THE FUTURE OF MOBILITY THROUGH INNOVATIONS IN INTELLIGENT TRANSPORTATION INFRASTRUCTURE

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AAAS 2018: Advancing Science Discovery to Application
February 16, 2018
MOBILITY21: Strategic Investments for Transportation Infrastructure & Technology

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FUTURE MOBILITY WILL IMPACT SAFETY, EFFICIENCY QUALITY OF LIFE

SAFETY
- 94 percent of U.S. crashes involve human error. [1]
- 1.2 million deaths worldwide due to vehicle crashes in 2013. [2]
- 37,461 road deaths in the U.S. in 2016 and 2.4 million injuries in 2015. [3]
- 2 out of 3 people will be involved in a drunk driving crash in their lifetime. [4]

SOCIETY
- $594 billion in harm from loss of life and injury each year. [5]
- $277 billion in annual economic costs. [6]
- $160 billion in gas burned and time lost each year. [7]

MOBILITY AND QUALITY OF LIFE
- 3 million Americans age 40 and older are blind or have low vision. [8]
- 79 percent of seniors age 65 and older living in car-dependent communities. [9]
- 42 hours wasted in traffic each year per person. [10]

On the road to fully self-driving, Waymo Safety Report, October 2017
FUTURE MOBILITY WILL IMPACT ECONOMY

Accelerating the Future: The Economic Impact of the Emerging Passenger Economy

2. Key Findings

The Passenger Economy represents a US$7 trillion global opportunity in 2050.

The Passenger Economy will stimulate value creation from the adoption of Mobility-as-a-Service and other new mobility services as well as emerging new applications and services as well as from savings in time and money associated with vehicle use and from the resulting freedom of movement.

Our research finds that autonomous driving technology will enable a new Passenger Economy worth US$7 trillion – more than the projected 2017 GDPs of Japan and Brazil combined.

Report Snapshot

Intel has engaged Strategy Analytics as a partner in the preparation of this report to validate the hypothesis that a “Passenger Economy” based on pilotless vehicles is on the horizon and that it holds massive economic potential. In assessing this opportunity, Strategy Analytics and Intel start a conversation that explores the catalysts for change, frames the economic opportunity, and begins to build use cases that can engage business decision makers to explore and develop actionable change strategies.

US$7 Trillion Opportunity

Autonomous driving technology will enable a new “Passenger Economy” worth US$7 trillion – more than the projected 2017 GDPs of Japan and Brazil combined.

Passenger Economy: Global Revenue from Services 2050 (US$, Millions)

- Consumer Mobility-as-a-Service
- Business/ B2B Mobility-as-a-Service
- New & Emerging Pilotless Vehicle Services

Source: Strategy Analytics
FUTURE TRENDS

1. AUTONOMOUS PLATFORMS
2. CONNECTIVITY
3. CITY-SCALE DATA
4. USER-AUTONOMY INTERACTION
1. AUTONOMOUS PLATFORMS
24 year old dies on the spot
Have Self-Driving Cars Stopped Getting Better

New reports from California suggest limits to autonomous vehicle performance
RESERCH CHALLENGE: SAFE AUTONOMY

For vehicle model, & safety requirements specified over time

Lane merge
Roundabout
Stop signs
Pedestrians

Provide safety guarantees for integration of controller, sensor, computing, learning

Who is responsible when autonomous cars crash with human-driven cars?
A Driver’s License Test for Autonomous Vehicles

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A NEW WIRELESS HACK CAN UNLOCK 100 MILLION VOLKSWAGENS
2. CONNECTIVITY

V2V

V2I
Vehicles connected to the cloud generate 1.5GB monthly data
Autonomous vehicles can generate up to a 1TB real-time data per trip!
There are one billion cars in the world that are increasingly sensor-rich
Internet of mobile autonomous platforms
Instrumented cars serve as infrastructure sensors
Networking with very high data rates for see-through buildings intersection (mm-wave)
V2V communications require low-latency, high-reliability wireless at high speeds
RESEARCH CHALLENGE – V2I INTEROPERABILITY
3. CITY-SCALE DATA

