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Discovery Park

Purdue University



**PURDUE CONNECTED AUTONOMOUS  
TRANSPORTATION INITIATIVE**

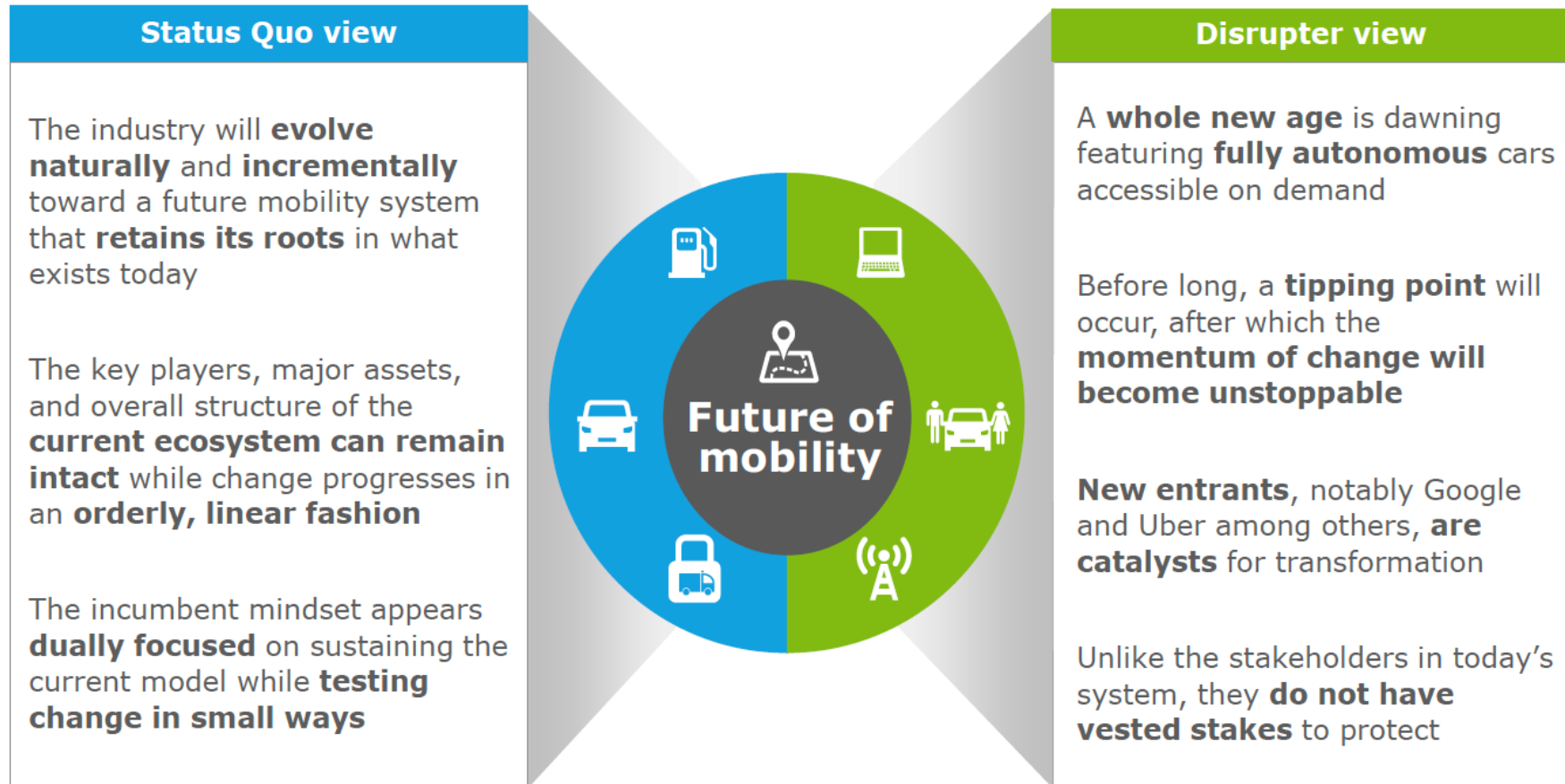
# OUR MISSION

Discovery Park at Purdue University is a place where challenge and innovation converge, a hub where researchers move beyond traditional boundaries, collaborating across disciplines and with policy makers and business leaders to create solutions for a better world.

# OPPORTUNITY

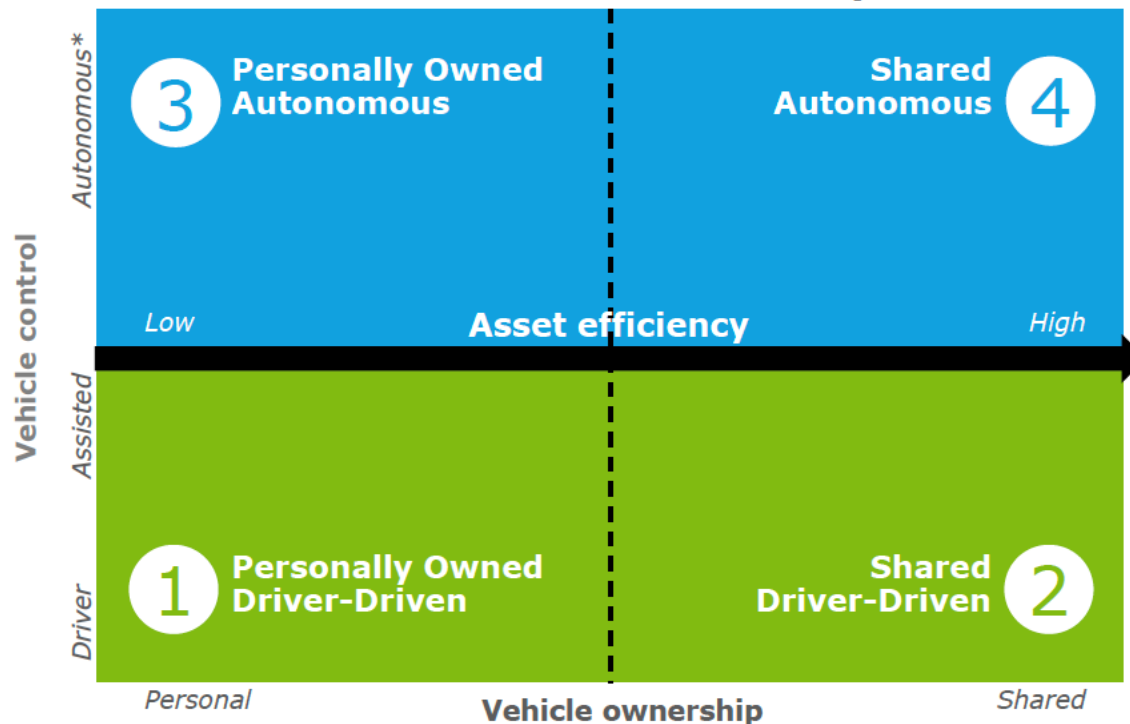
A feasibility study recently completed, in partnership with Deloitte, finds that Indiana and the Midwest are well-positioned to become leaders in the field of connected and autonomous vehicle transportation.

