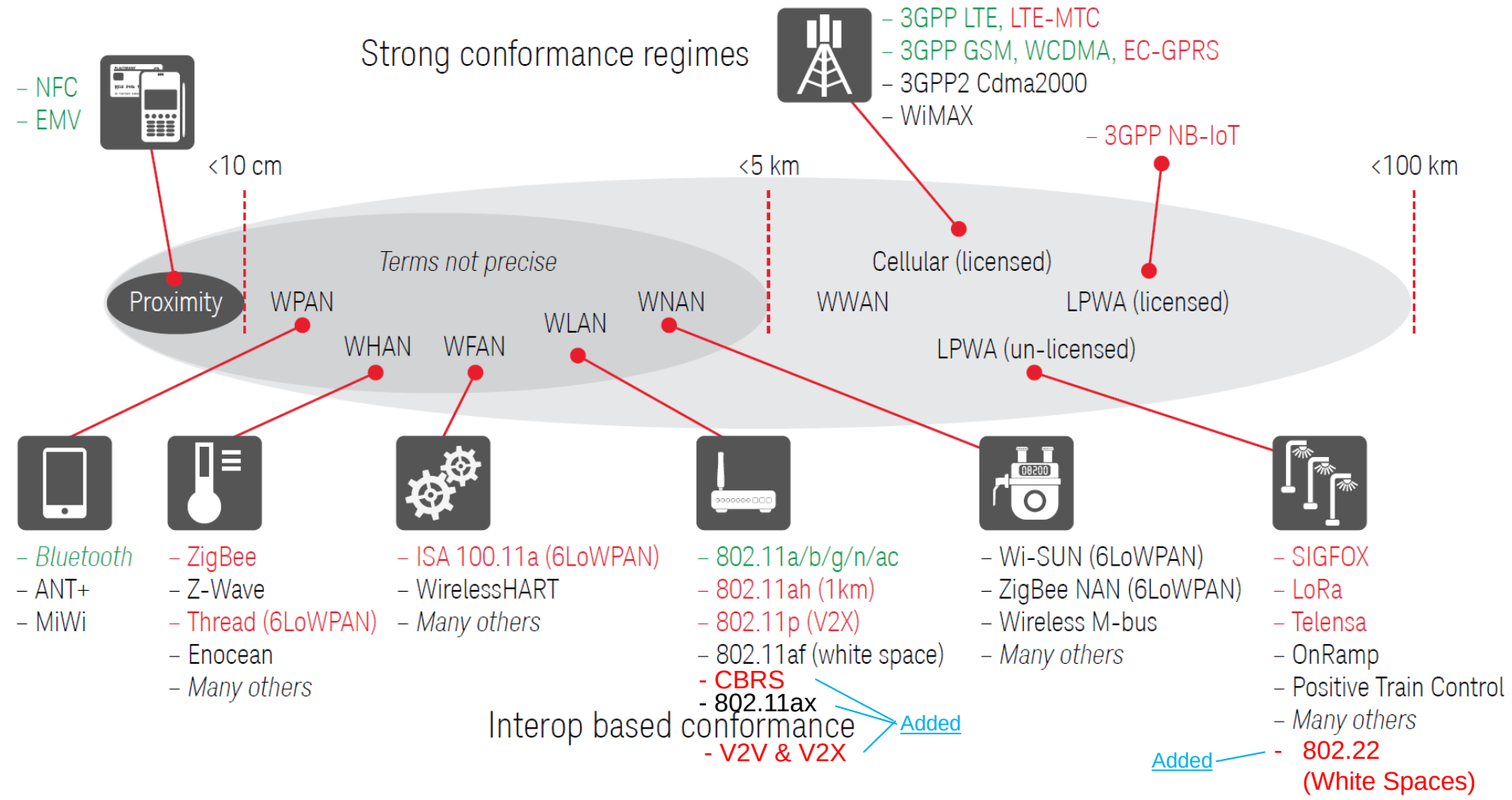
Critical Communications

Low-Latency, High-Reliability

<1 ms radio latency 10^{-9} error rate

Source: Information Technology & Innovation Foundation (ITIF) 2018

IoT Connection Technologies Operating Range



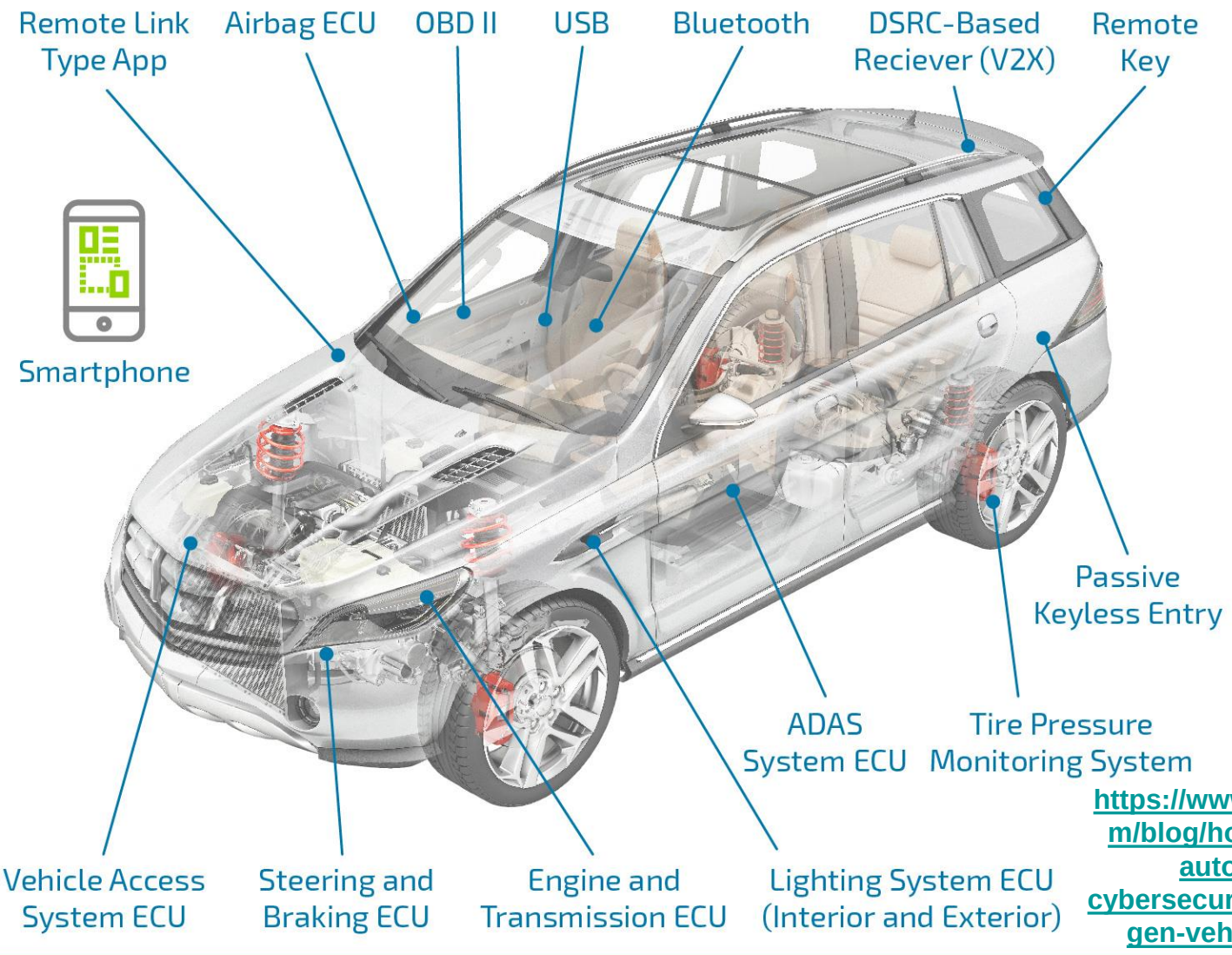
■ : > Billion units/year now
■ : Emerging

WPAN: Wireless Personal Area Network
WHAN: Wireless Home Area Network
WFAN: Wireless Field (or Factory) Area Network
WLAN: Wireless Local Area Network

WNAN: Wireless Neighborhood Area Network
WWAN: Wireless Wide Area Network
LPWA: Low Power Wide Area

Source: Keysight Technologies

Fifteen of the most hackable and exposed attack surfaces on a next-gen car



https://www.infopulse.com/blog/how-to-ensure-automotive-cybersecurity-in-the-next-gen-vehicles-part-1/

infopulse

Google X is building a few hundred self-driving cars that have no steering wheel, accelerator pedal or brake pedal. (2014)

http://www.npr.org/blogs/alltechconsidered/2014/05/27/316486989/google-is-becoming-a-car-manufacturer

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

http://www.youtube.com/watch?v=bDOnn0-4Nq8

PUSHING RESET

UBER

L4+ timeline*

2019

Miles driven

2M+

With the Waymo lawsuit in the rearview mirror, new CEO Dara Khosrowshahi has picked up his predecessor's AV enthusiasm.

Besides the TNC's autonomous truck program, Khosrowshahi sees a gradual "feathering in" of AVs into its ride-hailing mix.

Select partnerships & deals

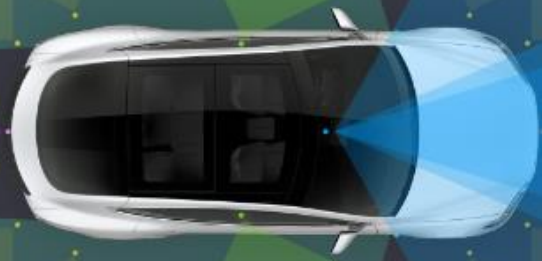
OTTO	TOYOTA	NVIDIA	VOLVO
Acquisition	*Partnership*	*Partnership*	*Supply deal*

CBINSIGHTS

*For Level 4+ autonomy deployment.

Source: CB Insights 2018

Enhanced Autopilot adds these new capabilities to the Tesla Autopilot driving experience. Your Tesla will match speed to traffic conditions, keep within a lane, automatically change lanes without requiring driver input, transition from one freeway to another, exit the freeway when your destination is near, self-park when near a parking spot and be summoned to and from your garage.



NHTSA/SAE Autonomous Driving Level 2-3

Eight surround cameras provide 360 degrees of visibility around the car at up to 250 meters of range. Twelve updated ultrasonic sensors complement this vision, allowing for detection of both hard and soft objects at nearly twice the distance of the prior system. A forward-facing radar with enhanced processing provides additional data about the world on a redundant wavelength that is able to see through heavy rain, fog, dust and even the car ahead.

TESLA

Full Self-Driving Hardware on All Cars

All Tesla vehicles produced in our factory, including Model 3, have the hardware needed for full self-driving capability at a safety level substantially greater than that of a human driver.

https://www.tesla.com/autopilot

TESLA

Electric car maker with Phoenix-area factory plans secures $1B from Saudis

PHOENIX BUSINESS JOURNAL

By Cromwell Schubarth – TechFlash Editor, Silicon Valley Business Journal
Sep 17, 2018, 9:55am

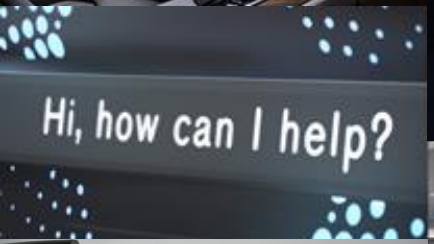
Lucid Motors Inc. said Monday that it's getting a $1 billion investment from Public Investment Fund of Saudi Arabia (PIF) to help it produce its first electric cars it plans to roll out in competition with Tesla Inc.

The Saudi fund is the same one that Tesla CEO Elon Musk said at one point this summer was going to help him take his company private at $420 per share. (Weeks later, Musk changed his mind and said Tesla would remain a publicly traded company. The chain of events has prompted scrutiny from the U.S. Securities and Exchange Commission.)

Newark, California-based Lucid said the PIF funds will help launch its first electric vehicle in 2020. The company launched in 2007 as a battery company called Atieva and had raised an estimated $151 million in venture and debt financing before the Saudi investment, according to PitchBook Data.

It shifted to designing a luxury sedan called the Lucid Air, which the company says will have a 400-mile driving range and will be able to hit speeds of more than 200 mph.

https://www.bizjournals.com/phoenix/news/2018/09/17/electric-car-maker-with-phoenix-area-factory-plans.html



Volvo 320c Concept Car

https://www.volvocars.com/us/cars/concepts/360c

https://www.youtube.com/watch?v=Mlh-_hoNLaI

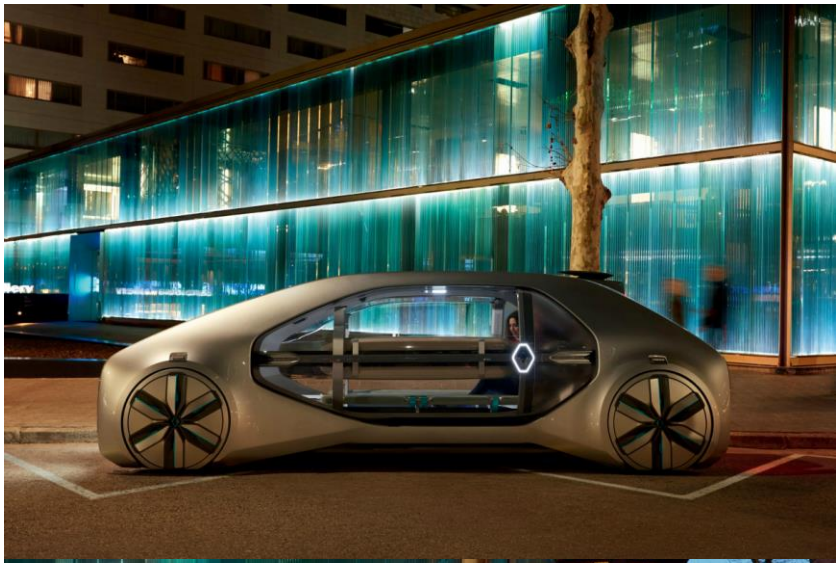
Renault unveils a shared and autonomous urban future

SmartCitiesWorld
Infrastructure intelligence in one place

https://smartcitiesworld.net/news/renault-unveils-a-shared-and-autonomous-urban-future-2679

News **07 Mar 2018**

The service can be operated by private or public organisations and aims to supplement car ownership and mass transit such as subways and buses



Automaker Renault has unveiled its vision of a future on-demand mobility service as it pledges to launch ride-hailing robo-taxi commercial services by 2022.

