TECHNOLOGY OVERVIEW: AUTONOMOUS VEHICLES

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CONNECTED CAR

Internet Connectivity

- Cellular Connectivity/WiFi Hotspot
- Infotainment Systems
- Smartphone Extension
- Telematics and Remote Access

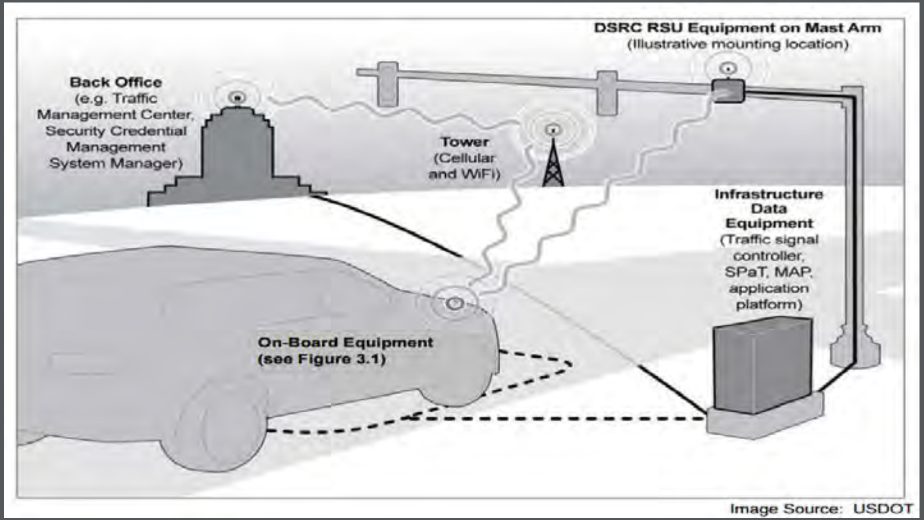
Source: Google

Source: Apple

CONNECTED VEHICLE

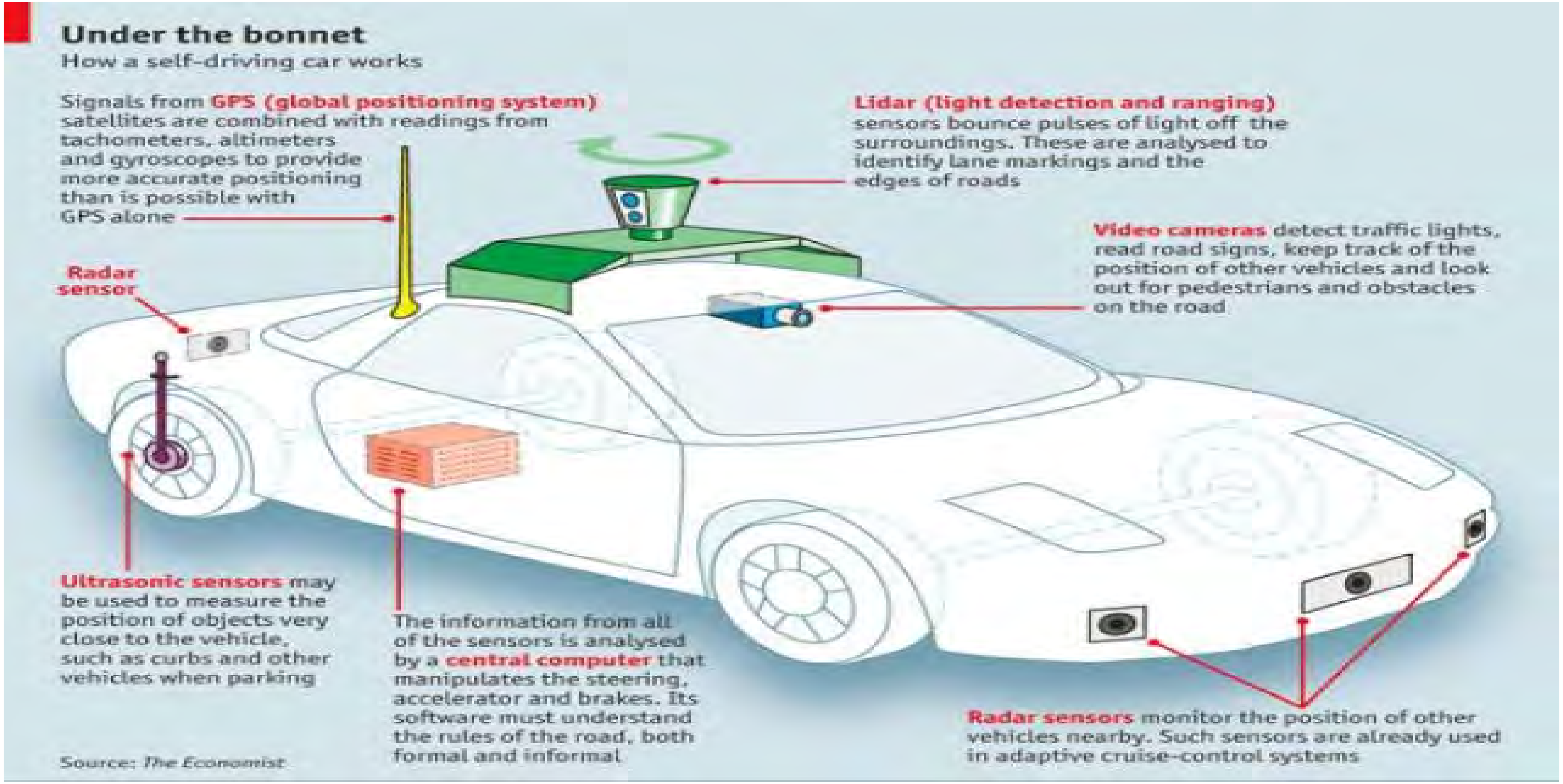
Point-to-Point Wireless Communications

- Dedicated Short Range Communications
- V2V (Vehicle-to-Vehicle)