There are two profoundly different visions about how the future could evolve



Converging forces will give rise to the emergence of four future states of mobility, which will exist in parallel

## Future states of mobility



**Extent to which autonomous vehicle technologies become pervasive:**

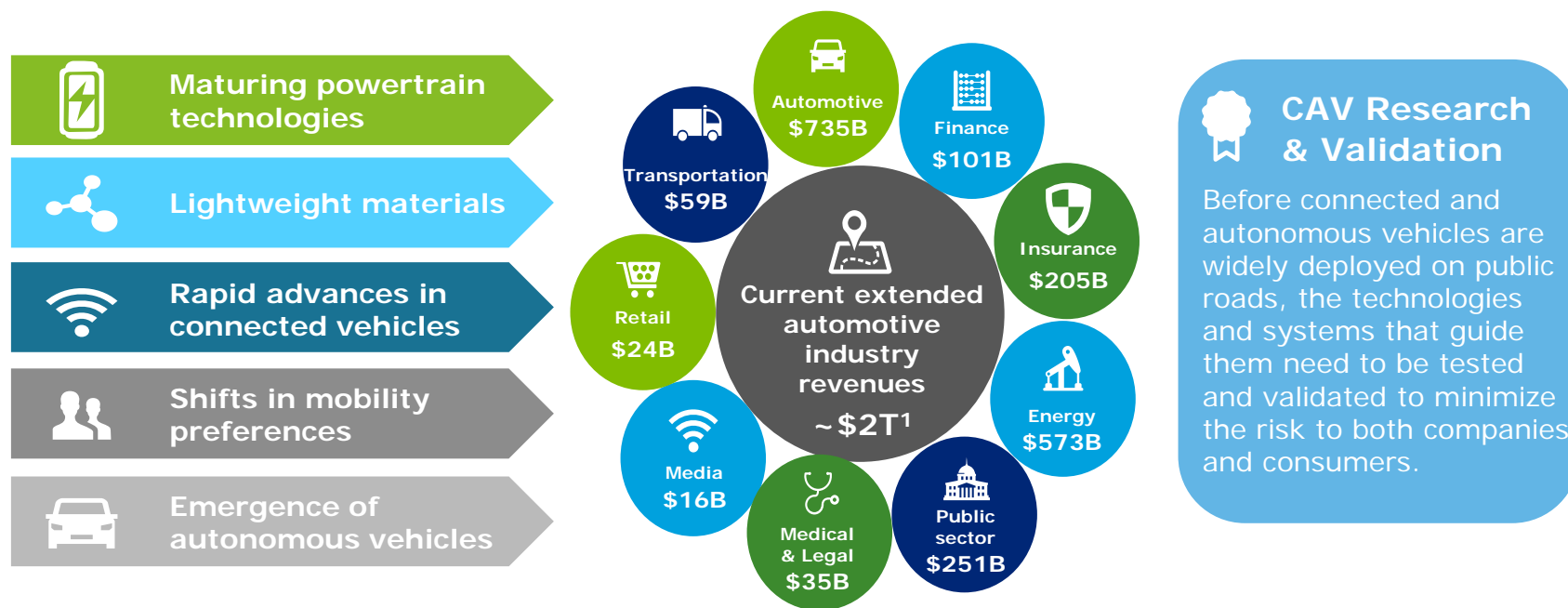
- Depends upon several key factors as catalysts or deterrents—e.g., technology, regulation, social acceptance
- Vehicle technologies will increasingly become "smart"; the human-machine interface shifts toward greater machine control

**Extent to which vehicles are personally owned or shared:**

- Depends upon personal preferences and economics
- Higher degree of shared ownership increases system-wide asset efficiency

## EXECUTIVE SUMMARY

The growth in connected and autonomous vehicles (CAVs) will have far reaching impact, but emerging technologies and capabilities need to be tested and validated.



Source: Deloitte analysis

<sup>1</sup> BNEF Press Release: Electric vehicles to be 35% of global new car sales by 2040 <sup>2</sup> Deloitte Global Automotive Consumer Study, 2014

## EXECUTIVE SUMMARY

The state of Indiana is well positioned to leverage existing assets to create a state-wide network of connected and autonomous vehicle research and testing offerings.

### Industry Presence



Indiana is home to many leading commercial vehicle manufacturing companies, many of whom have expressed interest in partnering with the state and Purdue University to develop and test emerging technologies in their vehicles.

### Regulation

Indiana is recognized as having a business friendly regulatory environment, but has enacted no legislation related to connected and autonomous vehicles.

### Existing Infrastructure



Leverage infrastructure Indiana has already invested in, and the lightly used triangle of highways connecting Indy and Lafayette.



IMS has very low utilization and could serve as a high speed test track.



Muscatatuck is home to advanced vehicle simulators.



Indianapolis and Lafayette offer densely populated cityscapes for public road testing.

### Funding



INDOT is investing heavily in infrastructure and already building out future-focused capabilities.



Purdue has dedicated millions of dollars worth of land.



Chicago is home to a large and dynamic investor base.



### Educational Institutions



Indiana is home to leading educational institutions, where students, faculty, and researchers can collaborate with government and industry on developing and testing new technologies and capabilities.