EZ-GO is a shared driverless electric vehicle ('robo-vehicle') designed to transport up to six passengers simultaneously. Renault unveiled its vision at the Geneva Motor Show, which takes place from 8-18 March, and describes the EZ-GO as "a car and a service", which aims to become part of a smart city's ecosystem.

It seeks to provide an on-demand mobility solution for all and works through an instant-booking service from an app, or from in-town stations, depending on the preference of the operator.

The service may be operated by private or public organisations. It can potentially operate 24/7 and it supplements car ownership and mass transit such as subways and buses. It combines the flexibility and comfort of individual transport with the efficiency and the safety provided by public transport.

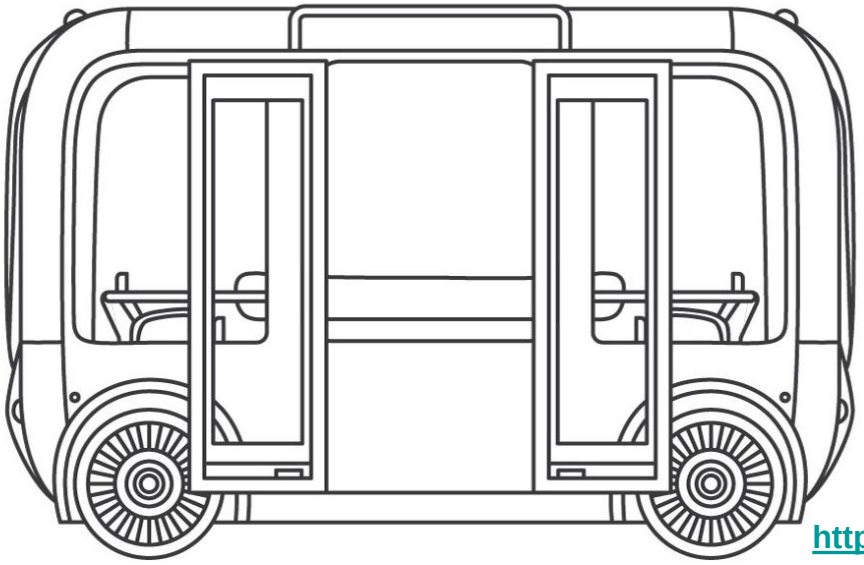
The EZ-GO has level 4 autonomous driving capability on the SAE International 5-level scale. This means the vehicle is able to manage its distance from the vehicle in front, stay in lane, change lanes (when overtaking, for instance) and turn all by itself at a junction. It can also move into a safe position in cases of exceptional incidents in its vicinity, either by itself or through its connectivity with a monitoring centre.

According to Renault, compared with a conventional or 'shuttle' type of vehicle, EZ-GO actively bolsters its users' safety thanks to its limited speed (30mph), its wide front opening is safe and away from the road for passengers when getting in and out, and a light marks the ground outside to indicate where the platform will land.

Local Motors Olli Project

#AccessibleOlli

https://localmotors.com/meet-olli/



https://www.ibm.com/blogs/internet-of-things/accessible-olli/

'EDIT' Self-Driving Car by Open Motors

from Open Motors (formerly OSVehicle)

https://www.openmotors.co/editselfdrivingcar/

BYOSDCACH: Bring Your Own Self-Driving Code And Custom Hardware Stack (Lidars, Sensors, CPUs, etc.)

ITALIAN DESIGNED & ENGINEERED

OPEN MOTORS
super computers on wheels

White-Label Models

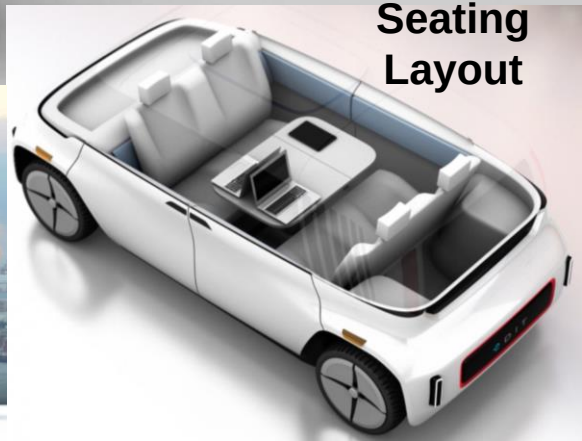
Alternate Framework

Open & Modular

https://openmotors.co/

Customizable Outside

"Vis a Vis" Seating Layout



Volkswagen Unveils Self-Driving Electric Microbus

A modernized version of the iconic 60's hippie bus is now emissions-free, self-driving, and highly customizable with 8 seats and a driving range up to 270 miles. The vehicle has an 110 kWh lithium-ion battery pack that can be powered up to 80% by a high-powered DC charger in just 3 minutes.
Source: http://anonhq.com/volkswagen-unveils-electric-microbus-thats-self-driving/

OPINION

Why we're getting self-driving delivery before self-driving Ubers

The public will have to wait another decade for self-driving Ubers. But autonomous vans are already delivering groceries.

By Mike Elgan
Contributing Columnist, Computerworld | FEB 3, 2018 2:00 AM PT

COMPUTERWORLD
FROM IDG

https://www.udelv.com/

https://www.computerworld.com/article/3252162/robotics/why-we-re-getting-self-driving-delivery-before-self-driving-ubers.html

A Silicon Valley startup claims to be the world's first real-world application of autonomous driving. If the claim is true, it beat Waymo, Tesla, Apple, the global car industry and all the other Silicon Valley startups. The startup is called Udelv. This week it delivered groceries to two customers of a local store called Draeger's Market. The delivery van drove autonomously from the store to the customers' houses, although (as required by California law) a "safety driver" sat in the driver's seat during the delivery.

I talked to Udelv CEO Daniel Laury, and he told me the delivery was "a huge milestone." Draeger's Market deliveries go online to the public "next week," according to Laury. The "milestone" Laury refers to is commercialization. He's saying that Udelv is the first company to actually use autonomous vehicles for a service that's paid for by a customer (in this case, the grocery store).

Udelv's model shows how autonomous deliveries could work on a massive scale.
Its custom, proprietary electric vehicles are basically robotic lockers. Each van has 18 lockers that can carry a collective weight of 700 pounds. When the van gets within a few minutes of a customer's house, that customer receives an alert via the company's free app (currently available on iOS, with the Android version coming soon, according to Laury). https://itunes.apple.com/us/app/udelv/id1341233287

Once the van arrives, customers use the app to unlock the compartment that holds their groceries. The Udelv fleet is monitored by a control room of humans, who can take over in "unique situations" and drive the vans by remote control if necessary. Udelv monetizes with a simple model. It charges companies to make deliveries. Its goal is to cut the cost of deliveries in half, according to Laury. Udelv also plans to expand beyond Silicon Valley and seek out autonomous-vehicle-friendly states to set up shop in.

Will Postmates start using robots for delivery?

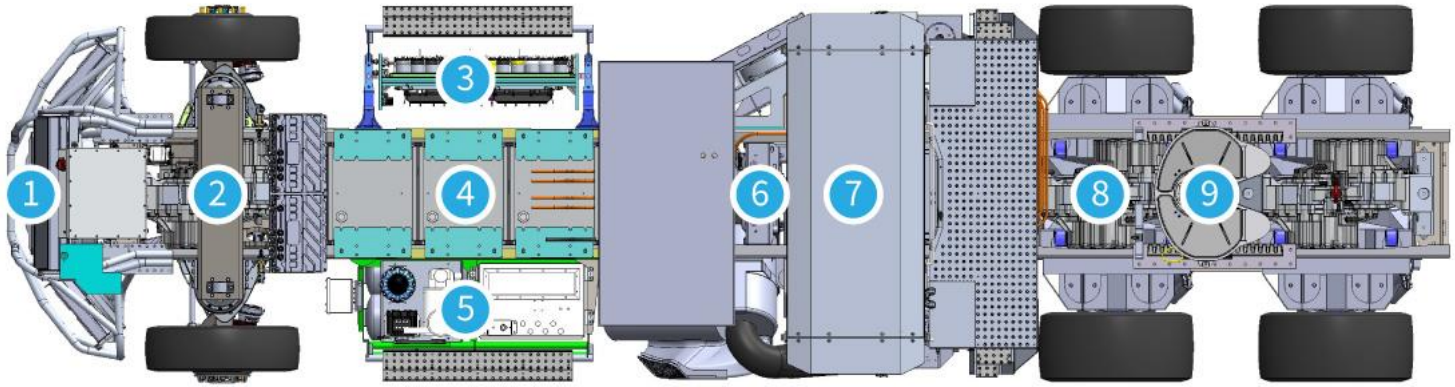
azcentral.
PART OF THE USA TODAY NETWORK

Startup Starship Tech raised $17.2 million in seed funding for its first delivery pilot program in the United States. The company is teaming up with Postmates in Washington D.C. Wochit https://www.starship.xyz/ https://get.postmatescode.com/ https://www.doordash.com/

https://www.azcentral.com/videos/entertainment/2017/05/04/-postmates-start-using-robots-delivery/101265926/

BAE Systems CV90 Man-Optional Tank
With Defense Aid Suite & Active Multi-Spectral Cloaking

https://www.foxnews.com/tech/terminator-tanks-with-invisibility-cloaking-will-fight-future-wars



NIKOLA MOTOR COMPANY

https://nikolamotor.com/

Tesla Semi Electric Big-Rig Truck with 500 Mile Range and 80,000 Pounds Cargo Capacity

https://www.tesla.com/semi/

Self-driving semi-truck startup creating 500 jobs in Tucson, expanding fleet

https://www.bizjournals.com/phoenix/news/2018/09/12/self-driving-semi-truck-startup-creating-500-jobs.html

PHOENIX BUSINESS JOURNAL

Arizona has become a leader in autonomous vehicle testing

Level 4 Autonomous Class 8 Truck

By Hayley Ringle – Reporter, Phoenix Business Journal
11 hours ago 9/12/18

TuSimple Inc., a San Diego-based autonomous semi-truck technology startup, is creating 500 new jobs with its facility expansion in Tucson.

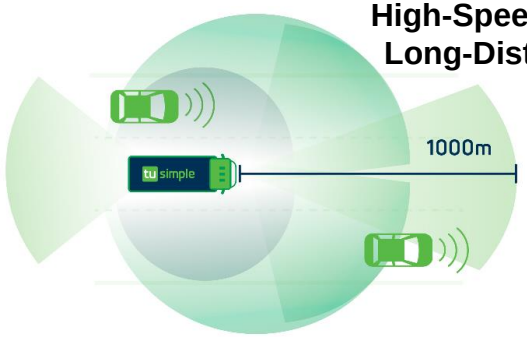
TuSimple opened its 6,800-square-foot testing and development facility in Tucson a year ago, and expanded it to 50,000 square feet in February. Plans are to continue expanding the facility and increase to 200 trucks by 2019.

The expansion has a projected total economic impact of $1.1 billion over the next five years.

With 55 employees now in Tucson, TuSimple plans to hire another 500 primarily in Tucson for positions including professional truck drivers, test operations engineers, office managers, fleet logistics, mechanical engineers and diesel mechanics.

The company has tested its Level 4, Class 8 autonomous trucks on Interstate 10 for over a year now, said Robert Brown, TuSimple's director of public affairs.