- V2I (Vehicle-to-Infrastructure)
- V2X (Vehicle-to-All)
- Low Latency Wireless (Milliseconds)
  - 5.9 GHz
  - 802.11p wireless router, IEEE1609.X



AUTONOMOUS VEHICLES

- How do they work?

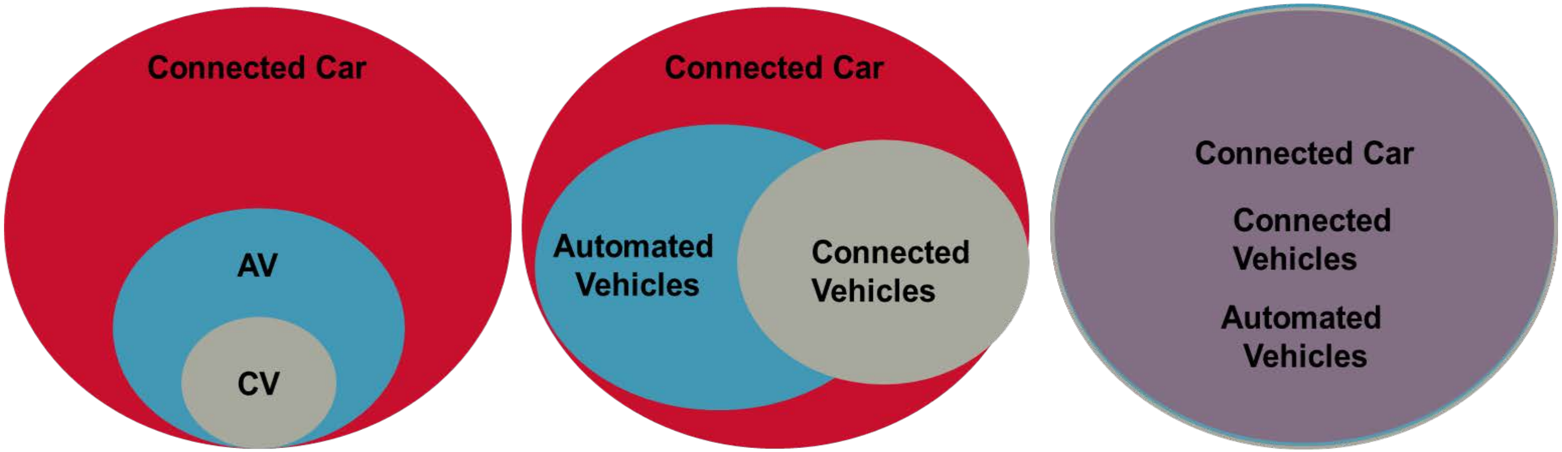


RELATIONSHIP BETWEEN CONNECTED CARS, CONNECTED VEHICLES AND AUTONOMOUS VEHICLES

- Cars connected to Internet
- Some Level of Autonomy
- CVs in Pilot Deployments

- Cars connected to Internet
- AV production vehicles (Level 3)
- CVs in Production Vehicles