## EXECUTIVE SUMMARY

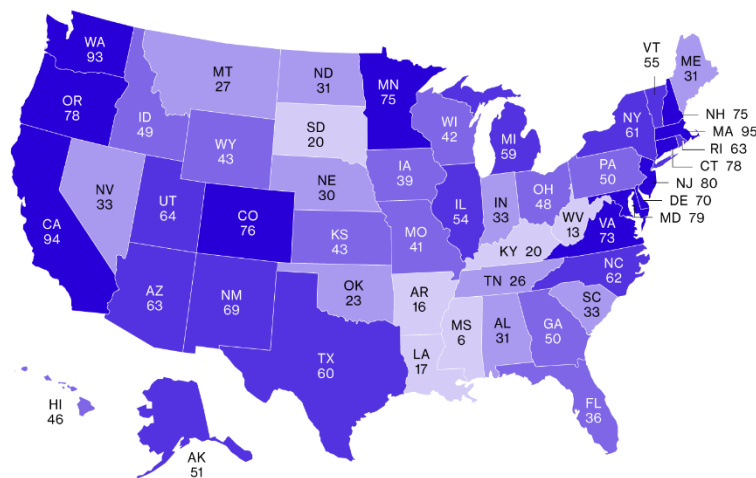
Indiana lags behind many other states in innovation and enacting Connected and Autonomous Vehicle (CAV) friendly legislation.

**Innovation:** Indiana ranks 36<sup>th</sup> in Innovation among U.S. states and is not perceived as a technology hub.

**Legislation:** Indiana has announced funding and incentives for advanced technologies, like CAV, but lags behind many more proactive states.

### Bloomberg 2016 State Innovation Index

Most innovative  
 ■ 70-95 ■ 51-69 ■ 36-50 ■ 21-35 ■ 6-20  
 Least innovative



State	Limited Liability	Committee	Test	Stds/Rules	Operate	Platooning	Funding
Michigan	✓	✓	✓		✓		
Florida	✓	✓	✓		✓		
Utah		✓	✓	✓			
New York		✓	✓	✓			
Nevada	✓		✓	✓			
Tennessee	✓					✓	
California			✓	✓			
Washington, D.C.	✓						
Virginia	✓						
Pennsylvania							✓
<b>Indiana</b>							✓
North Dakota		✓					
Alabama		✓					
Arkansas						✓	

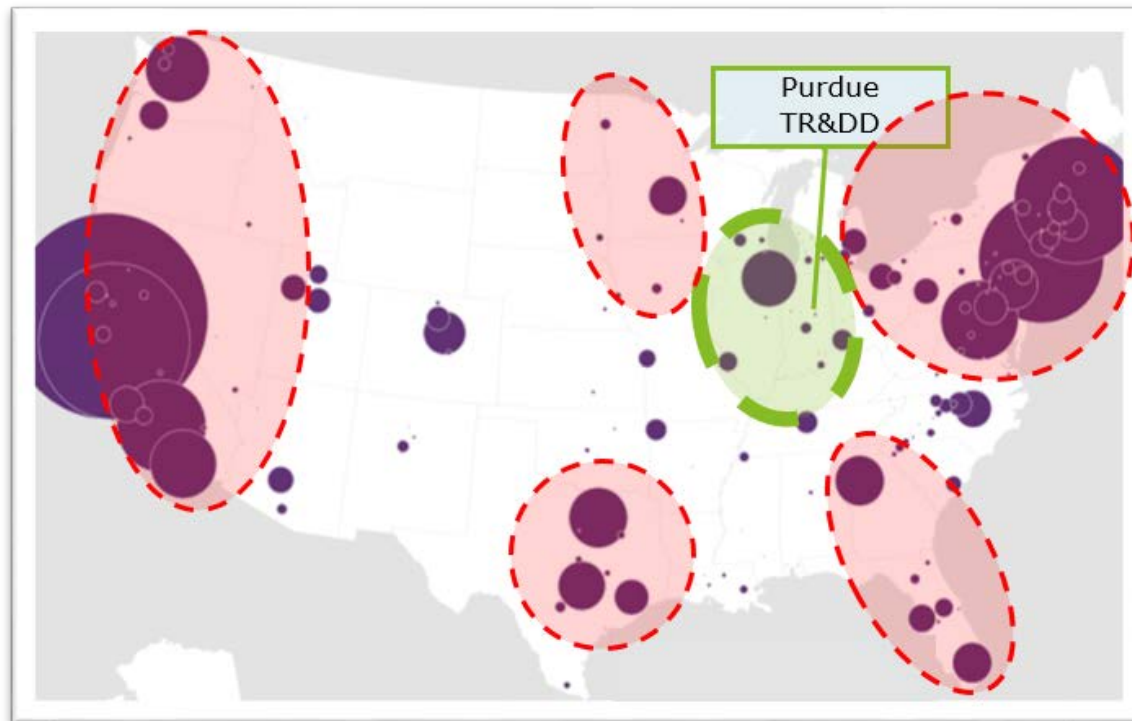
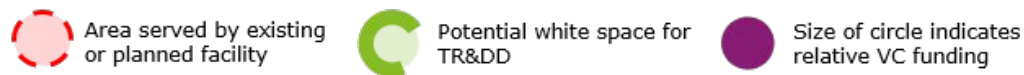
Example Legislative Actions:

1. Access to public roads like "automated corridors" (VA)
2. Reduce reporting requirements (AZ vs CA)
3. Permit operation of a platoon (TN)
4. Limit liability for OEMs and mechanics (MI)



## Project Takeaways

The state of Indiana has an opportunity to play a role in this space, **especially with commercial vehicle manufacturers**, but is currently behind many states who are supporting and enabling CAV research, development, and validation