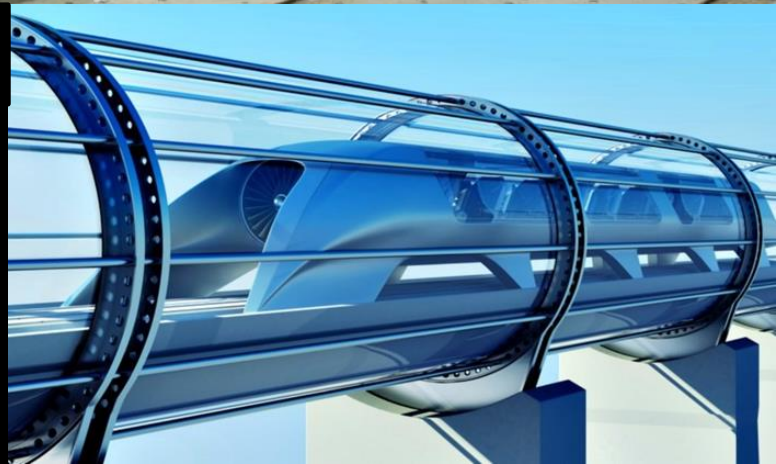
High-Speed Environment Long-Distance Sensing



Full-Stack Autonomous Driving Technologies

THE BORING COMPANY

https://www.boringcompany.com/



Elon Musk's Boring Company's Proposed Hyperloop Between New York and Washington DC

The Boring Company has received 'verbal government approval' to build an underground tunnel to transport passengers between New York and Washington DC in just 29 minutes (4.5 hrs. via NJ Turnpike). https://www.boringcompany.com/

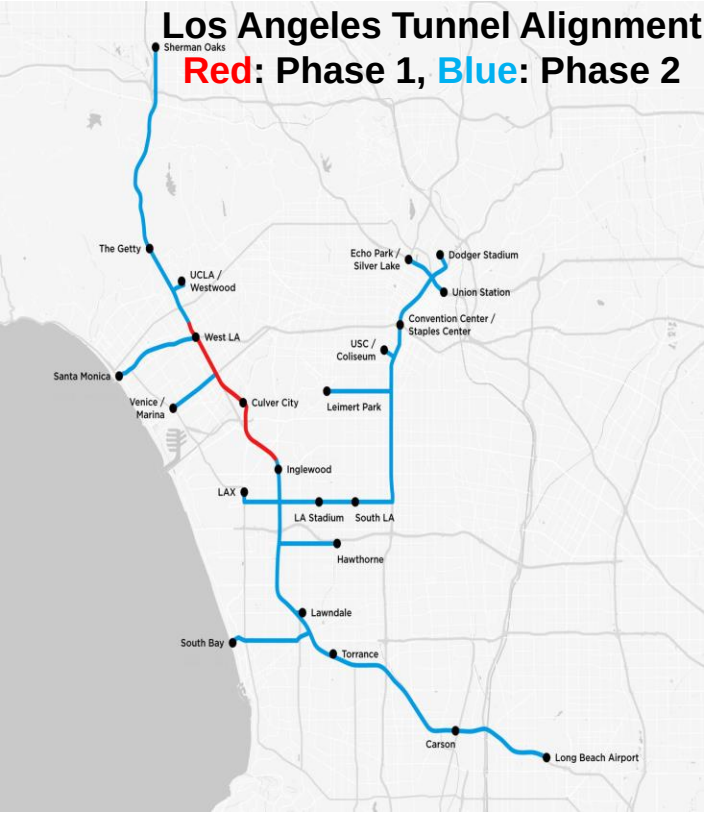
The Boring Company's Vehicle Transport Tunnels

https://www.boringcompany.com/

https://www.youtube.com/watch?v=u5V_VzRrSBI

Vehicle Transport Tunnels

To solve the problem of soul-destroying traffic, roads must go 3D, which means either flying cars or tunnels. Unlike flying cars, tunnels are weatherproof, out of sight and won't fall on your head. A large network of tunnels many levels deep would fix congestion in any city, no matter how large it grew (just keep adding levels). The key to making this work is increasing tunneling speed and dropping costs by a factor of 10 or more – this is the goal of **The Boring Company**. Fast to dig, low cost tunnels would also make Hyperloop adoption viable and enable rapid transit across densely populated regions, enabling travel from New York to Washington DC in less than 30 minutes.

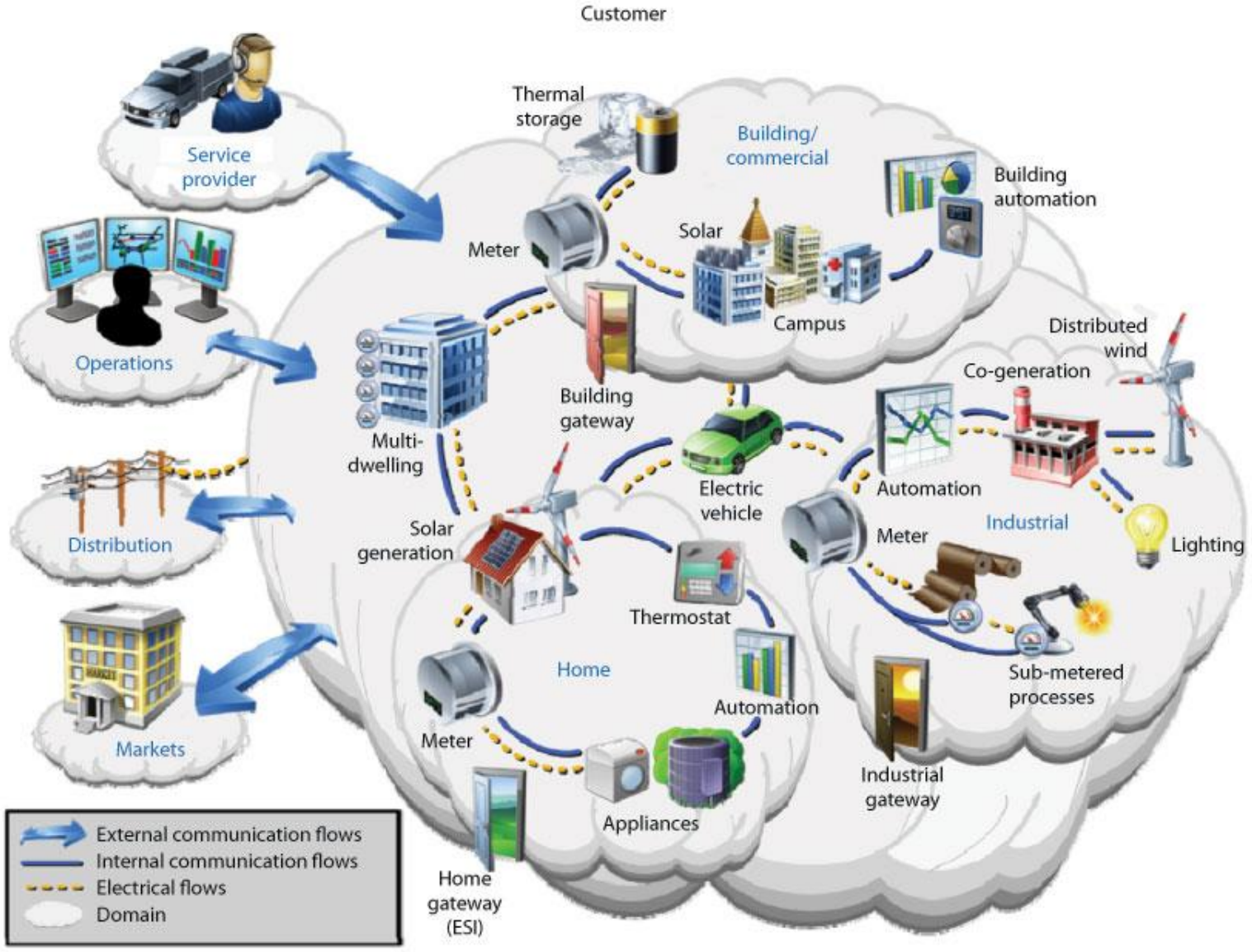


https://www.boringcompany.com/
https://www.youtube.com/watch?v=u5V_VzRrSBI

To alleviate traffic, transportation corridors, like the buildings that feed into them, must expand into three dimensions. One option is to “go up” with flying cars. However, flying cars have issues with weather, noise, and generally increase anxiety levels of those below them. The other option is to “go down” and build tunnels. The benefits are:

- There is no practical limit to how many layers of tunnels can be built, so any level of traffic can be addressed.
- Tunnels are weatherproof.
- Tunnel construction and operation are silent and invisible to anyone on the surface.
- Tunnels don’t divide communities with lanes and barriers.

Plug-in Electric Vehicle (PEV) and Smart Grid Ecosystem

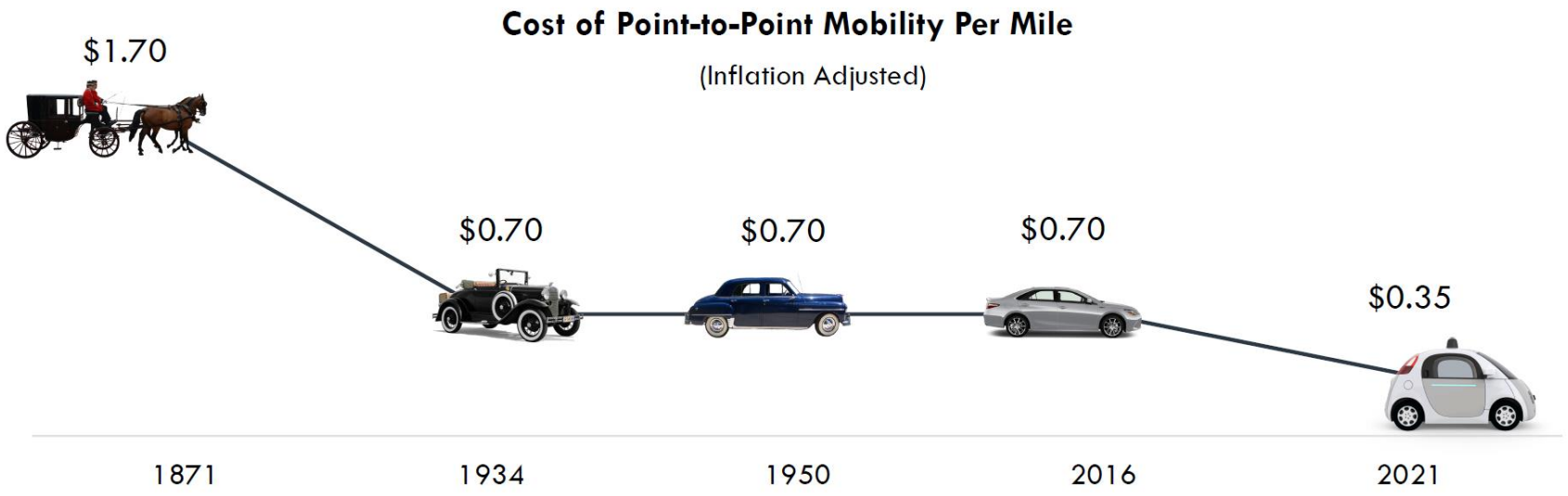


2. While the car is at the center of the Smart Grid for both electricity and information flow, the initial vehicle will only take electricity from the grid. Electricity will not be returned to the grid, and no information flow will occur. The security of the information paths is one of the considerations for the vehicle and for all aspects of the Smart Grid.

Source: Electronic Design Magazine 6/10

Personal Mobility Should Become More Affordable

The price of personal mobility has not changed since the Model T.



Sources: ARK Investment Management LLC, 2017 | Morton Salt Company Records, American Automobile Association (AAA)

THE ENDGAME: ELECTRIC ROBOTAXI FLEETS?

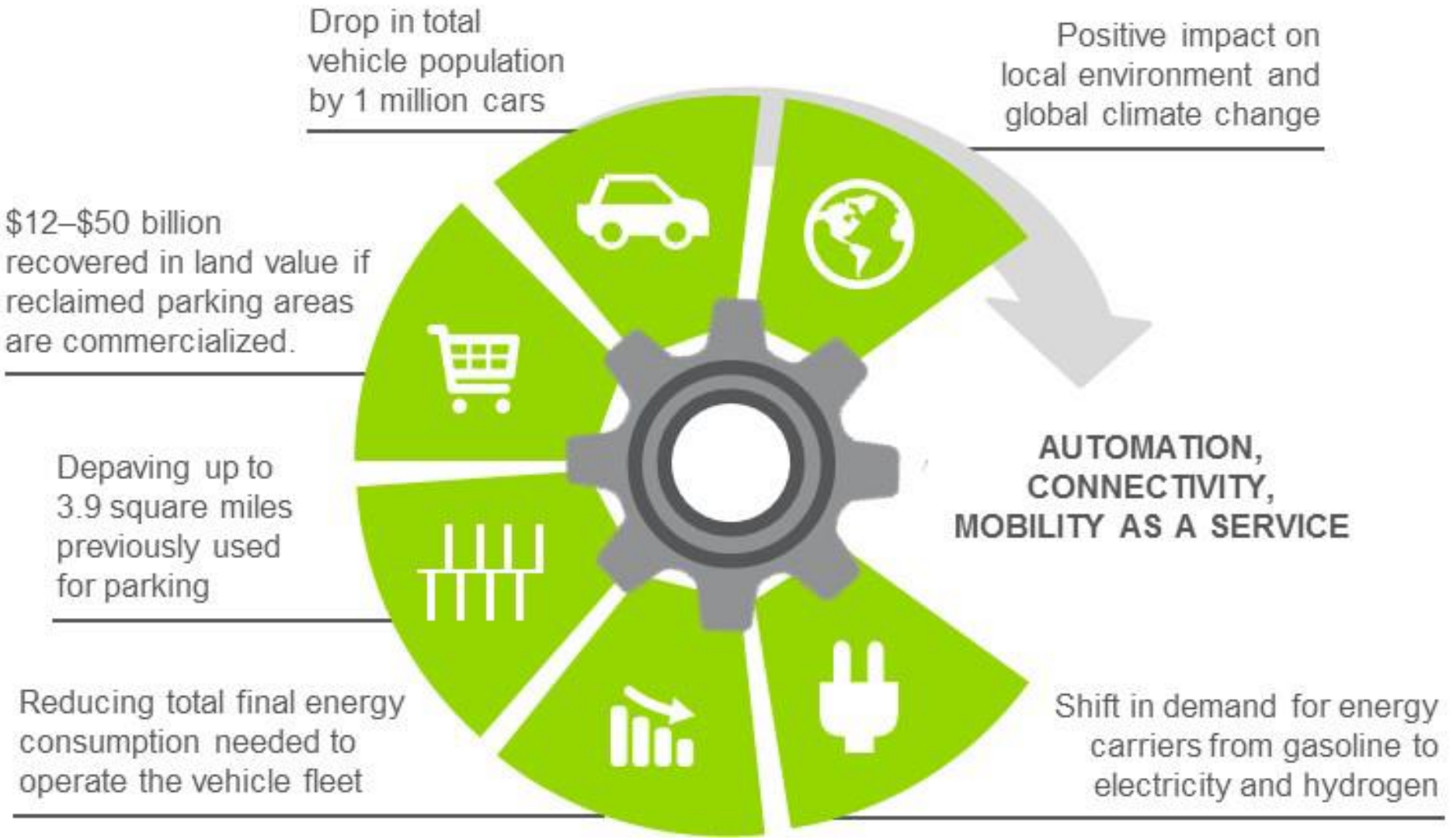
"What would happen if a whole city converted all at once to self-driving cars? ... people will be like, 'This is paradise.' You just push a button and a car pops up and takes you wherever you want to go. You have more pedestrian space, and the air smells better."

