CONNECTED

An Overview of Autonomous Vehicle Technology in Central Ohio

UNION COUNTY OHIO

Logan-Union-Champaign Regional Planning Commission

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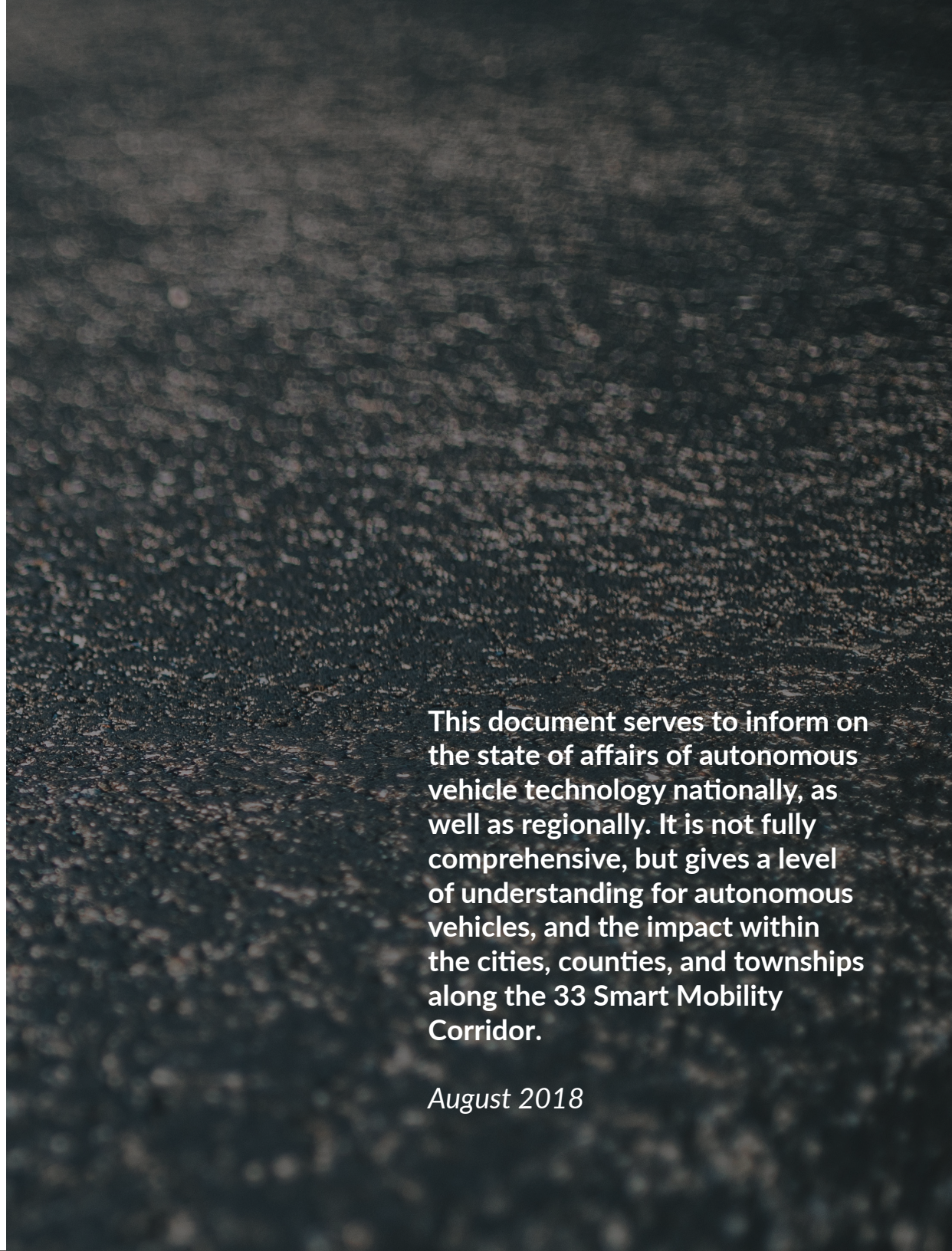


This document serves to inform on the state of affairs of autonomous vehicle technology nationally, as well as regionally. It is not fully comprehensive, but gives a level of understanding for autonomous vehicles, and the impact within the cities, counties, and townships along the 33 Smart Mobility Corridor.

August 2018

Source: Marysville-Union County Port Authority

What are autonomous vehicles?