- Cars Connected to Internet
- AV production vehicles (Level 4)
- CVs Ubiquitous



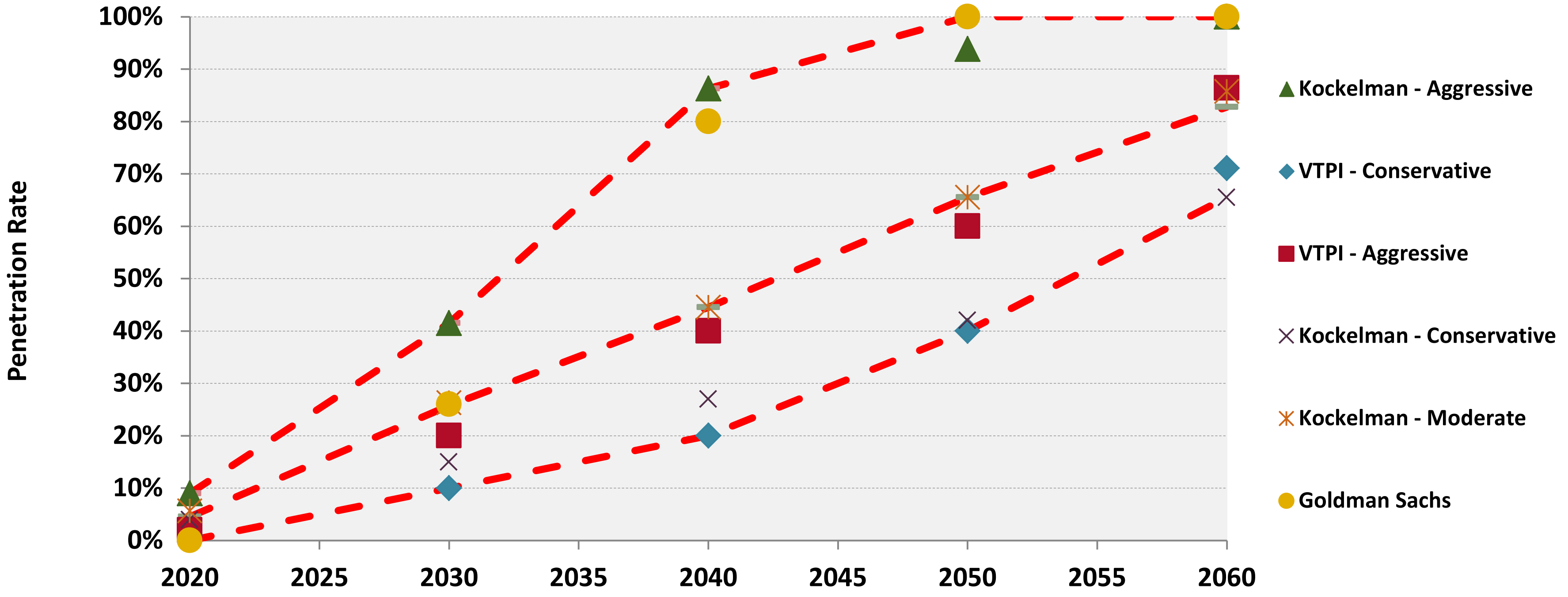
Today

1-3 Years

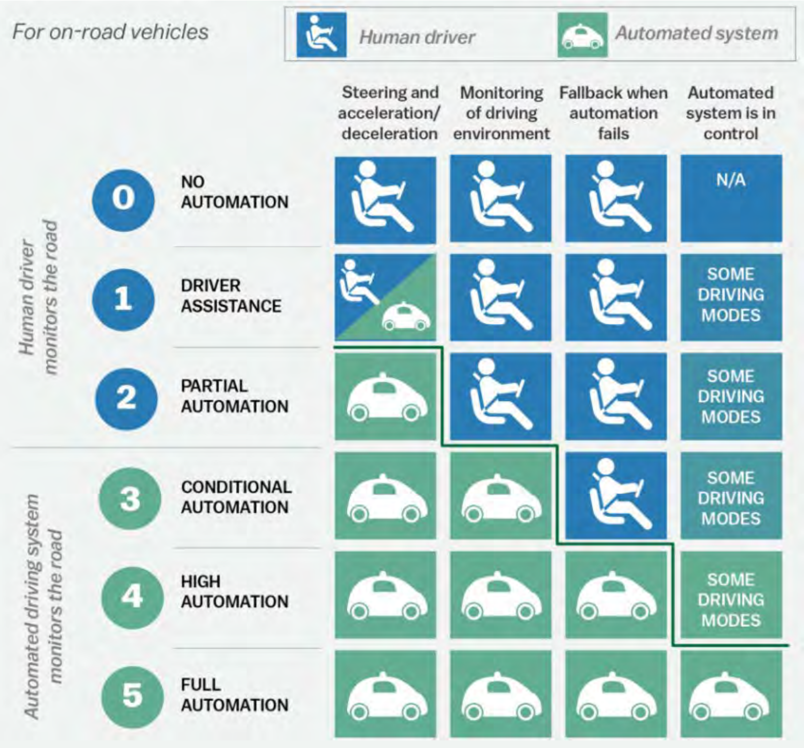
7-15 Years

AUTONOMOUS VEHICLES – LITERATURE PROJECTIONS

Passenger Vehicle Fleet Adoption of Level 3 or above: 10% to 40% by 2030



AUTONOMOUS VEHICLES




Source: Google

Source: Innova


Source: Navya


Source: SARTRE

AUTONOMOUS VEHICLE MANUFACTURERS (TRANSIT)

Olli by Local Motors
- 12 passenger
- Electric
- Lidar and Optical
- Human Monitored
- Based upon IBM Watson
- Deployed (Pilots) 2016
  - Washington, DC
  - Miami
  - Los Vegas

EZ10 by EasyMile
- 12 passenger
- Electric
- Deployed (Pilots) 2016
  - Helsinki, Finland
  - Concord, California
  - Singapore (2015)
  - Tampa Florida (2017)
- 1.5M rides

ARMA by Navya
- 15 passenger
- Electric
- Lidar, Optical, GPS
- Deployed (Pilots)
  - Cologne
  - Germany
  - Australia
- Deployed
  - SION (2016)

AUTONOMOUS TRANSIT

Physical and Operational Characteristics (EasyMile EZ10)