Chris Dixon

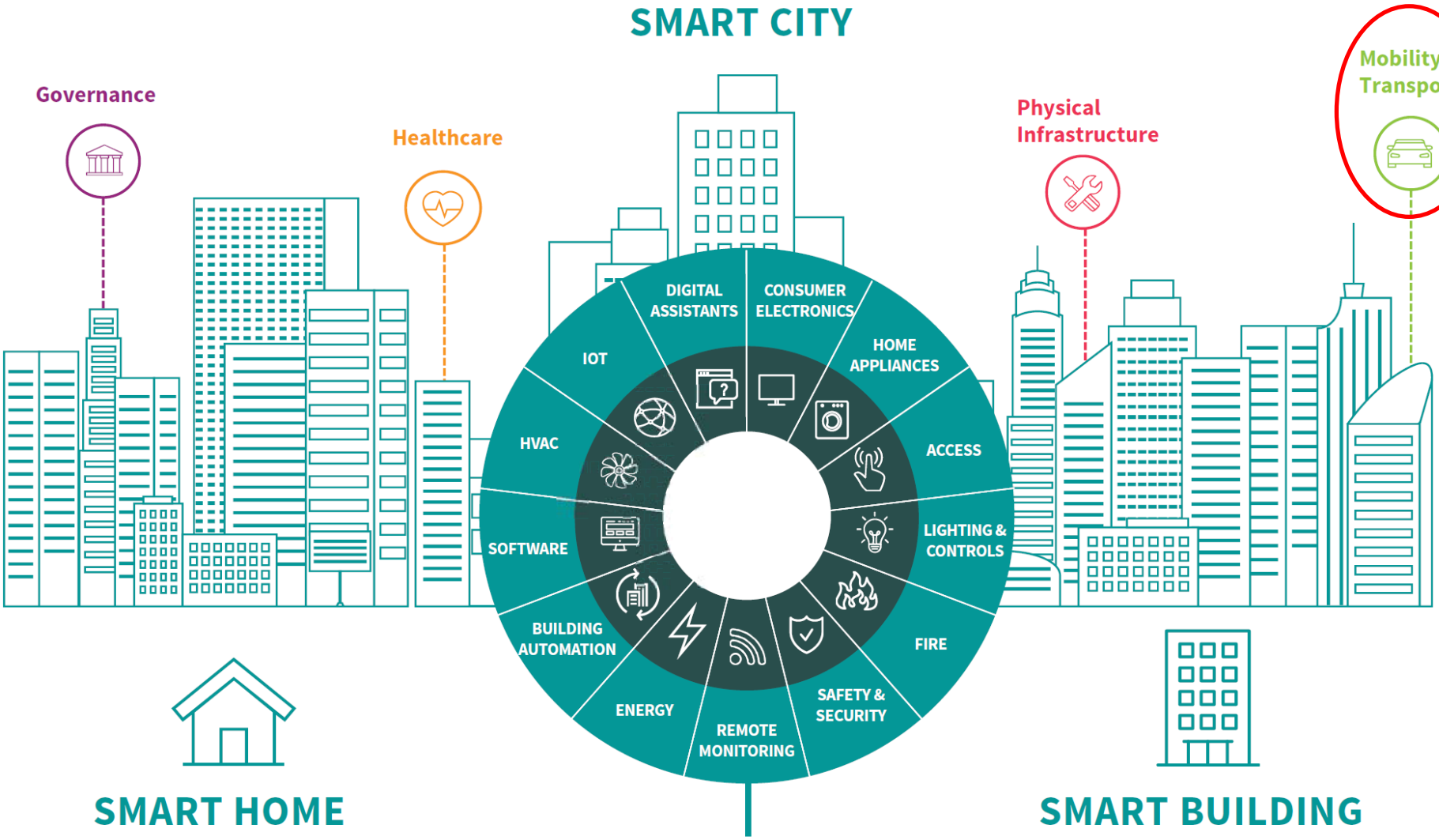
Partner, Andreessen Horowitz

Source: CB Insights 2017

Impacts of Driving Automation, Connectivity, and MaaS in a Model City



Source: Navigant Research 2017



Source: IHS Markit 2018

Robotic Vehicle Addressable Markets

Forecasted revenue from robotic cars

~$2.4T in 2032

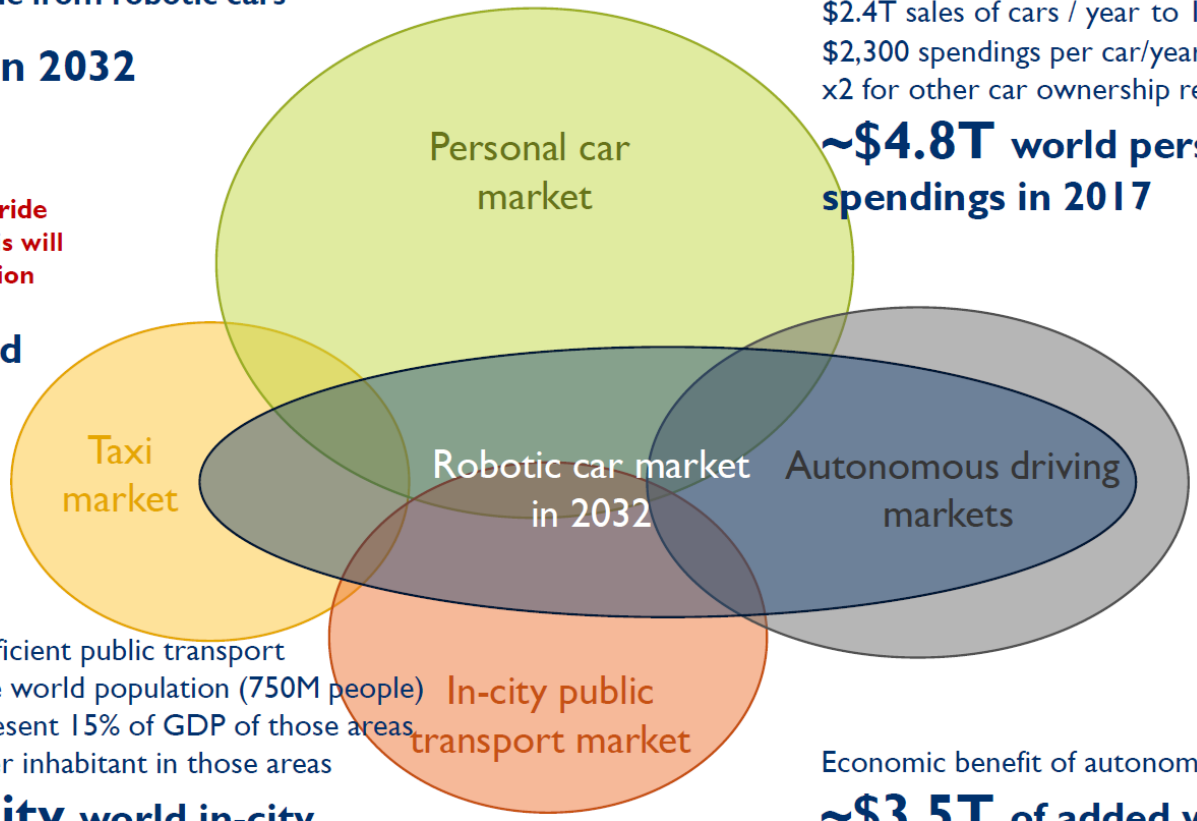
$2.4T sales of cars / year to 1B owners
$2,300 spendings per car/year
x2 for other car ownership related spendings

~$4.8T world personal car spendings in 2017

Car manufacturers and insurance companies will be disrupted

Already weakened by ride hailing companies taxis will suffer another disruption

~$1.9T world Taxi spendings in 2017



YOLE Développement

75 large cities with efficient public transport
This cover 10% of the world population (750M people)
Public transport represent 15% of GDP of those areas
$20k average GDP per inhabitant in those areas

~$2.3B in-city world in-city public transport spending in 2017

Robotic car offering could alow reduction in public transport investments

Economic benefit of autonomous driving

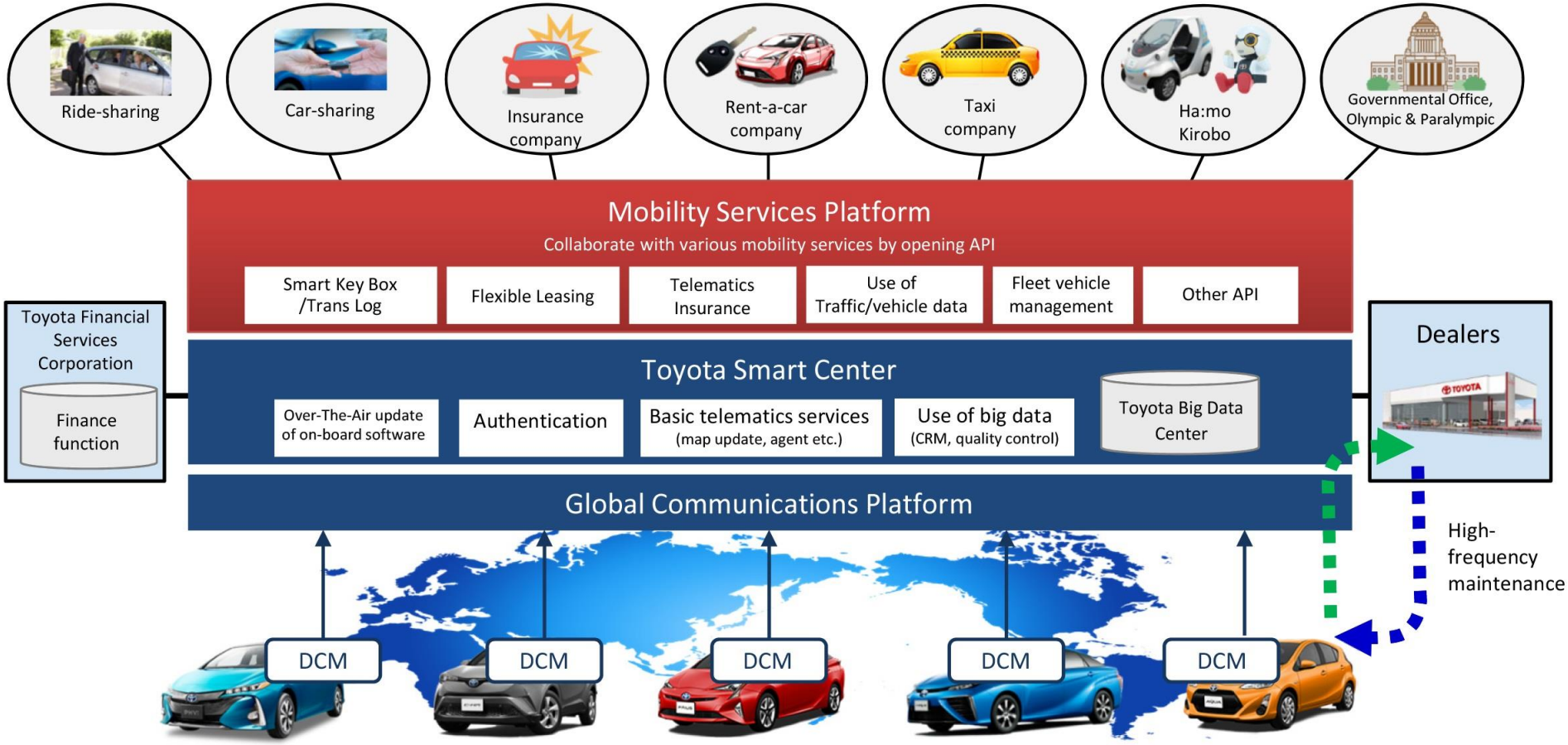
~$3.5T of added value generated by robotic cars in 2032