Autonomous vehicles are able to guide and navigate without any human input. Their systems are independent from the user, using hardware and software simultaneously to guide itself. While there are levels of autonomy, usually the term autonomous vehicles refers to the highest level of autonomy, where cars truly do not need a driver. This level of technology is right around the corner, and will reach highways worldwide in the near future.

There can be confusion when dealing with the terms autonomous vehicle and connected vehicle. Connected vehicle refers to the cars ability to connect with other vehicles on the roadway, as well as infrastructure, such as streetlights. Connected vehicles can still have drivers behind the wheel, whereas an autonomous vehicle would not.

What are the advantages of autonomous vehicles?

The reason for the explosion of development, research, and news around autonomous vehicles lies with the wide breadth of advantages they offer. A human can become distracted, tired, or reckless while driving. A human can be driving drunk, or simply less skilled. Each and every one of these factors are removed when you replace the driver with a sophisticated combination of hardware and software. Now there is an increase in safety on the road by an order of magnitudes. According to the National Highway Traffic Safety Association, in the year of 2016 alone 37,461 people were killed due to automobile accidents. That is an average of 102 per day. Human error is cited as the reason for around 93% of crashes also according to the NHTSA. In 2017 there were 1,177 traffic fatalities in Ohio, which have risen for the fourth year in a row. The Ohio Department of Transportation's project Zero Deaths aims at bringing this number to zero fatalities. An attractive option for achieving the targets is the adoption of autonomous vehicles.

A symposium by the American Planning Association focused on preparing communities for autonomous vehicles identified other potential benefits of autonomous vehicles. One of these benefits was more efficient vehicle movement. The efficiency of autonomous vehicles would allow for reduced traffic, typically shortening many commutes, which in the US is a 27 minute trip. People unable to drive due to disability or age, such as seniors o children, would now have access to a safe form of mobility.

Who makes autonomous vehicles?

Nearly every traditional automobile manufacturer is active in the field of autonomous and connected vehicles. Each are at varying stages in terms of their technology and deployment time lines. Almost all have partnerships with other companies to supplement their development. A single autonomous vehicle could have multiple companies that creates the sensors, the software, and the actual manufacturing of the car.

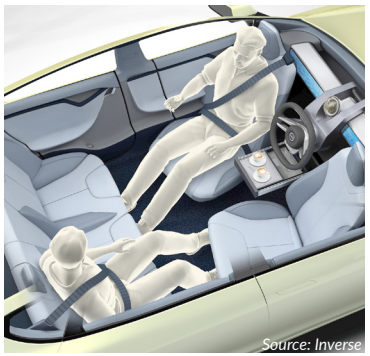
There is no clear leader when it comes to making autonomous vehicles at this point. The Google company, Waymo, has been in this field the longest, pioneering many aspects that have led the industry to where it is today. However, many other companies are hot on the heels to take the throne. This industry is in many ways an arms race, with companies pouring hundreds of millions of dollars into research and development. This race is to reach the gold medal of Levels 4 and 5 autonomy, which are when these vehicles become truly driver-less. Below are just a handful of the huge list of companies in this rapidly growing.

What do they look like?

Source: Waymo

The design of autonomous vehicles changes almost as much as the technology itself. Above can be seen the difference in design over the span of a few years. The left shows the original "Google Car", which now looks like most other vehicles on the street. Even the sensors mounted on top of the car will soon not be visible. By the time these vehicles are actually on the road they will most likely be indistinguishable from other vehicles.

One area that will definitely see an immense amount of change is the interior of the car. Once the need for a steering wheel and peripheries are no longer needed, the cabin of a vehicle gains much more space. Below can be seen the interior of the Nissan IDS, an electric self driving concept car. The dashboard is now occupied with touch screens and displays. In addition, basic layout of the interior can be changed. Drivers will be free to socialize with other passengers, made easier by seats that can rotate. The potential changes are imaginative and wide ranging, but exciting nonetheless.



Source: Inverse

Source: Nissan

What do all these acronyms stand for?

AV - “Autonomous Vehicle”

An autonomous vehicle is simply a vehicle that can perform all driving tasks by itself. There is not a need for the driver to be monitoring the car and the driver is allowed to do non-driving tasks. There are multiple levels of AV, this definition describes the highest level.

CV - “Connected Vehicle”

A connected vehicle is one that is wirelessly connected to other vehicles, the infrastructure, or both. This is not a mutually exclusive term, vehicles can be both connected and autonomous. The first vehicles of this technology to hit the roads will be connected, but non-autonomous.