**Notable potential CV partners in Indiana and Illinois:**



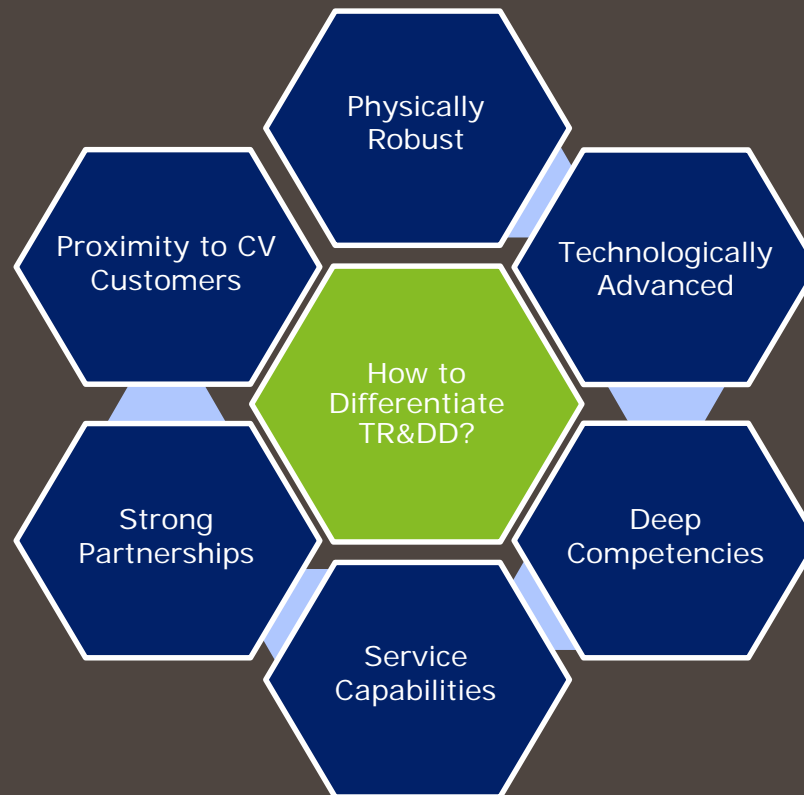
# VISION

Purdue and its partners will be a leading innovators in Indiana and the nation in the development of autonomous vehicle research, testing, evaluation and implementation.

Discovery Park will provide integrated, world-class engineering, data science, policy, economic and social science problem solving capabilities and solutions.

# OUR ECOSYSTEM

Purdue's facilities and competencies mirror those needed to fill this need for connected and autonomous vehicle transportation in Indiana and the Midwest.



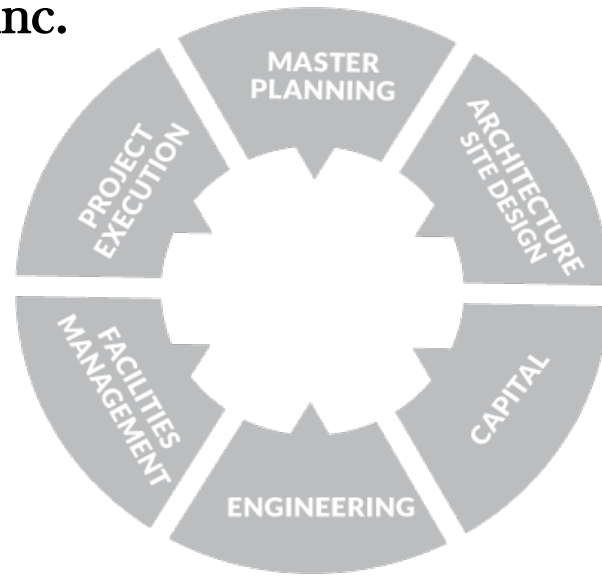
Thomas J. Snyder  
Retired CEO, Remy, Inc.

## TRANSPORTATION DEVELOPMENT GROUP

**BROWNING  
DAY MULLINS  
DIERDORF**

**PURDUE**  
RESEARCH FOUNDATION

  
**INDIANA**  
A State that Works



PURDUE UNIVERSITY  
**Discovery Park**

  
**Lhp**  
engineering solutions

## IDENTIFYING WHERE TO PLAY

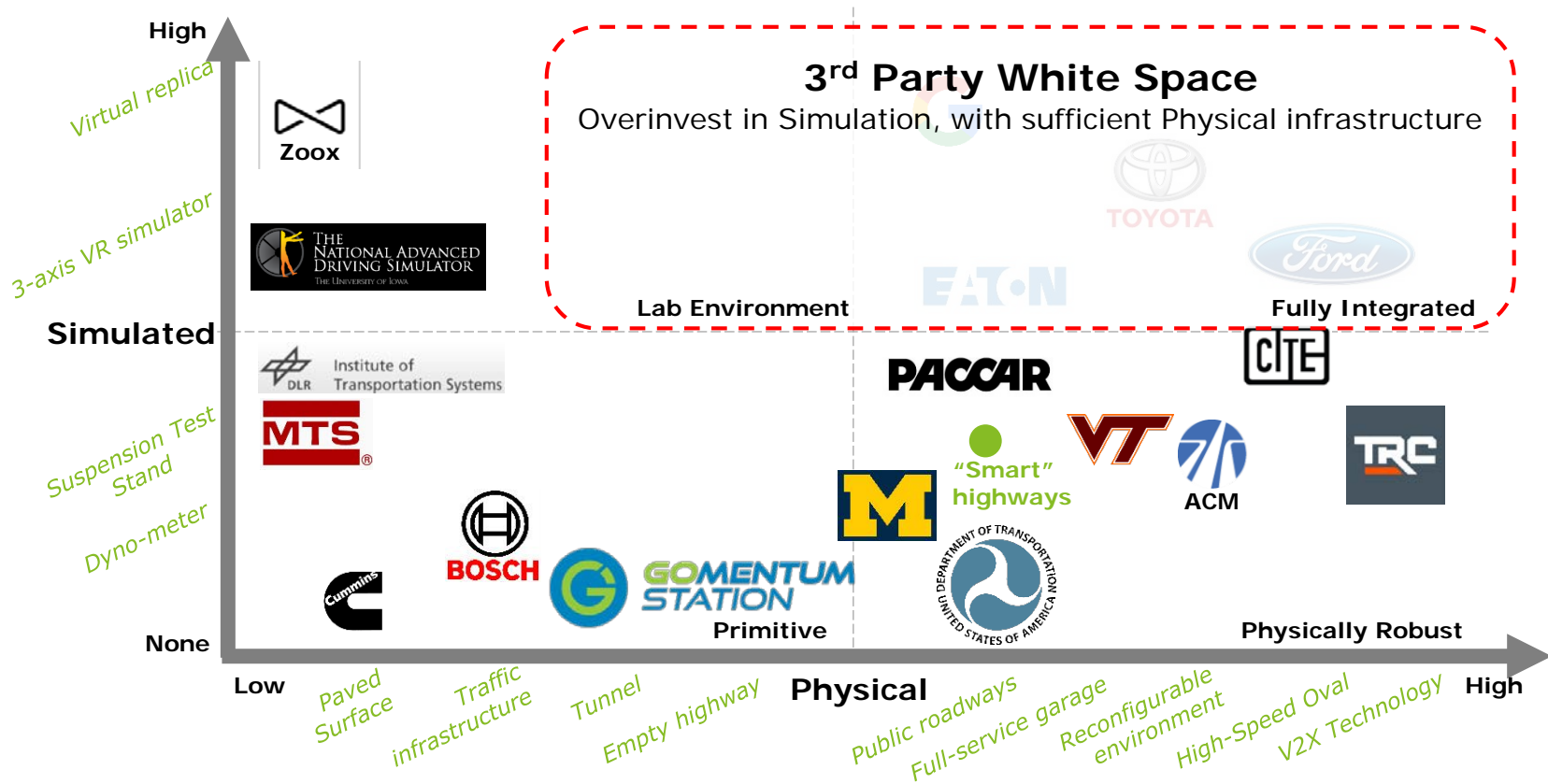
There exists opportunity in the market for fully integrated and highly sophisticated 3rd party test & research facilities.