New mobility service companies will benefit from AD technology

Source: Yole Development 2018

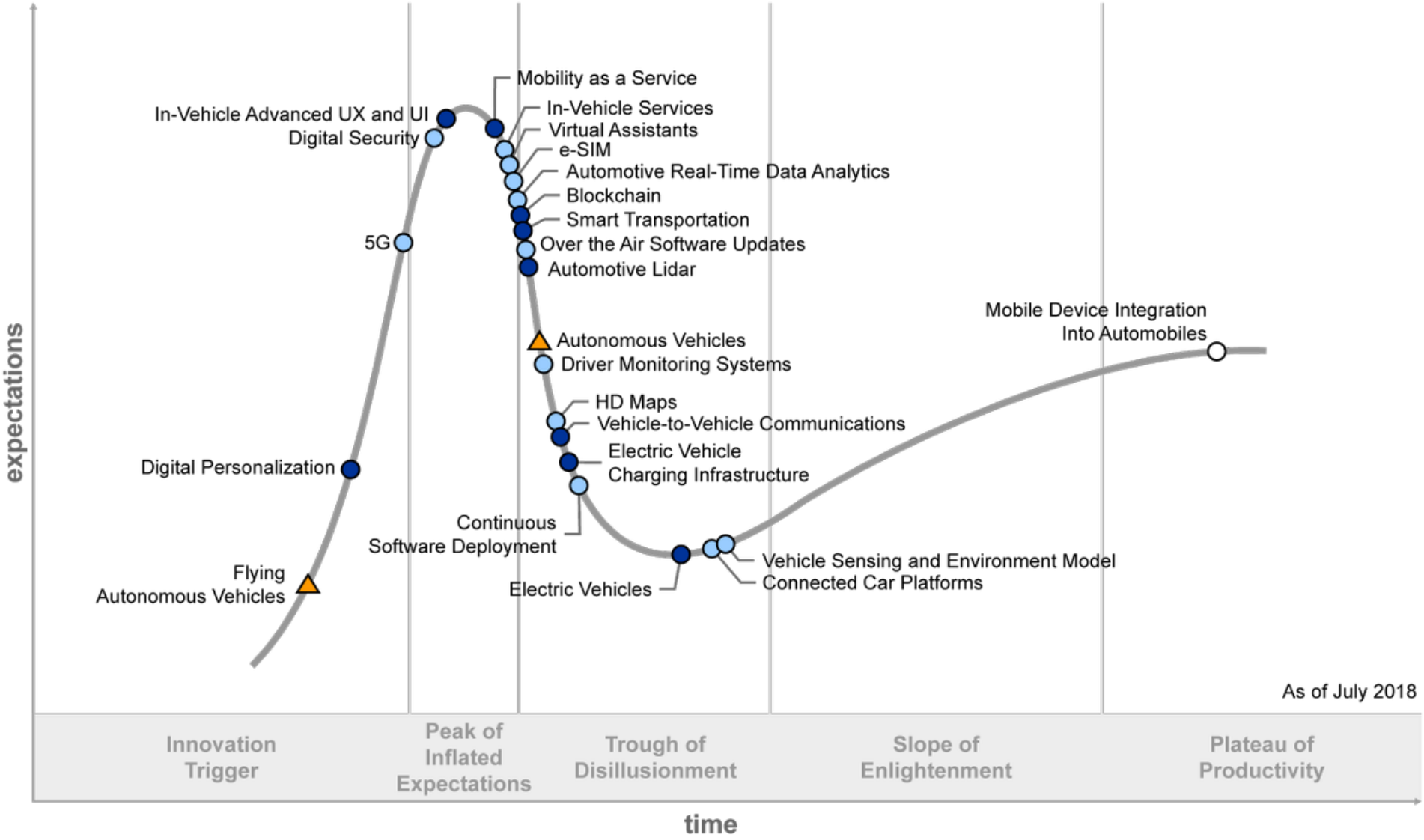
Toyota Mobility Services Platform

TOYOTA connected



http://blog.toyota.co.uk/toyota-connected-bring-advanced-mobility-services-europe

Connected Vehicles and Smart Mobility Hype Cycle



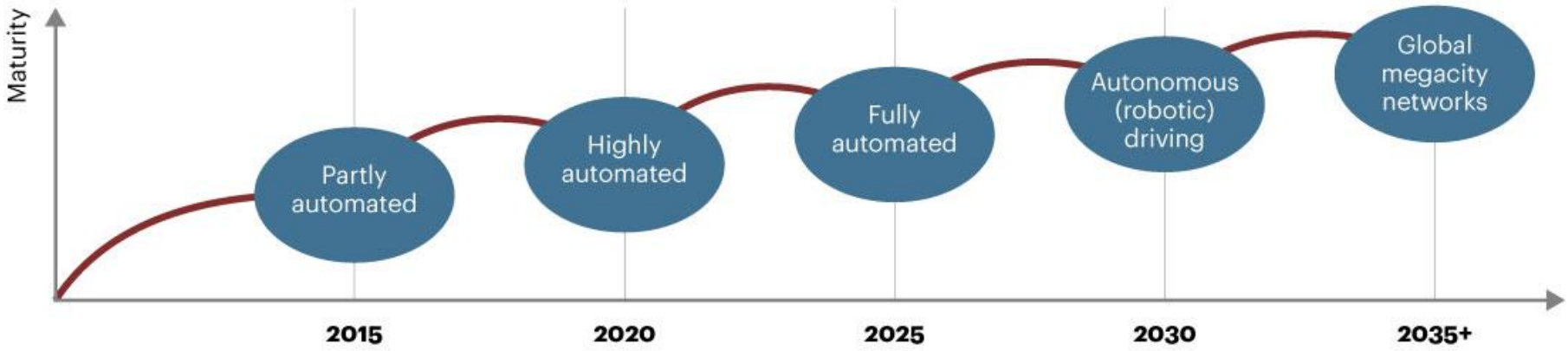
Plateau will be reached:

○ less than 2 years ● 2 to 5 years ● 5 to 10 years ▲ more than 10 years ⊗ obsolete before plateau

© 2018 Gartner, Inc.

https://www.gartner.com/doc/3883166/hype-cycle-connected-vehicles-smart

Autonomous driving technology will advance in waves



	2015	2020	2025	2030	2035+
Legal protection	Scoring system for preventive driving	Daily legal protection for car rental and car-to-go	Legal protection based on mobile devices	Legal protection for all kinds of devices	Legal protection for all kinds of devices
Technology	First-generation automation and control	Second-generation automation, pooling	Third-generation fixed-distance automation	Fourth-generation automated traffic junctions	Fully automated traffic flow management
Infra-structure	Highway networks	Regional or national network	Selected megacities	Micro-/mobile city metropolises	Globally interconnected megacities
Standards	Internet standards for mobility apps	Camera and image processing and interfaces	Radio frequency and interface standards	Control and automation standards	Fully automated networks/ telematics

Sources: Rinspeed; A.T. Kearney analysis

https://www.nytimes.com/2017/11/11/technology/arizona-tech-industry-favorite-self-driving-hub.html

PHOENIX — Three weeks into his new job as Arizona's governor, Doug Ducey made a move that won over Silicon Valley and paved the way for his state to become a driverless car utopia.

It was January 2015 and the Phoenix area was about to host the Super Bowl. Mr. Ducey learned that a local regulator was planning a sting on Lyft and Uber drivers to shut down the ride-hailing services for operating illegally. Mr. Ducey, a Republican who was the former chief executive of the ice cream chain Cold Stone Creamery, was furious.

"It was the exact opposite message we should have been sending," Mr. Ducey said in an interview. "We needed our message to Uber, Lyft and other entrepreneurs in Silicon Valley to be that Arizona was open to new ideas." If the state had a slogan, he added, it would include the words "open for business."

Mr. Ducey fired the regulator who hatched the idea of going after ride-hailing drivers and shut down the entire agency, the Department of Weights and Measures. By April 2015, Arizona had legalized ride-sharing.

Waymo, Valley Metro partner for inaugural self-driving vehicle program (Video)

https://www.bizjournals.com/phoenix/news/2018/07/31/waymo-valley-metro-partner-for-inaugural-self.html

Two-year program aims to start slow but expand to include Phoenix-area residents

By Hayley Ringle – Reporter, Phoenix Business Journal
Jul 31, 2018, 1:06pm

PHOENIX BUSINESS JOURNAL

Waymo and Valley Metro announced a partnership Tuesday to offer autonomous vehicle rides to and from nearby light rail and bus stops or park-and-ride locations.

The goal of the partnership — the first of its kind in the U.S. — is to enhance public transportation with autonomous car ride-share services and fill that "last mile" gap, said Shaun Stewart, chief business development officer for Waymo, Google's self-driving technology company.

"We've been looking for the right partnership for a while," Stewart said.

Valley Metro CEO Scott Smith said the service fills a gap for people who need a ride to connect with public transportation.

"People don't want to use public transit because they don't want to drive to a park-and-ride or their business is not on the light rail," Smith said. "Now we can connect them with autonomous cars."

The two-year pilot program will begin in August available to Valley Metro employees for first- and last-mile connections to public transportation.

A volunteer group of between 30 and 50 Valley Metro employees will be able to hail a ride through the Waymo app. The service then will be offered to Valley Metro's RideChoice program participants who have vouchers for discounted or free public transportation rides. This group covers people traditionally underserved by public transit.

Valley Metro CEO Scott Smith & Shaun Stewart of Waymo

Valley Metro CEO Scott Smith & Phoenix Acting Mayor Thelda Williams

ARIZONA COMMERCE AUTHORITY

I A M

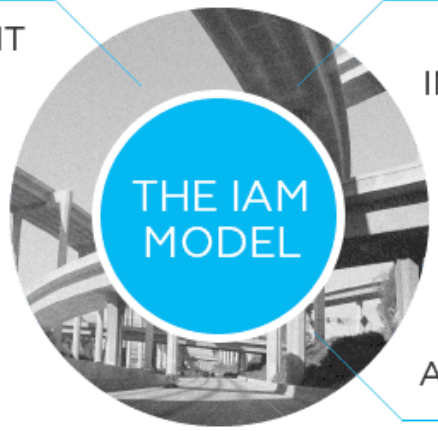
Shaping the future of transportation science, safety, and policy

The Institute of Automated Mobility (IAM) is a new consortium of private sector companies, public officials and university research faculty that will collaborate on state-of-the-art research and testing in Arizona.

ARIZONA COMMERCE AUTHORITY

ADOT

intel

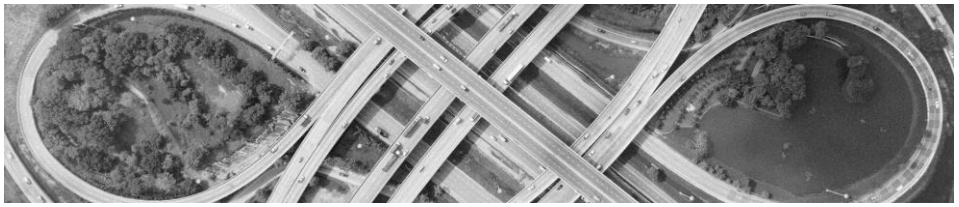


ASU Arizona State University

THE UNIVERSITY OF ARIZONA

NORTHERN ARIZONA UNIVERSITY

https://azcommerce.com/iam/



https://www.bizjournals.com/phoenix/news/2018/10/11/arizona-to-launch-autonomous-technology-consortium.html

ARIZONA IS LEADING THE WAY IN ENCOURAGING THE DEVELOPMENT AND TESTING OF AUTOMATED VEHICLE TECHNOLOGY

2015

- Governor Ducey leads the nation in issuing an executive order supporting automated vehicle technology, establishing consistent regulatory and operational environment in Arizona
- Governor Ducey establishes Self-Driving Oversight Committee

2016

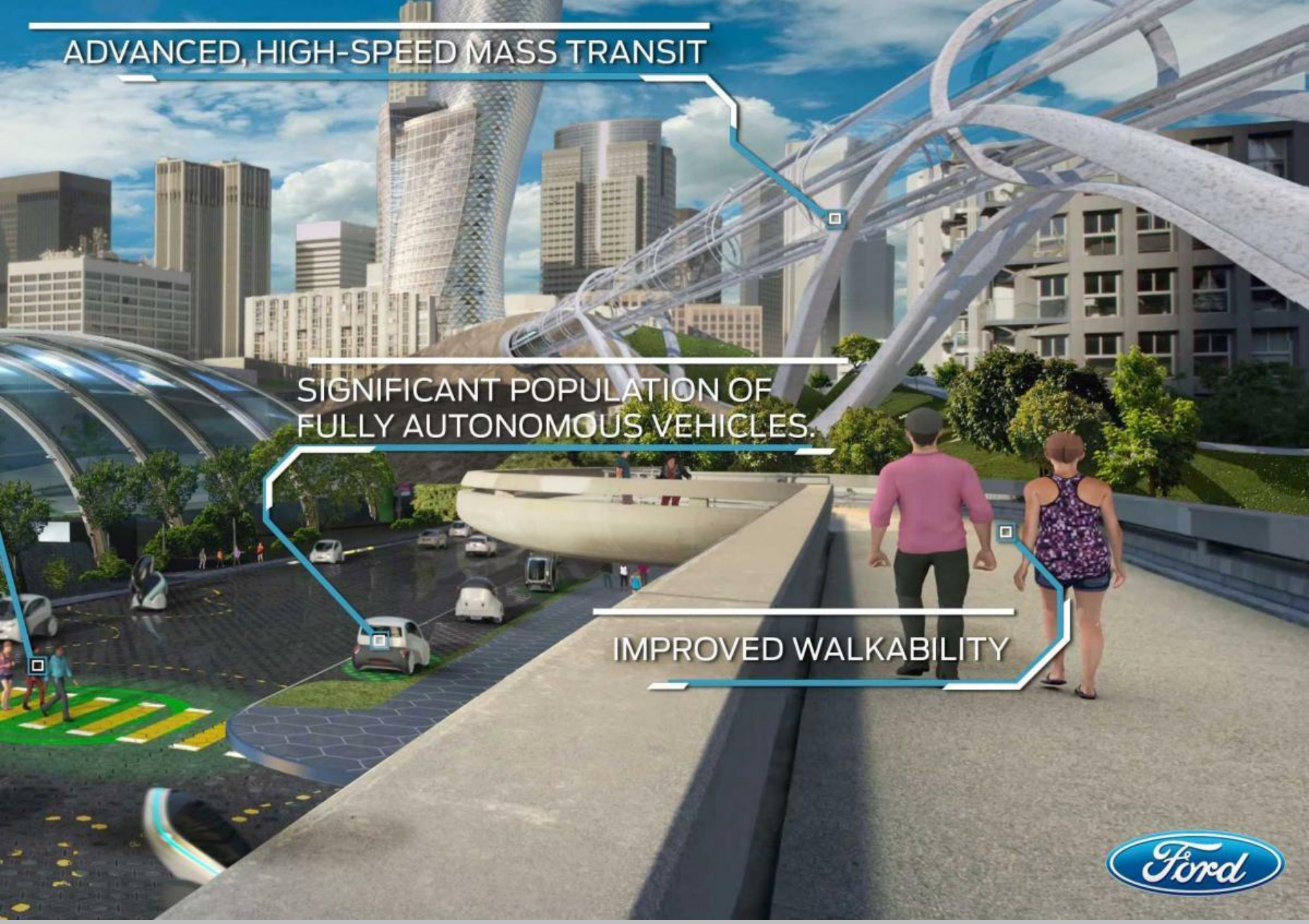
- Intel forms Automated Driving Division in Arizona
- Google launches self-driving car program called Waymo in Chandler
- Ford conducts trials in Arizona
- Uber relocates automated vehicle fleet to Arizona
- GM and Cruise Automation move testing to Arizona