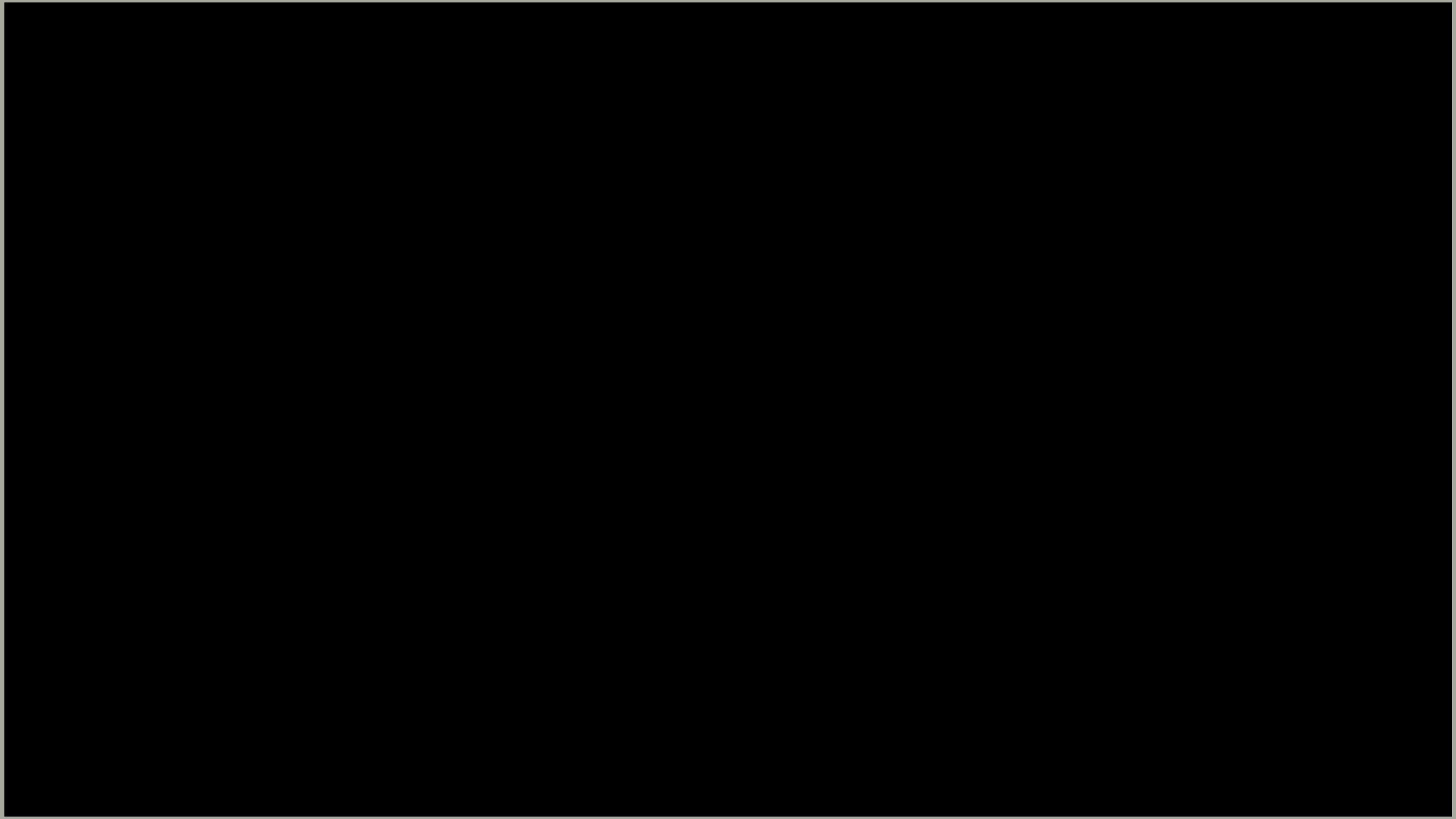
- Three Modes of Operation
  - Traditional Metro (every stop)
  - Commuter (Stop on demand)
  - On-Demand (Dynamic Transit) for First Mile/Last Mile
- 12 Passenger
  - 6 seated, 6 standing
- Electrically Powered
  - **Battery:** Lithium-ion (LiFeP04)
  - **Battery Charger**: 230V 16A
  - 14 hours running on single charge

Length	12.9 ft	Cruising Speed	12.4 mph
Width	6.5 ft		
Height	9.0 ft	Max Speed	24.9 mph
Curb Weight	6,173 lbs		

EASY MILE IN OPERATION: HTTPS://VIMEO.COM/137217228

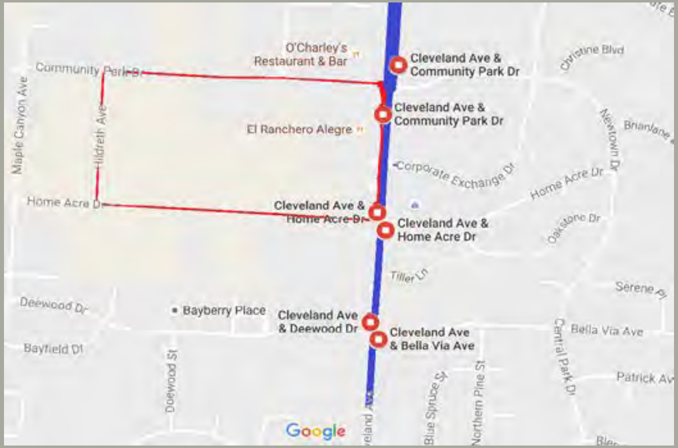
OLLI BY LOCAL MOTORS:

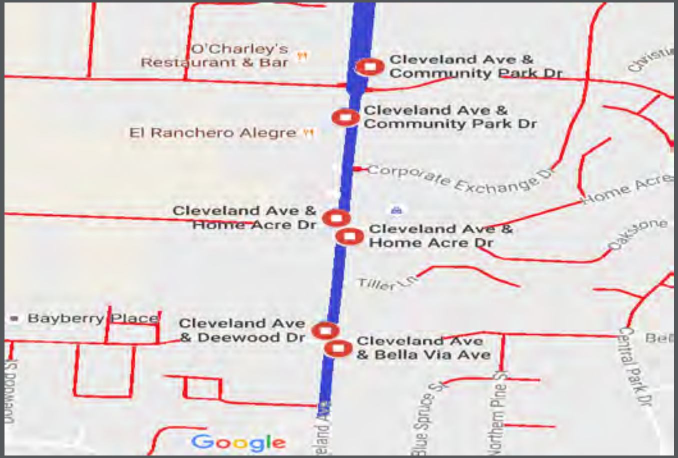
HTTPS://WWW.YOUTUBE.COM/WATCH?V=9JOESWIYFEI



LIKELY OPERATIONAL DEPLOYMENTS

- First Mile/Last Mile
  - Connect travelers to existing transit options
    - Circulator
    - Hub-Spoke
- On-Demand Transit
  - Paratransit surrogate
  - Door-to-door
- Full Service Operations
  - Replaces traditional Transit





FULL TRANSIT SERVICE OPERATIONAL MODELS

- Modular Lanes
  - Dynamically modify width of lanes to accommodate autonomous vehicles
- Exclusive Autonomous Lanes
  - Grade segregated, dedicated
  - At-grade segregated, dedicated by time-of-day
  - Mixed use lanes

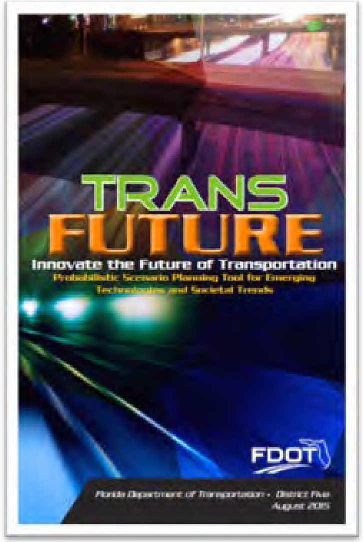
Modular Lanes

HOT/HOV Managed Lanes with Transit

Grade Segregated Dedicated Lanes

At-Grade, Dynamic Shoulder

AUTONOMOUS VEHICLES – IMPLICATIONS ON TRANSPORTATION




Contract #DTFH61-13-D-00012

Desk Reference and Tools for Estimating the Local, Regional, and State-Wide Economic Development Benefits of Connected Vehicle to Infrastructure Deployments

Desk Reference for Estimating the Local, Regional, and State-Wide Economic Development Benefits of Connected Vehicle to Infrastructure Deployments
Revised

Submitted To

Federal Highway Administration
Office of Policy and Governmental Affairs
1200 New Jersey Avenue, S.E.
Washington, DC 20590

Submitted by

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Autonomous Vehicles – Implications for Transit

Autonomous Vehicles Complement Transit

- Jarrett Walker (Human Transit) – "mass transit will remain crucial in places defined by a shortage of space per person. Mass transit, where densities are high enough to support it, is an immensely efficient use of space"