DSRC- “Dedicated Short Range Communication”

These are communication devices that provide information and data among vehicles, and between vehicles and infrastructure. They can be installed at roadside access points (RSUs), providing safety with the data they are receiving and sending.

LIDAR - “Light Detection and Ranging”

An expensive, but extremely accurate technology. Used in many autonomous vehicles, the LIDAR unit has a 360-degree view around the vehicle that is able to create a 3D map of the environment in real time by bouncing lasers off surfaces up to 320 ft. away.

SPaT - “Signal Phase and Timing”

This refers to that state of the signal at an intersection and how long the signal will remain for each approaching vehicle depending on the lane a vehicle is in. This allows for a vehicle connected to the infrastructure to know ahead of time before it sees the signal light how long it will remain green rather than having to react to the signal.

V2V/V2X/V2I - “Vehicle to ...”

These are the technical terms for connected vehicles. Each refers to the type of connection the vehicle is making. V2V is the connection between vehicles, V2I is the connection between vehicles and infrastructure, and V2X is the connection between both and more, such as various Internet applications.

There are many more terms when it comes to this technology. If you would like to read more you can find a full glossary of these terms at the University of Virginia Center for Transportation Studies’ website.
cts.virginia.edu

Levels of Autonomy

5
4
3
2
1
Level

Driver Assistance

Vehicle is controlled by the driver, but some driving assist feature may be included in the vehicle design. An example of this would be adaptive cruise control.

5
4
3
2
1
Level

Partial Automation

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. Tesla's Autopilot mode is within this level.

5

4

3

Level

2

1

Conditional Automation

Driver is still a necessity, but is not required to monitor the environment. The car is able to handle most of the driving task, however the driver must be ready to take control of the vehicle at all times with notice.

5

4

Level

3

2

1

High Automation

The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.

5

Level

4

3

2

1

Full Automation

The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

Economic Development Impact

When it comes to autonomous vehicles, much of the focus is placed on various societal benefits that this technology will have. A few of these have already been touched upon such as increased safety, increased mobility access, and reduced congestion. However, the other driving force behind AV technology is the impact it will have on the local, regional, and national economy. The disruption that this will cause reaches far across the economy, influencing a range of industries. The amount of potential economic growth has the ability to drastically improve the quality of life for communities. While the fear of job loss due to automation is a very real and serious issue, the amount of growth is projected to far outweigh this negative. Forward thinking economic decisions that take this technology into account will be necessary to capitalize on these gains, and to negate the potential harms autonomous vehicles may bring. This section focuses on some of the supporting industries of autonomous vehicles, as well as highlights of some of the latest economic development impact studies on autonomous vehicles.

According to a report entitled America's Workforce and the Self-Driving Future released in June 2018 by leading transportation and economics researchers, the commercial use of AVs will have an intense impact upon society, as well as the economy. Within their executive summary they outline some of these impacts.

AVs will create positive economic impacts due to their ability to stimulate innovation.

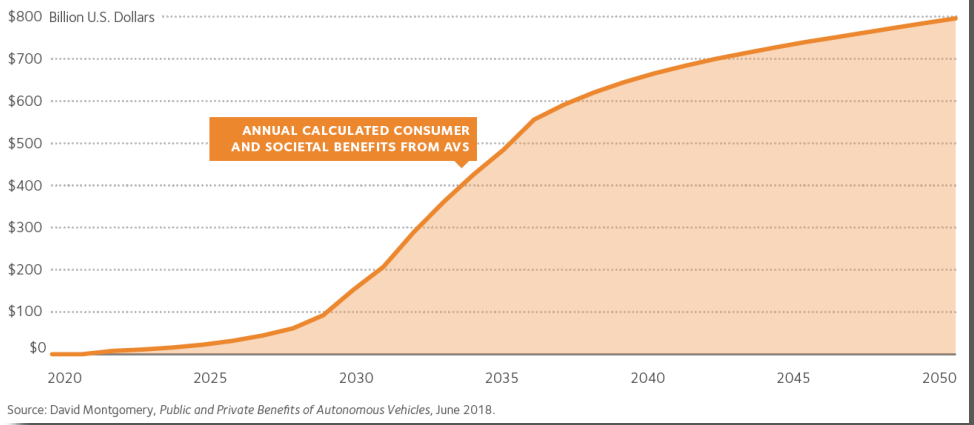
By 2050, nearly $800 billion in economic benefits will come from reducing vehicle crashes, increasing productivity by saving time for commuters, and improving energy security by reducing oil dependence.