Note: Ranking of facilities is based on the qualities *currently available* or that have been published as *planned enhancements*

## IDENTIFYING WHERE TO PLAY

There exists opportunity in the market for fully integrated and highly sophisticated 3rd party test & research facilities.



Note: Ranking of facilities is based on the qualities *currently available* or that have been published as *planned enhancements*

- **Connected and autonomous trucks**
  - Next-Generation Energy Technologies for Connected and On-Road Vehicles (NEXTCAR)
- **Policy, ethics, regulation**
  - Purdue Policy Research Institute
- **Connected and autonomous passenger vehicles**
  - Center for Connected and Autonomous Transportation (CCAT), NEXTRANS
- **Transportation infrastructure of the future**
  - Joint Transportation Research Program
- **Data analytics and machine learning, AI, human-machine interface**
  - Computer Science, Engineering
- **Sensors**
  - Birck Nanotechnology Center
- **Cybersecurity**
  - Center for Education and Research in Information Assurance and Security (CERIAS)
- **Control systems and robotics**
  - Engineering, Purdue Polytechnic
- **Urban and Landscape Architecture**
- **Safety**
  - Indiana Department of Transportation, Center for Road Safety

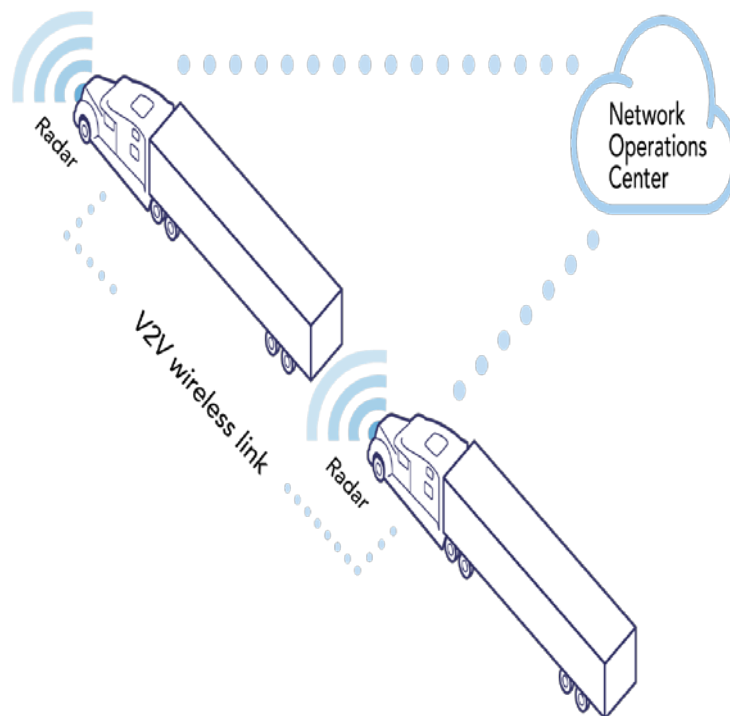


**DISCOVERY PARK IS THE  
NATION'S PREMIER  
MULTIDISCIPLINARY  
RESEARCH CENTER**

**LOOKING TO DEVELOP A RDT&E FACILITY LOCATED NEAR  
PURDUE CAMPUS WHICH INTEGRATES EXISTING STRENGTHS**

## MORE EFFICIENT TWO-TRUCK PLATOONING USING CONNECTIVITY-ENABLED CONTROLS

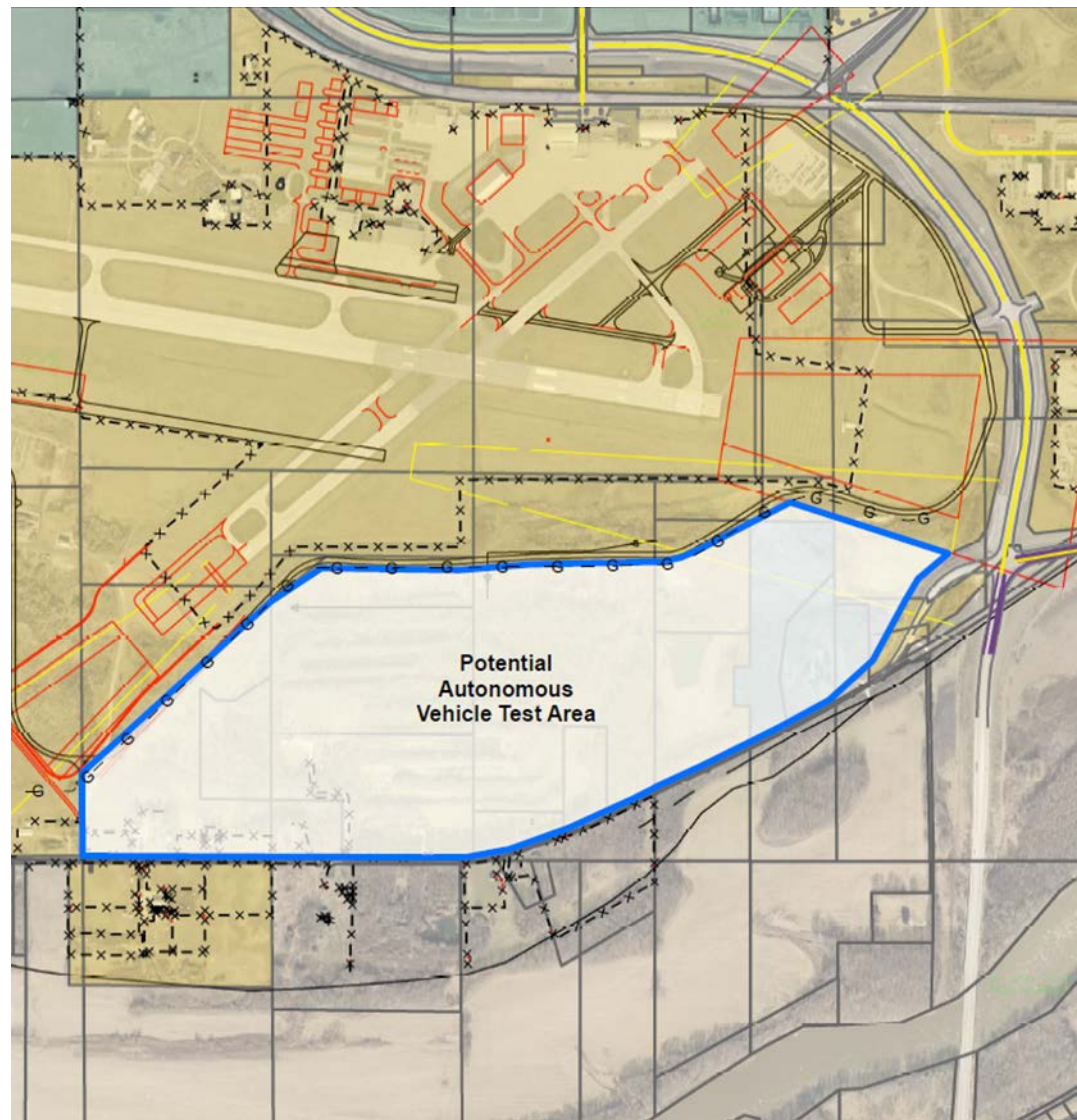
- Predictive cruise
  - Front driver “feet off”
  - Avoid torque saturation of rear truck
  - Compute optimal speed profile and gap
- Coordinated Shifting
  - Avoid disturbances in the platooning gap
- Full integration of platooning controller with ECU, transmission.
- Data considered:
  - Maps, grades, traffic, weather look-ahead information
  - Truck masses & powertrain capabilities
- Expected fuel savings: **12.25%**
- Sponsor: DOE ARPA-E