Autonomous Vehicles Replace Transit

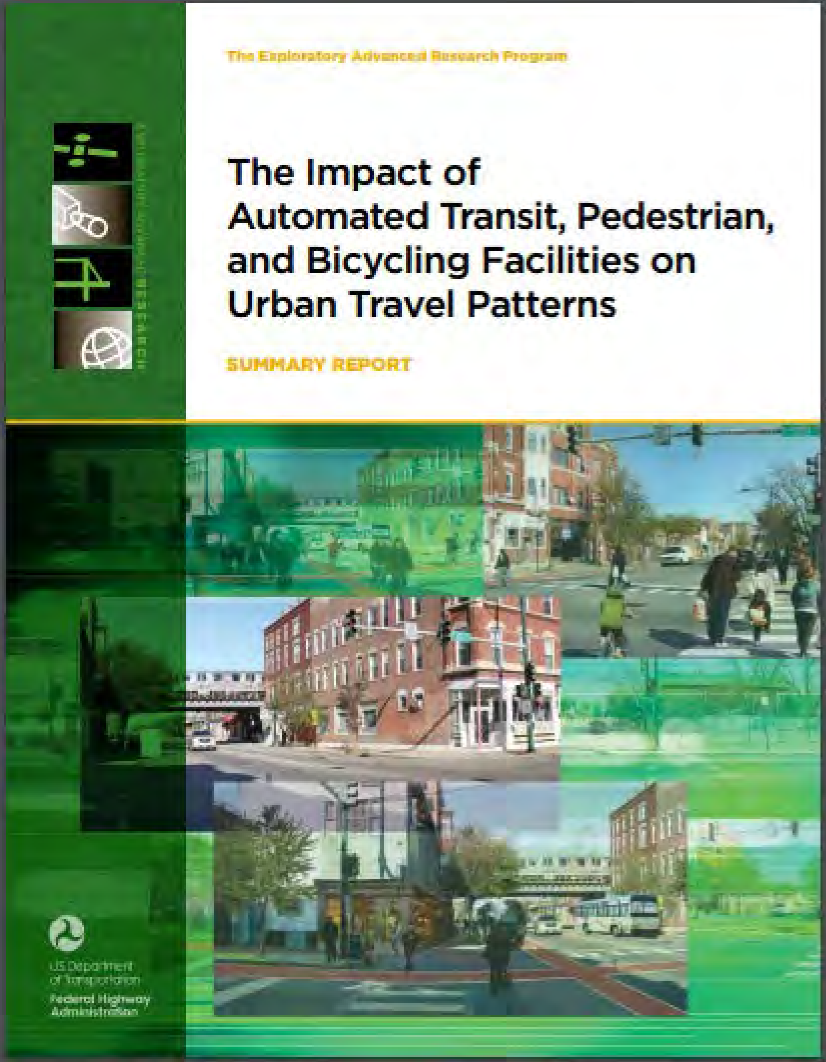
- Robin Chase (Zipcar) – Autonomous vehicles will replace traditional transit with public transit providing vouchers for trips.

Meeting in the Middle (Austin Good)

- Emphasis on fast, high capacity fixed-route corridors
- Flex-routes in low demand areas
- Stations as transfer hubs
- No more schedules or off hours
- Less of a need for paratransit
- Ride share/transit fare integration
- Frequent & fast intercity fixed-routes

IMPACTS OF AUTOMATED TRANSIT ON URBAN TRAVEL

- "presence of the community transit [automated first-mile/last-mile shuttle] and urban-design improvements had a marked effect on the sample population…"
- "…community shuttle produced greater change in the lower density areas…"
- "…high-frequency transit shuttles **could trigger significant shifts from driving to public transit.** Shifts to public transit may be larger in low-density neighborhoods that are more automobile-oriented and in neighborhoods where bus service is unavailable, unreliable, or infrequent."



POTENTIAL IMPACTS WITH MAJOR TRENDS

Factors	Auto Ownership	Trips (#)	Distance Travelled	Roadway Capacity	Safety	VMT	Speed
Automated Vehicle—Passenger	↓	↑	↑	↑	↑	↑	↑
Automated Vehicle—Commercial	—	↑	↑	↑	↑	↑	↑
Aging Population	↓	↓	↓	—	↑	↓	↑
Gen Z, Alpha Travel Behavior	↕ ?	↕ ?	↕ ?	—	↕ ?	↕ ?	↕ ?
Telecommuting	↓	↓	↕	—	↑	↓	↑
Car Sharing	↓	↕	↕	—	↑	↕	↑
Ride Hailing Service	↓	↕	↕	—	↑	↕	↑

STRENGTHS AND WEAKNESSES

Strengths

- Cost economical compared to traditional transit systems
- Opportunity for "personalized" and flexible service models
- Several manufacturers – more emerging rapidly
- Interoperability between existing transit and manufacturers and infrastructure
- Provides significant safety and environmental benefits

Weaknesses

- Still relatively new technology/mode; durability for long operations has not been verified
- Requires new policies, training, and operational support
- Current technology will be challenged to move significant numbers of people expeditiously
- Acceptance by public has not been validated

KEY CONCLUSIONS

- Autonomous vehicles with Transit are beginning to be realized
  - Adoption will continue to rise
- Autonomous transit vehicles could increase transit ridership through
  - First-Mile/Last-Mile connectivity; particularly in low density areas
  - Reduces need for parking services in central business district
- Autonomous transit vehicles not likely to replace traditional transit in the near future (10-15 years)
  - May begin to replace fixed route transit in 15-25 years
- Significant uncertainty of impact of AV on travel and capacity remains
  - Very little uncertainty of the technology itself

HDR