Economically depressed regions could see massive improvements due to individuals having access to larger job markets from the deployment of AVs.

The loss of jobs due to automation will eventually be negated by the growth of new jobs created from AV and other related industries.

The current estimates show these impacts will start to be felt in the early 2030s.

Projected Annual Consumer and Societal Benefits from AVs



Source: David Montgomery, *Public and Private Benefits of Autonomous Vehicles*, June 2018.

The full research report can be found at: *https://avworkforce.secureenergy.org/*

Supporting Industries

- Industry Increase
- Mixed Industry Change
- Industry Decrease

Automotive

VMT (Vehicle-Miles Traveled is used to measure automotive travel. There is a possible expansion of automotive production due to an increase in VMT with the ability of children, disabled persons, and the elderly to have higher transportation access. The possible decrease in the automotive industry is due to the possible dramatic fall in private ownership with “on-demand” driver-less services.

Electronics and Software Technology

Software will play an ever increasing vital role in driver-less cars. With the systems inside these cars and trucks become more and more complex, the tech industry stands to see massive growth.

Trucking and Freight Movement

Current estimates predict economic gains of $100-500 billion per year by 2050 in the trucking industry with the advent of autonomous trucks. Part of this increase comes from autonomous trucks avoiding human hours restrictions, which will increase efficiency and productivity. The disruption comes from automation posing a serious threat to the employment of around 3 million truck drivers.

Personal Transport

Short and long commutes will see incredible change when it comes to personal transportation. “On-demand” services similar to that of Uber and Lyft are predicted to become the predominate means of transportation. This is due to it being the economic decision of not needing to own a personal vehicle. According to the Brookings Institute, personal vehicles sit unused an average of 95% of the time.

Auto Repair

Most safety agencies agree that between 90-94% of car crashes are due to human error. Once this is removed the massive reduction in crashes will see economic losses for collision repair shops. The decreased need of new parts for these vehicles will create less business for manufacturers. While AV/CV specialized repair industry will see large growth, the majority of the auto repair industry will experience difficulty.

Oil and Gas

A 2012 study from the Texas Transportation Institute estimated that the cost of congestion for Americans annually is 4.8 billion hours, 1.9 billion gallons of fuel. These total to around $101 billion in productivity delay and fuel costs. Reduction in congestion through higher traffic efficiency, and movement toward electric vehicles will mean significant economic gains. The ability for cars and trucks to platoon on highways also presents an opportunity to save fuel costs during travel.

Medical

According to the Economist, nearly two million hospital visits and about 240,000 extended hospitalizations within the US can be attributed to car crashes. With a huge proportion of these eliminated the medical industry will experience a significant loss in annual revenue. The bright side of this, however, is that resources and medical personnel will be able to be relocated toward other needs.

Insurance

More than any other industry, the increase in safety through the reduction in crashes will result in an overhaul the insurance industry. According to research at the University of Texas at Austin, insurance agencies gain $180 billion annually from insuring against car accidents and medical costs. Estimates on the auto insurance industry read that it could be reduced by up to 60%.

Legal Profession

About 76,000 attorneys in the U.S. are within the personal injury specialization. The decrease in automobile injuries through increased safety from autonomous vehicles will impact much of this profession. While not the most significant industry in terms of impact, it does signal that the wide variety of jobs that will be disrupted. These changes could create a change in a significant portion of the legal industry.

Construction and Infrastructure

For decades the attempted solution to solve traffic problems was to widen the size of our roads. Increases in traffic efficiency is projected to result in the narrowing of highways. Furthermore there are many components to roadways that might no longer be needed. Some of these include extra-wide lanes, guardrails, traffic control signals, wide shoulder, or rumble strips. These present large infrastructure savings.

Land Development

Parking garages and lots encompass a large amount of land area in U.S. cities, more than one-third of the total land area on average. These present land use opportunities for redevelopment due to the reduction in parking needs from autonomous vehicles. Changing these oceans of asphalt into businesses, homes, or pedestrian space will help increase economic activity.