2017

- Intel announces Arizona as a testing location
- Intel and ASU initiate collaborative research on autonomous safety
- Mobileye, an Intel company, introduces Responsibility, Sensitivity, Safety (RSS) Model
- Waymo announces Arizona as its global testing location

2018

- Governor Ducey updates first executive order in light of advancements in technology and testing
- Governor Ducey issues new executive order creating the Institute for Automated Mobility (IAM) under the Arizona Commerce Authority


ADVANCED, HIGH-SPEED MASS TRANSIT
SIGNIFICANT POPULATION OF FULLY AUTONOMOUS VEHICLES.
IMPROVED WALKABILITY
Ford

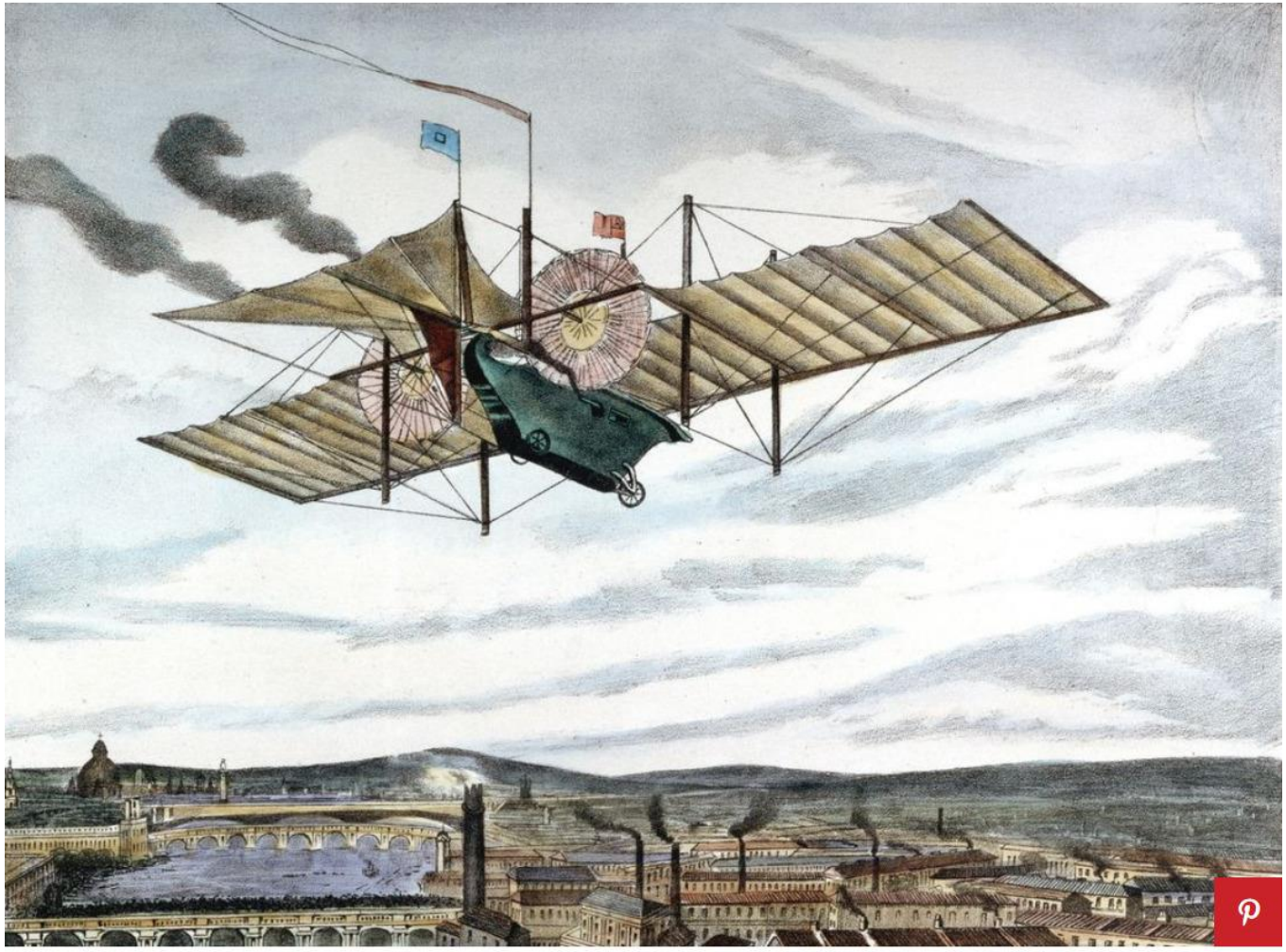
https://www.aerospacearizona.org/summit2018

Autonomous Vehicles Take to the Air

© 2018 - International Research Center

International Research Center
Your Research Edge

The 1841 Henson Aerial Steam Carriage



ANN RONAN PICTURES/PRINT COLLECTOR

William Samuel Henson and John Stringfellow, the Wright brothers before the Wright brothers existed, patented this flying car in 1841. The duo were never able to build a functional version of their monoplane, which had a theoretical wingspan of 150 feet.

Source: Popular Mechanics 2018
https://www.popularmechanics.com/technology/infrastructure/g2021/history-of-flying-car/

The 1947 ConVairCar Model 118

FPG/HULTON ARCHIVE

The ConVairCar, Model 118 flying car was not a hoax, as evidenced by this test flight in California in November 1947. Theodore P. Hall designed this creation for the Consolidated Vultee Aircraft Company. The one-hour demonstration flight ended early due to low fuel, an emergency landing that destroyed the car and damaged the plane's wings. Everyone survived—that is, everyone except the ConVairCar dream.

Source: Popular Mechanics 2018

https://www.popularmechanics.com/technology/infrastructure/g2021/history-of-flying-car/

Flying Car Developer Says He's $80 Million Closer to Making Sci-fi Dreams Real

Moller International

http://moller.com/dev/

http://www.youtube.com/watch?v=gOR_SzLW2Ns

http://www.youtube.com/watch?v=FY85eExk7Zo

moller
MOLLER INTERNATIONAL

Are You Ready to Fly Without a Human Pilot?

Automated flight controls go back to the 1920s and through World War II they had rudimentary autopilots. As those autopilot features grew more sophisticated through the 20th century, flying also grew safer. Autopilot features vary by aircraft type and airline, with some planes even able to land themselves under certain conditions. Southwest uses an autopilot technology that assists pilots during every part of the flight, including descent. Some think automation could obviate the need for human pilots, but experts say the technology, the industry, and the passengers are not quite ready for fully autonomous flying. Regulators are already taking steps toward downsizing the role of humans on the flight deck, but advances in autonomy will be on the margins instead of earthshaking,

https://www.nytimes.com/2018/07/16/business/airplanes-unmanned-flight-autopilot.html

EVs are here. Try to keep up.
CHARGED
ELECTRIC VEHICLES MAGAZINE

Experimental NASA airplane features 14 propellers driven by 14 electric motors

https://chargedevs.com/newswire/experimental-nasa-airplane-features-14-propellers-driven-by-14-electric-motors/

Posted August 9, 2018 by Charles Morris & filed under Newswire, The Vehicles.

NASA is building an experimental airplane in order to demonstrate that electric propulsion can make planes quieter, more efficient and more environmentally friendly.

The X-57, nicknamed "Maxwell," has 14 electric motors turning 14 propellers, integrated into a specially-designed wing.

NASA Aeronautics researchers hope to use Maxwell to validate the idea that distributing electric power across a number of motors will result in a five-time reduction in the energy required for a private plane to cruise at 175 mph.

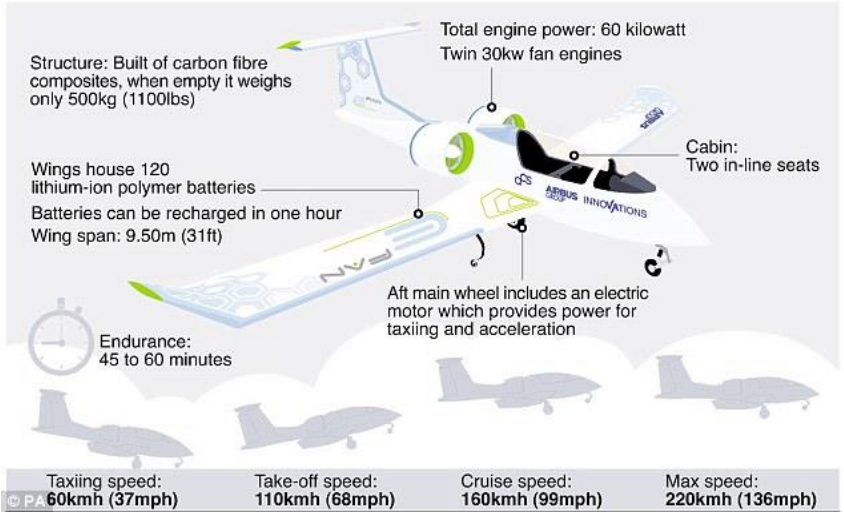
Typically, to get the best fuel efficiency, an airplane has to fly slower than it is able. Electric propulsion essentially eliminates the penalty for cruising at higher speeds. NASA researchers estimate that the higher energy efficiency of X-57 technology could reduce operational costs for small aircraft by as much as 40 percent.

How the promise of electric power could transform aviation

Peggy Hollinger in London – Financial Times
Sep 18, 2018, 5:02am
PHOENIX BUSINESS JOURNAL

Airbus E-Fan: the world s first plug-in plane PA

Currently a demonstrator for electric aircraft technology, Airbus says that the E-Fan will be used as the basis for building a new pair of electric training aircraft models



Airbus thought it was about to make aviation history. When the company's battery-powered E-Fan aircraft lifted into the air with barely a sound on a summer day in 2015, a cheer went up from those on the ground at Lydd airport in southern England. Just over a century after Louis Blériot made the world's first aeroplane flight across the English Channel, an electrically-powered crossing was on its way into the record books.

Except, it was outsmarted. After hearing of the Airbus plan, a French stunt pilot had taken off in his own small aerobatic e-plane a few hours earlier and crossed the channel from the other direction.

Aviation is on the brink of the biggest revolution since Frank Whittle invented the jet engine in 1937. After decades in which jets have been powered by fossil fuels, advances in materials, battery technology and electrical systems are holding out the promise of cleaner, cheaper commercial flight.

In this new era of electric aviation, the market will not just be for so-called flying taxis – small vehicles carrying a handful of passengers over very short distances. A growing number of projects are focusing on the potential for regional aircraft carrying dozens of passengers with ranges of up to several hundred miles – with the larger aircraft aiming at 100 passengers.

