Tomás Díaz de la Rubia
Chief Scientist and Executive Director
Discovery Park
Purdue University

Purdue Connected Autonomous Transportation Initiative
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.

**Status Quo view**

The industry will **evolve naturally and incrementally** toward a future mobility system that **retains its roots** in what exists today.

The key players, major assets, and overall structure of the **current ecosystem can remain intact** while change progresses in an **orderly, linear fashion**.

The incumbent mindset appears **dually focused** on sustaining the current model while **testing change in small ways**.

**Disrupter view**

A **whole new age** is dawning featuring **fully autonomous** cars accessible on demand.

Before long, a **tipping point** will occur, after which the **momentum of change will become unstoppable**.

**New entrants**, notably Google and Uber among others, are **catalysts** for transformation.

Unlike the stakeholders in today’s system, they do **not have vested stakes** to protect.

---

Source: Deloitte analysis, based on publicly available information and company websites
Converging forces will give rise to the emergence of four future states of mobility, which will exist in parallel.

**Future states of mobility**

**1. Personally Owned Driver-Driven**
- Personal
- Driver
- Assisted
- Low

**2. Shared Driver-Driven**
- Personal
- Driver
- Assisted
- High

**3. Personally Owned Autonomous**
- Shared
- Autonomous
- Low

**4. Shared Autonomous**
- Shared
- Autonomous
- High

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

CAV Research & Validation
Before connected and autonomous vehicles are widely deployed on public roads, the technologies and systems that guide them need to be tested and validated to minimize the risk to both companies and consumers.

Source: Deloitte analysis
1 BNEF Press Release: Electric vehicles to be 35% of global new car sales by 2040  2 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

<table>
<thead>
<tr>
<th>Company</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allison</td>
<td>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.</td>
</tr>
<tr>
<td>NaviStar</td>
<td></td>
</tr>
</tbody>
</table>

### Funding

<table>
<thead>
<tr>
<th>Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDOT</td>
<td>INDOT is investing heavily in infrastructure and already building out future-focused capabilities.</td>
</tr>
<tr>
<td>Purdue</td>
<td>Purdue has dedicated millions of dollars worth of land.</td>
</tr>
<tr>
<td>Chicago</td>
<td>Chicago is home to a large and dynamic investor base.</td>
</tr>
</tbody>
</table>

### 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.

### 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 36th 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.

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

**OUR ECOSYSTEM**

How to Differentiate TR&DD?

- Physically Robust
- Technologically Advanced
- Deep Competencies
- Service Capabilities
- Proximity to CV Customers
- Strong Partnerships
Thomas J. Snyder  
Retired CEO, Remy, Inc.

TRANSPORTATION DEVELOPMENT GROUP
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

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

**DISCOVERY PARK IS THE NATION’S PREMIER MULTIDISCIPLINARY RESEARCH CENTER**
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
PROPOSED PHASES

Phase I
Possible Phase II & III?
U.S. 231
Purdue Airport

Potential Autonomous Vehicle Test Area
Phase I

Approx 207 acres
PRF
PU
Approximate VCTREN Gas Line
Purdue and Discovery Park are creating a corporate partnership ecosystem.
THANK YOU
Others have recognized the need to prove out autonomous technologies and are scrambling to create the necessary capacity.

1. Many facilities exist for the testing of connected and autonomous vehicle (CAV) technologies, with just as many variations in capability and ownership models.

2. OEM’s and Suppliers prefer to invest in their own facilities, or use publicly available roadways, rather than going to a 3rd party.

3. Certain 3rd party test facilities are in high demand but capacity will increase significantly in the TR&DD go-to-market timeframe.

4. Simulation & Virtual Reality is also becoming an increasingly popular as a substitute for real world testing.

5. Supply of specialized testing & certification services has not yet met growing demand.

Google has logged more than 3 million miles on California roadways. 11 companies filed autonomous “disengagement” reports with the California DMV.

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 3rd party facility can distinguish itself in the market by configuring around the following criteria.

- Physically Robust
- Technologically Advanced
- Proximity to CV Customers
- Strong Partnerships
- Deep Competencies
- Service Capabilities

How to Differentiate TR&DD?
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
- 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
This transformation has important implications for all the players in the new mobility ecosystem.

1. Companies must transform their business models to take advantage of new opportunities arising in a more complex and expansive mobility ecosystem.

2. The speed of the transformation will require companies to innovate, invest and engage in new partnerships beyond traditional sector boundaries.

3. The trend toward shared mobility will require developing new ways to monetize mobility, but it will also open up new opportunities in the mobility management space.

4. There will be various market segments delineated by each future state and geographic divides and companies will need to decide where to play.
## Executive Summary

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

<table>
<thead>
<tr>
<th>Assets</th>
<th>Key Offerings*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tracks, labs, and public roads that test and simulate all <strong>road conditions</strong></td>
<td>• High speed loop&lt;br&gt;• Test labs&lt;br&gt;• City scape&lt;br&gt;• Smart infrastructure</td>
</tr>
<tr>
<td>Mixed reality environment (servers, dynos, simulators) capable of simulating and testing all <strong>scenarios</strong></td>
<td>• Scenario research and testing&lt;br&gt;• Data analysis&lt;br&gt;• CAV certification&lt;br&gt;• Cyber security gauntlet</td>
</tr>
<tr>
<td>Office park and storage facilities where public and private staff collaborate, work, and store equipment</td>
<td>• Research reports/white papers&lt;br&gt;• Test plans&lt;br&gt;• Regulatory perspectives&lt;br&gt;• Software validation</td>
</tr>
</tbody>
</table>

* Not an exhaustive list