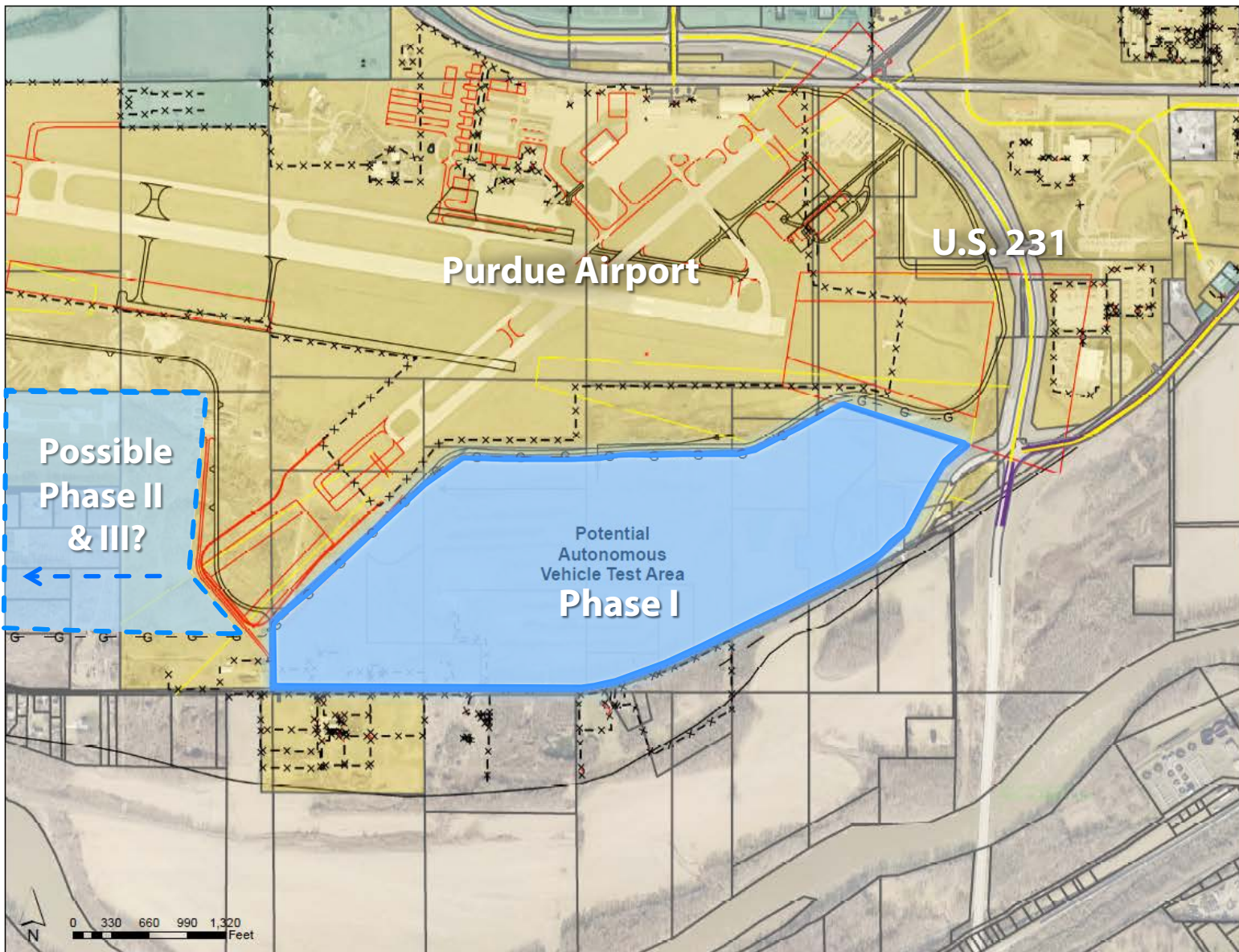




**THE PURDUE/TDG CONNECTED  
AUTONOMOUS VEHICLES INITIATIVE  
WILL BE COMPRISED OF SIX UNIQUE  
COMPONENTS:**

- System-wide IoT, data analytics and next-gen IT technology development and validation
- Urban-inspired, streetscape “Science City” for autonomous vehicle technology validation
- Multi-surface, highway speed, banked, managed and shared test track
- Mobility planning and design standards—Next-gen materials testing
- Research and development assets: office-laboratory-garage-pilot center facilities.
- Partnership with private development group





- APPROX 207 ACRES
- PRF
- PU
- ⊕ APPROXIMATE VECTREN GAS LINE

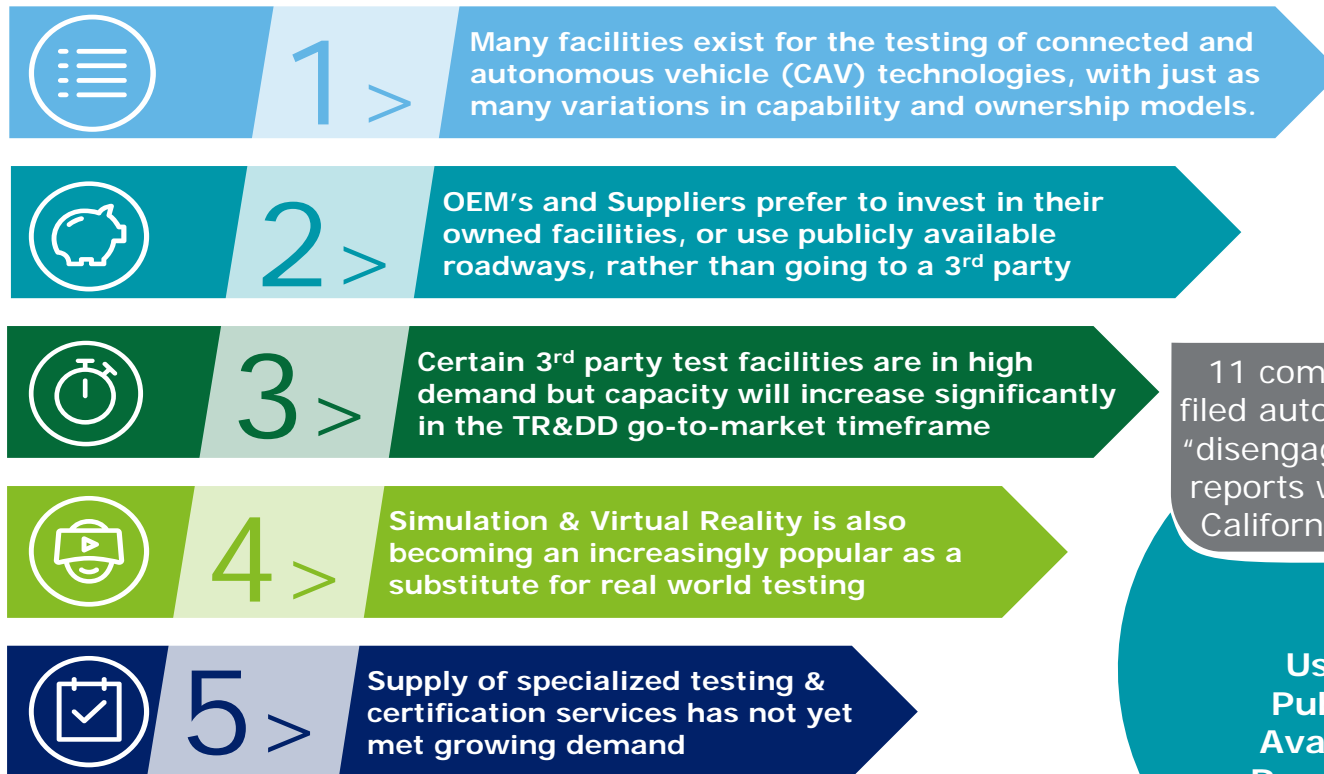