Mobile Millenium, ITS, UC Berkeley
Fast machine learning with real-time, streaming physical data
Privacy-aware algorithms and computation over user/car data
Access and sharing of SmartCity and transportation data
Data ownership models (economy?) for transportation data

SmartBay Project, ITS, UC Berkeley
RESERCH CHALLENGE: DATA PRIVACY

April 2015 Report by

Sen. Deb Fischer (Nebraska)
Sen. Cory Booker (New Jersey)
Sen. Kelly Ayotte (New Hampshire)
Sen. Brian Schatz (Hawaii)
4. USER-AUTONOMY INTERACTION

Users exploit richness of real-time data for safe and efficient routing
Mobility-as-a-service provides new ownership models, new incentives, new economics
Variable autonomy levels from human driver to fully autonomous
Distracted driving results in 9 deaths and 1,000 injuries every day in the U.S.
RESEARCH CHALLENGE – IMPACT OF USERS HAVING ACCESS TO NEW DATA SOURCES
Driving apps like Waze are creating new traffic problems

By ELI WIRTSCHAFER • MAR 23, 2017

The app Waze suggests a circuitous route around traffic in Fremont. (Screenshot)

ELI WIRTSCHAFER
Driving apps like Waze are creating new traffic problems

Roadshow: Stay off my street! Waze woes spreading to more cities
FINAL THOUGHTS

Opportunities across heterogeneous transportation/SmartCity modalities
  Data integration and optimization across biking, cars, subway, energy grid, etc

Research will require collaboration across many disciplines
  Computing, transportation, social scientists, economics, law, etc

Very limited research initiatives that holistically address these challenges
  DoT centers, NSF CPS, NSF S&AS, NSF Smart & Connected Communities

Transportation planning institutions are more reactive than proactive in planning for
new technology and regulating/accommodating as necessary.

Partnerships between academic, government, city planners, and industry are critical
  Interoperability, standards, urban data access, data ownership,
  safety regulation, privacy norms, autonomy liability etc

Analyze skills and education requirements to facilitate new technical jobs for shared,
autonomous and data-driven transportation. Rethink education across boundaries to
prepare the workforce
RESEARCH CHALLENGE – WHO IS RESPONSIBLE FOR SAFETY WHEN TRAFFIC IS MIXED BETWEEN LEVEL 3 & CONVENTIONAL VEHICLES

<table>
<thead>
<tr>
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<th>Driver:</th>
<th>Vehicle:</th>
<th>Physical Environment</th>
<th>Social Environment</th>
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<tr>
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<td>Conventional:</td>
<td>Autonomous:</td>
<td>Conventional:</td>
<td>Autonomous:</td>
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<tr>
<td>Pre-Event</td>
<td>Driving skill, experience, attention and physical/mental state</td>
<td>Driver attention and re-engagement</td>
<td>Vehicle design &amp; handling; anti-lock brakes; electronic stability control; vehicle condition</td>
<td>HAV computer and sensor capability; Sensors detecting ODD</td>
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<td>(⇒ primary prevention)</td>
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<td>Road design; road signs; speed limits; weather conditions</td>
<td>Presence and security of connected vehicle infrastructure</td>
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<td>Existence and enforcement of traffic safety laws; traffic flow and congestion.</td>
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<td>Market penetration of HAVs</td>
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<tr>
<td>During the event</td>
<td>Seatbelt use and occupant position</td>
<td>Brace position of driver</td>
<td>Vehicle alert systems; Presence of “minimal risk condition” to reach safety after failure</td>
<td>Speed of communications network to transmit messages</td>
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<td>(⇒ secondary prevention)</td>
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<td>n/a</td>
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<td></td>
<td>Presence of trees, guardrails, etc.; Separated traffic</td>
<td>Mix of HAVs and conventional vehicles immediately proximate</td>
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<tr>
<td>Post-event</td>
<td>(⇒ tertiary prevention)</td>
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- Haddon Matrix is for understanding responsibilities pre, during and post car crash
- Penn Researchers envisioned how the Haddon Matrix will have to change with mixed HAV and conventional vehicle traffic
People Want to Interact -- Even with an Autonomous Car

Semcon's smiling car experiment shows pedestrians' fear of self-driving cars

By Kristen Hall-Geisler  September 21, 2016