Limitations to electrical systems mean that for the foreseeable future these aircraft will mainly be hybrids, combining traditional gas turbines with power from on-board generators. But even hybrids will enable designers to reimagine the modern aircraft. Instead of jet engines hanging off a wing, multiple motorised fans could be distributed across an aircraft, offering a new canvas for designers to dream up more aerodynamically efficient and potentially safer vehicles.

https://www.bizjournals.com/phoenix/news/2018/09/18/how-the-promise-of-electric-power-could-transform.html

ZUNUM Aero

Piloted or drone

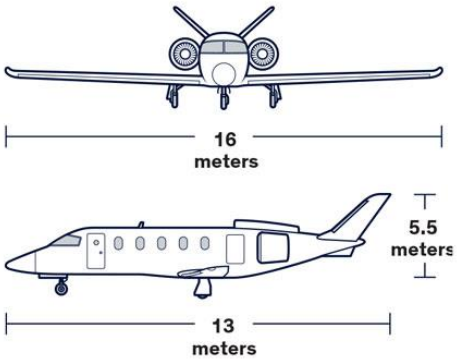
Pilot optional cockpit
Fly-by-wire

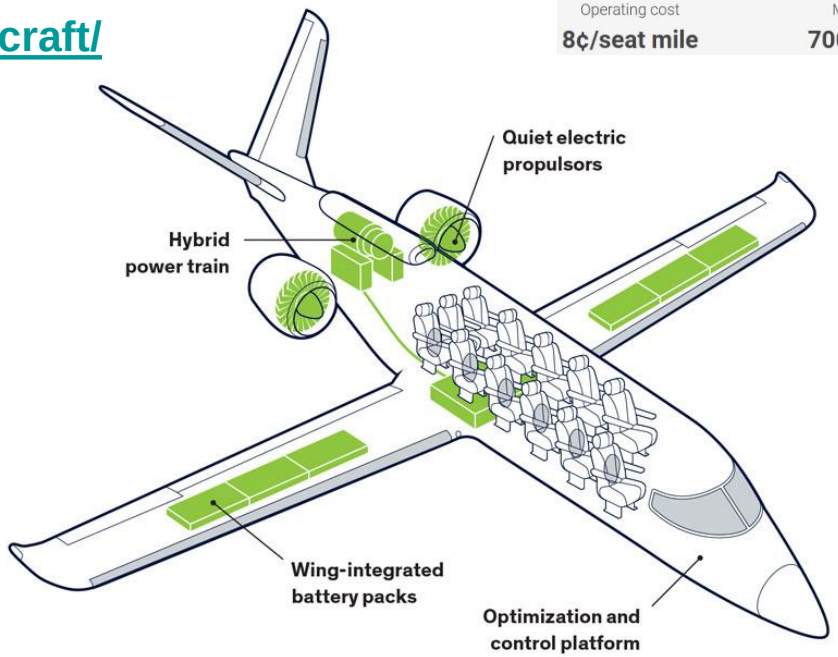
Intuitive control and optimization

Flight optimized energy delivery
Integrated control, 1-touch modes

Operating cost	Max range	Max cruise speed	Take-off distance
8¢/seat mile	700+ miles	340 mph	2,200 ft

https://zunum.aero/aircraft/





Max cruise speed	340 mph
Max range	700+ miles
Max altitude	25,000 ft
Runway with 50 ft obstacle	2,200 ft
Landing distance with 50 ft obstacle	2,500 ft
Rate of climb	1,600 ft per minute
Time to climb	sea level to FL 25 18 minutes
Stall speed	73 KIAS

Centaur is a small civilian airplane based on the Diamond DA42 is a pilot optional reconnaissance platform from Aurora Flight Sciences (https://www.aurora.aero/), who also operates Boeing's Aerospace & Autonomy Center in MA (http://www.boeing.com/company/key-orgs/aerospace-autonomy-research-center/).

Platform for Unmanned Cargo Aircraft (PUCA)

PUCA aims to facilitate the development of unmanned cargo aircraft (UCA) and to let its members play a meaningful and profitable role in this development capitalizing on the strengths of its members: logistics, systems integration, sensors and development of subsystems. UCA can be both cheaper to build and operate as well as be more productive than manned cargo aircraft. The advantages of UCA manifest themselves in particular with small planes where they can open new markets currently deprived of high-quality transport.

https://www.platformuca.org/

Futurism

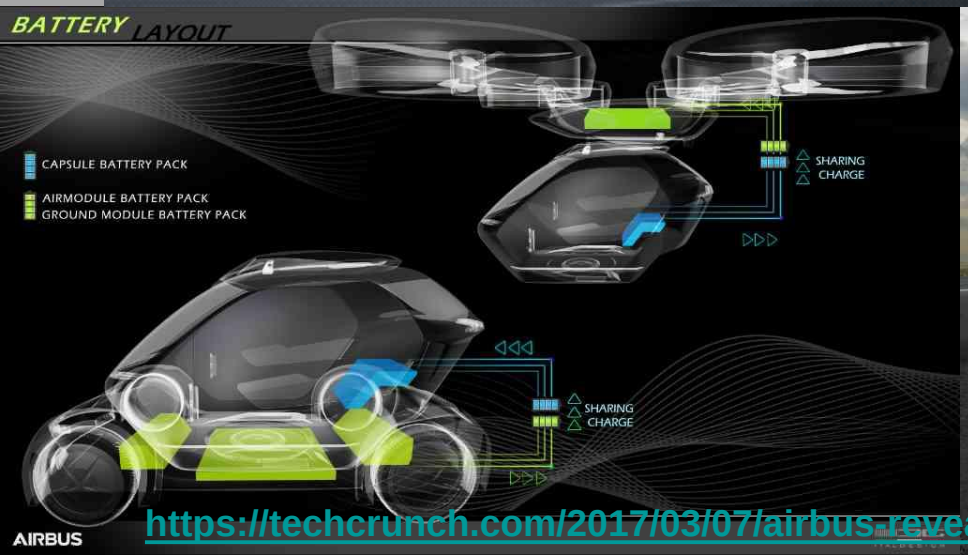
Advanced Transport

PAL-V's Flying Car Design Has Been Finalized, Will Arrive in 2019

The Dutch PAL-V Liberty is designed to comfortably hold two passengers, take off while carrying more than 908 kg (2,000 pounds), and can operate as both a car and an aircraft. In car mode, it has a top speed of 160 km/hour (99 mph) and a range of 1,315 km (817 mph). In flight mode, its top speed increases to 180 km/hour (112 mph) and its range drops to 500 km (310 miles). The aircraft has already received certification from both the European Aviation Safety Agency (EASA) and the Federal Aviation Administration (FAA) in the U.S.

https://futurism.com/flying-car-design-finalized-arrive-2019/

Purchase Your PAL-V: https://www.pal-v.com/en/purchase-your-pal-v



https://techcrunch.com/2017/03/07/airbus-reveals-a-modular-self-piloting-flying-car-concept/

Futuristic Bell Helicopter Air Taxi Cabin Offers Fully Integrated User Experience

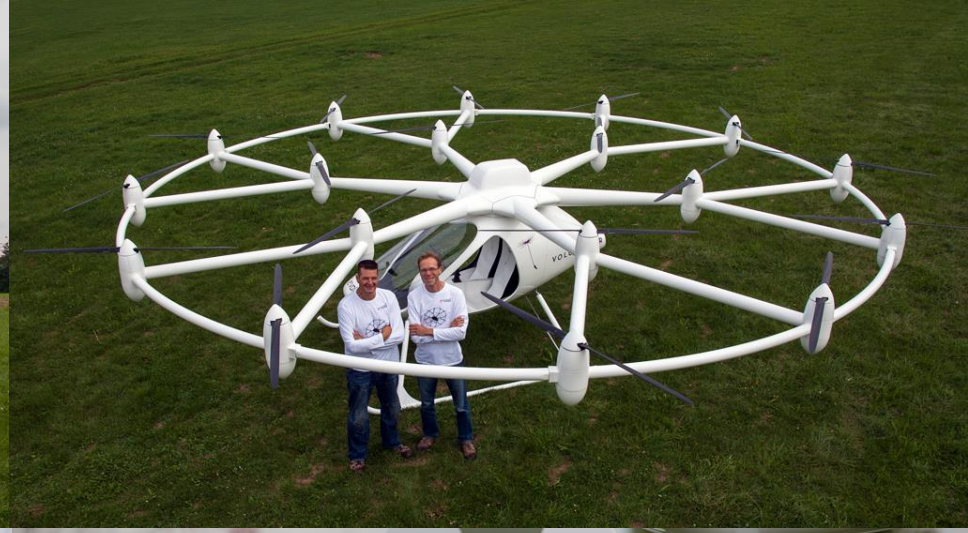
Bell Helicopter presents you, **futuristic air taxi cabin** design that features fully integrated user experience. This is a four-passenger cabin, a future vision from Bell Helicopter about an on-demand mobility aircraft that focuses on user experience tailored with an urban air taxi ride. This futuristic project aims to challenge the limit of vertical flight, it wants to break the limit of aviation technology to solve real-world problems. This is the future of urban air taxi and it is closer than you think.

Bell's air taxi cabin reveals luxurious and expertly crafted interior, it is based on years of customer insight and attention to detail. Passengers would enjoy a fully integrated user experience control center, while riding, they still can catch up on world news, share documents with others, hold a video conference, or just imply unplug from noise world and just relax.

http://www.tuvie.com/futuristic-bell-helicopter-air-taxi-cabin-offers-fully-integrated-user-experience/

http://www.bellflight.com/

Tuvie



E-volo's Volocopter is a revolution in aviation made in Germany. It's safer, simpler, and cleaner than normal helicopters with a unique way of moving, a groundbreaking innovation. The Volocopter is an environmentally friendly and emission- free private helicopter. http://www.e-volo.com/

https://www.volocopter.com/en/

CityAirbus

A multi-passenger, self-piloted electric vertical takeoff and landing (VTOL) demonstrator designed for urban air mobility with cost efficiency, high-volume production and a low environmental footprint in mind.

AUTONOMY
15 minutes

ENGINES
- 8 fixed pitch propellers powered by direct drive engines
- 8 x 100 kW electric motors

SIZE
Compact size for ideal integration into urban landscapes

BATTERIES
- 140 kW power x 4 batteries
- 110 kW energy in all 4 batteries

Ducted high lift propulsion units designed for efficiency, low acoustic footprint and safety

CAPACITY
Transports up to 4 passengers

Avionics and autopilot built for optimised urban air traffic management

CRUISE SPEED
120 km/h

Making CityAirbus a reality

2015

Feasibility study
Study confirms that CityAirbus will meet operating cost targets and safety requirements to be certified for public use

2016

Full scale component testing
Key technologies demonstrated at full size

Flight testing with small scale drone
Control algorithms and flight mechanics developed

2017

Demonstrator team created
Collaborative team of highly dynamic and experienced engineers set up

2018

Full size demonstrator
Full-scale in-flight demostration and verification of a full electric, RPM-controlled multi-propeller vertical takeoff and landing (VTOL)

2023

CityAirbus takes to the sky
Fully certified CityAirbus becomes part of public urban transport mix, in conjunction with upgraded urban air traffic management

Benefits of adding the third dimension to urban transport networks

1 URBAN DEVELOPMENT
The third dimension increases the geographic accessibility to remote and underserved areas of the city

2 HIGHER SPEED AND RANGE
Self-piloted flying vehicles can operate at three times the speed of the average road vehicle and extend commuters' geographical reach by tenfold

3 ENVIRONMENTAL FOOTPRINT
Self-piloted flying vehicles are fueled by electricity and are energy efficient

AIRBUS

Defining the FUTURE AVIATION FLEET

Army scientists, engineers lead joint effort

BY DAN LAFONTAINE, RDECOM PUBLIC AFFAIRS

Artist's conception of future Army rotorcraft. (U.S. Army graphic by AMRDEC VizLab)

Source: Army Technology Magazine 3-4/15

S.H.I.E.L.D. HELICARRIER

KEY
1. Aircraft deck lift (starboard)
2. Aircraft ready room
3. Aft aircraft lift
4. Ship's communication core
5. Main computer core array
6. Nuclear reactor core
7. Heat exchangers
8. Stem repulse lift array
9. Emergency bail-out tubes

KEY (continued)
18. Fuel cells
19. Crew quarters
20. Life-support pods
21. Back-up computer core
22. Turbo lift
23. Repulse lift array
24. Planning room
25. Forward command and control

KEY (continued)
10. Gatling guns
11. Side loading bay
12. Super missiles
13. Forward lift (mostly for stores)
14. Military storage
15. Marines vehicle park
16. Marines tactical room.
17. Marine training room

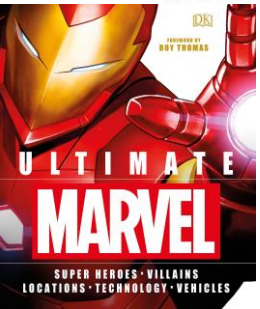
Aircraft deck lift
Air-traffic control
Missile Storage
Attack helicopter
Plane pulling tractor
Rescue and marine delivery helicopter
Reinforced deck
Food and ships stores
Fast-attack jet
Rear stairway
Warning lights
Maintenance deck power matrix
Forward looking eye
Latest generation Phalanx Gatling gun
Air-purification unit and air-conditioning pipework
Radar array
Turbo lifts
Power converters
Docking tractor beam
Bathrooms
Billets
Gangways to inspection points
VTOL (Vertical Take-Off and Landing) aircraft
Aft engine, twin prop
Forward strength girders
Pressure-equaling tube
Window with heads-up display
Fan blades
Boiler room crew
Durasteel protection grid
Engine vent
Escape hatches
Swivel join to give forward and reverse thrust
Anti-missile battery
Air vent
Radar ball deck
Vent for cruise missile gas
Cruise missile launch deck
Central information center
Radar heat exchange vent
Triple skin
Shield
Anti-missile battery
Anti-missile battery

S.H.I.E.L.D. HELICARRIER DATA

LENGTH: 1,000ft (305m)
TOP FLIGHT SPEED: 35mph (56kph)
CEILING: 60,000ft (18,288m)
CREW: 450–1,000
ARMAMENTS: 70mm anti-missile/anti-aircraft cannon; cruise missiles; nuclear warheads; experimental weapons

Security breach
The Helicarrier's command and control center possesses the latest failsafe technology. This prevents hacking by cyber criminals.