**PURDUE AND DISCOVERY  
PARK ARE CREATING A  
CORPORATE PARTNERSHIP  
ECOSYSTEM**



**THANK YOU**

## COMPETITIVE OVERVIEW

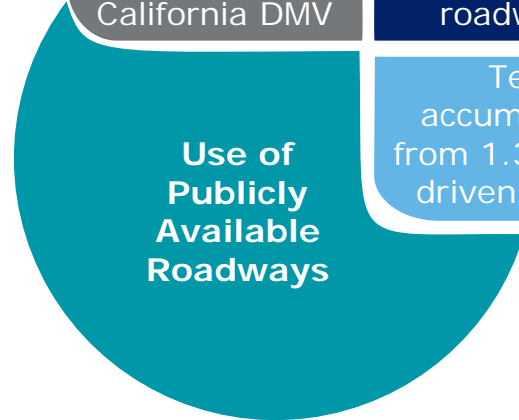
Others have recognized the need to prove out autonomous technologies and are scrambling to create the necessary capacity.



11 companies filed autonomous "disengagement" reports with the California DMV

Google has logged more than 3 million miles on California roadways

Tesla has accumulated data from 1.3 billion miles driven in AutoPilot



## OPPORTUNITY TO DISTINGUISH FROM COMPETITORS

Given the current and growing capacity for autonomous vehicle test facilities, it is *critical* for new entrants to distinguish themselves to earn a spot in the market.