MARVEL
marvel.com
© 2017 MARVEL



http://marvel.wikia.com/wiki/S.H.I.E.L.D._Helicarrier

https://en.wikipedia.org/wiki/Helicarrier

https://medium.com/@UberPubPolicy/fast-forwarding-to-a-future-of-on-demand-urban-air-transportation-f6ad36950ffa

http://uber.com/elevate/whitepaper

Architects and interior designers at Corgan created their Uber Skyport concept to fit over existing highway systems, so it won't take up additional city space. The architecture firm plans to connect the hub to existing transportation options, adding bus and rail transfers to make the landing pads more useful to the community beyond *just* Uber's flying taxis.

https://www.cntraveler.com/gallery/first-look-these-are-the-futuristic-hubs-designed-for-ubers-flying-cars

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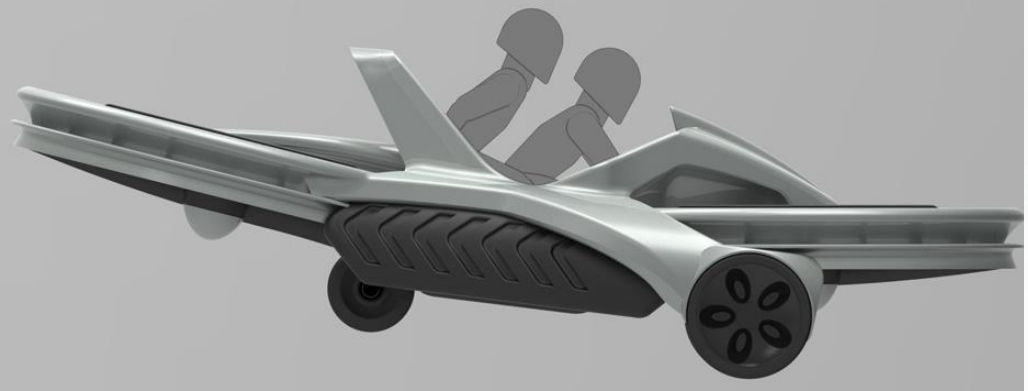
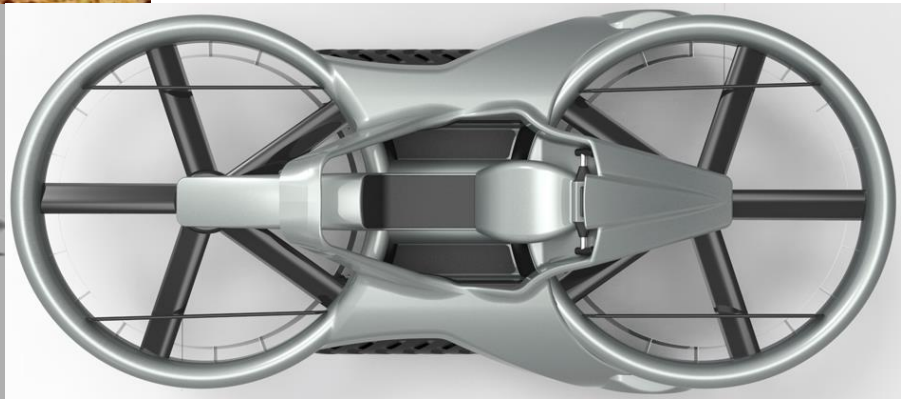
Aero-X Hoverbike from Aerofex

Where you're going, there are no roads. That's why you need the Aero-X, a vehicle that makes low-altitude flight realistic and affordable. Flying up to 10 feet off the ground at 45 miles per hour, the Aero-X is unlike any vehicle you've seen. It's a hovercraft that rides like a motorcycle - an off road vehicle that gets you off the ground. The Aero-X can be adapted for unlimited outdoor uses: surveying, search and rescue, border patrol, disaster relief, aerial agricultural, ranching, and much more. Or maybe you just want go out to the desert and fly. http://aerofex.com/



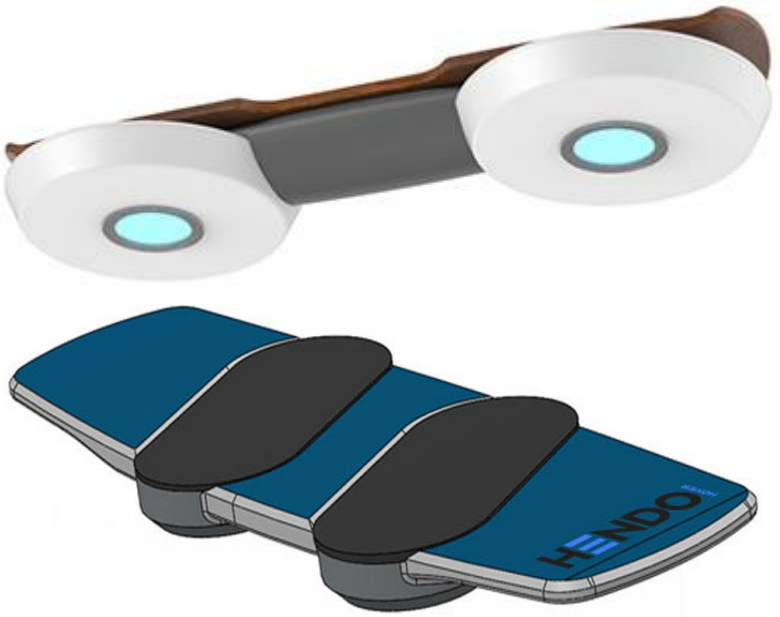


NASA Puffin VTOL Personal Air Vehicle Concept

Scientific American Article 1/10:
http://www.scientificamerican.com/article.cfm?id=nasa-one-man-stealth-plane

YouTube Video:
http://www.youtube.com/watch?v=rhpPhvWvLgk&feature=player_embedded

Hendo Hoverboards - World's First Real Hoverboard



http://hendohover.com/

https://www.kickstarter.com/projects/142464853/hendo-hoverboards-worlds-first-real-hoverboard

FOR UNOFFICAL USE ONLY (FUUO)

DRONE SURVIVAL GUIDE

FAA Projecting Huge Increase in Commercial Drones

THOMAS

By Jeff Reinke, 4/27/18

https://news.thomasnet.com/featured/faa-projecting-huge-increase-in-commercial-drones

The Federal Aviation Administration (FAA) recently unveiled statistics showing that as many as 450,000 unmanned aerial vehicles, or drones, could be operating in the domestic airspace by 2022. The agency estimates the current number at about 110,000.

That increase doesn't account for potential changes to federal drone restrictions that could make it easier to buy and operate drones in public spaces. If these guidelines are loosened, that projection could grow significantly. Another significant factor that will undoubtedly influence this projection is the use of drones by retailers and logistics companies. Notable stakeholders on this front include Amazon and UPS.

The agency also sees the ranks of commercial-drone pilots climbing past 300,000 during this same period. This number would be more than a 400 percent increase from the roughly 70,000 current pilots. These projections would imply there will be more commercial drones and pilots than private aviators and manned aircraft.

If the regulations governing drone operation continue to become laxer, the agency estimates overall commercial-drone numbers could top 600,000 by 2030. At this level, the number of drones would be nearly triple the size of the country's general aviation fleet.

Platform for Unmanned Cargo Aircraft (PUCA)

In January, 2018 Boeing unveiled a new unmanned electric vertical-takeoff-and-landing (eVTOL) cargo air vehicle (CAV) prototype that will be used to test and evolve Boeing's autonomy technology for future aerospace vehicles. It is designed to transport a payload up to 500 pounds presenting new possibilities for autonomous cargo delivery, logistics, and other transportation applications. Powered by an environmentally-friendly electric propulsion system outfitted with eight counter rotating blades it measures 15 feet long, 18 feet wide, and 4 feet tall, weighing 747 pounds.

http://boeing.mediaroom.com/2018-01-10-Boeing-Unveils-New-Unmanned-Cargo-Air-Vehicle-Prototype

AI-controlled armed, autonomous UAVs may take over when things start to happen faster than human thought in future wars. From Call of Duty Black Ops 2
(Credit: Activision Publishing)

http://www.kurzweilai.net/the-proposed-ban-on-offensive-autonomous-weapons-is-unrealistic-and-dangerous

Unmanned Aircraft System (UAS) Traffic Management (UTM) Enabling Civilian Low-Altitude Airspace and Unmanned Aircraft System Operations

Source: NASA 2018 (https://utm.arc.nasa.gov/)

Aerospace & Autonomy Center Technology Areas

SAFETY & SECURITY

- Software reliability
- Cyber physical system security
- Verification and validation techniques
- Certification of autonomous systems
- Flight system integration & test

ENTERPRISE OPERATIONS

- Maintenance and support
- Manufacturing
- Supply chain

INTELLIGENT DECISION & CONTROL

- Extensible, vehicle agnostic, autonomy architecture
- Detect and Avoid (DAA)
- Mission and task planning and re-planning in complex dynamic, uncertain settings
- Machine Learning and Cognitive Decision Systems
- Perception and situational awareness
- Robust Guidance, Navigation, and Control

ROBOTICS

- Aerial manipulation
- Robotic services
- Improved manufacturing
- Space applications

ADVANCED VEHICLES AND AIRSPACE

- Electric power systems
- Highly integrated aircraft configurations
- Advanced materials and structures
- Advanced airspace concepts

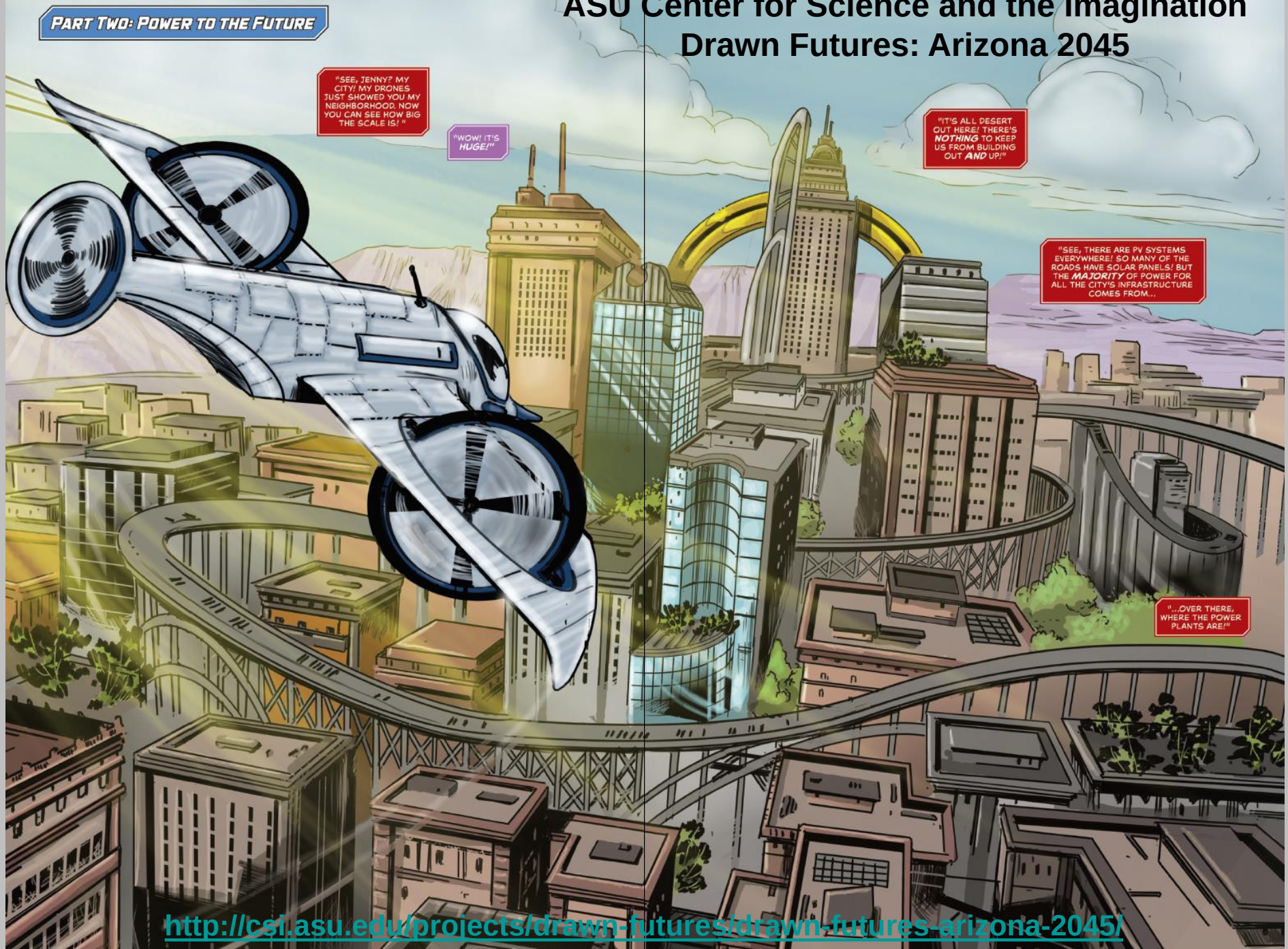
HUMANS & AUTONOMY

- Trustworthy, safe, knowledgeable interfaces
- Human-autonomy collaborative decision-making
- Manned-unmanned teaming
- New interaction paradigms

BOEING

http://www.boeing.com/company/key-orgs/aerospace-autonomy-research-center/

ASU Center for Science and the Imagination
Drawn Futures: Arizona 2045



http://csi.asu.edu/projects/drawn-futures/drawn-futures-arizona-2045/