A 3<sup>rd</sup> party facility can distinguish itself in the market by configuring around the following criteria.

## **CAPABILITIES OVERVIEW**

There is a significant and growing demand to test and prove autonomous vehicle technologies/capabilities from various stakeholders.

### **STRENGTHS**

Purdue University is **highly ranked and well-regarded** for its expertise in the capabilities necessary to develop to CAV technologies.

Indiana is in close proximity to **Commercial Vehicle** customers.

### **OPPORTUNITIES**

The state of Indiana is home to a number of **Commercial Vehicle manufacturers**, who are developing advanced technologies and products that need to be tested before going on public roads (e.g. Cummins, Allison, Wabash).

The TR&DD would be the closest CAV test facility to Chicago, where there is **significant venture funding**.

### **WEAKNESSES**

The TR&DD is a **late entrant** into the CAV research and testing market, and not centrally located for many potential users.

Indiana is **not highly ranked** for both innovation and venture funding.

### **THREATS**

Indiana has **not passed any legislation** favorable to autonomous vehicles.

CAV testing may be creating **temporary demand** that could shift to the next emerging technology by the time TR&DD is open.

The TR&DD could develop a facility with specific offerings targeted to serve the unmet needs of commercial vehicle manufacturers located in the Midwest

# Truck Platooning Research at Purdue

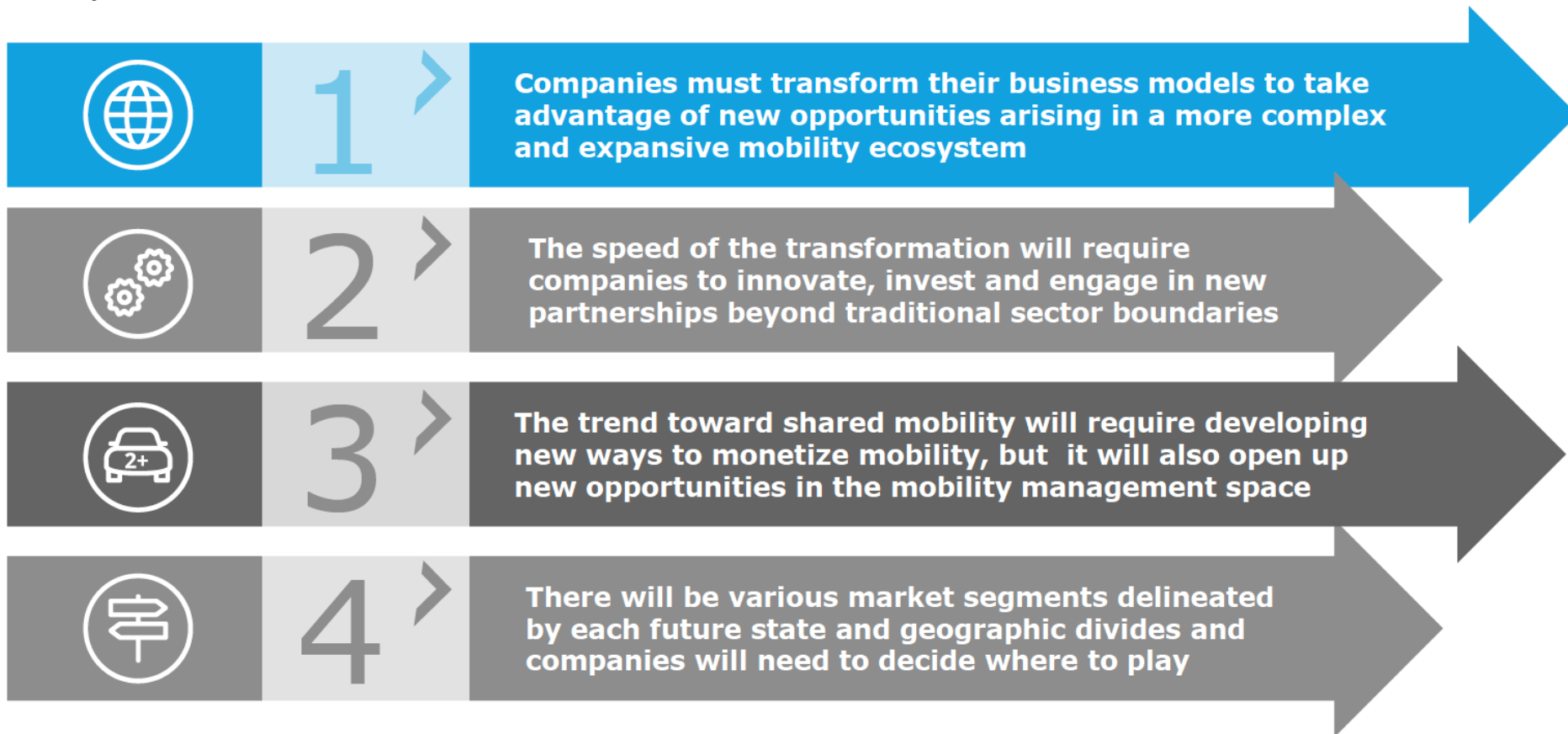
## More efficient two-truck platooning using connectivity-enabled controls

- Predictive cruise
  - Front driver “feet off”
  - Avoid torque saturation of rear truck
  - Compute optimal speed profile and gap
- Coordinated Shifting
  - Avoid disturbances in the platooning gap
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This transformation has important implications for all the players in the new mobility ecosystem



## EXECUTIVE SUMMARY

A connected and autonomous vehicle research and testing concept should be focused on certain assets to develop key offerings.

### Assets

### Key Offerings\*



Physical

Tracks, labs, and public roads that test and simulate all **road conditions**

- High speed loop
- Test labs
- City scape
- Smart infrastructure



Technological

Mixed reality environment (servers, dynos, simulators) capable of simulating and testing all **scenarios**

- Scenario research and testing
- Data analysis
- CAV certification
- Cyber security gauntlet



Research Park

Office park and storage facilities where public and private staff collaborate, work, and store equipment

- Research reports/white papers
- Test plans
- Regulatory perspectives
- Software validation



\* Not an exhaustive list