Traffic Policing

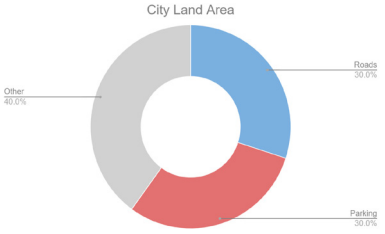
The decrease in human error and offenses will likely result in less need for traffic policing. Driver-less cars will mitigate drunk drivers, as well as remove speeding as a common occurrence. With around 85% of all stops being traffic related, an immense portion of law enforcement time and money will be able to be re-diverted toward more serious offenses. Loss in revenue from traffic tickets could possibly harm municipal budgets, which means alternate revenue streams will need to be explored.

Land Use Changes

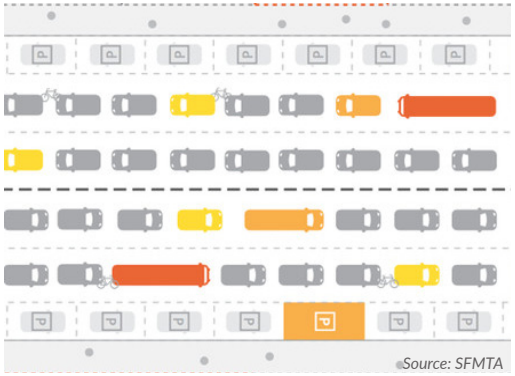
As the adoption rate of AV/CV increases, changes to transportation related land uses will need to be addressed. These changes present equal parts challenge and opportunity. This opportunity lies with the ability to redevelop areas impacted from driver-less vehicles. The following are areas that stand most likely to require some form of redevelopment to its use.

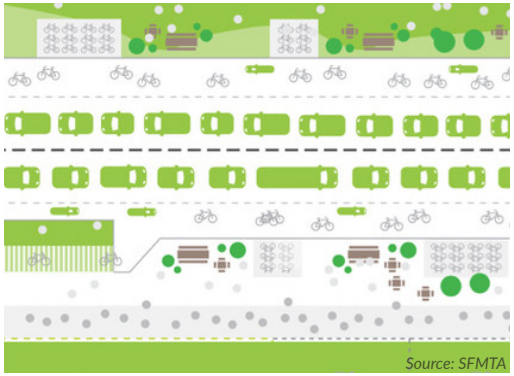
Road Space

Transportation experts believe that the increased efficiency of AV/CV will result in municipal road diets reduction. Traffic induced congestion, parking lanes, and multi-lane roadways will give way to redesigned spaces. Narrowing lanes makes pedestrians and bicyclists feel safer.



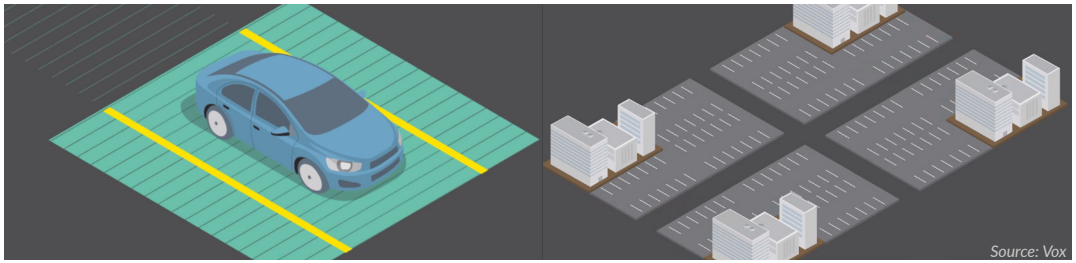
Source: Transportation and the Urban Form


Source: SFMTA


Source: SFMTA

Parking Lots

The average parking spot takes up nearly 300 square feet. Many cities are consumed with surface parking lots. AV/CV will reduce the need for parking, turning these oceans of asphalt into islands of redevelopment. Policies such as “Off-Street Parking Requirements” for development will also need to be reworked, due to fall in parking demands. With most estimates showing that nearly a third of cities are consumed by parking, thinking around reuse of these vacant lots will need to increase.


Source: Vox

Gas Stations

Gas station and convenience store locations will experience disruption as automobiles move toward electrification. Located extensively in clusters along highways, these sites present prime locations for redevelopment due to their proximity to main interchanges, intersections, and roadways. The cost of cleanup from the environmental factors of a gas station is significant, however their value when re-purposed is far greater. One of the easiest conversions is installation of charging stations for electric vehicles.


Source: Cathy Flynn

Source: Fortune

Truck Stops

Trucking and logistics is one of the main industries projected to be disrupted by AV/CV. Most experts foresee a decline in trucking employment with many companies shifting toward automation. With this, many highway-side trucking stops will see abandonment. These offer re-purposing opportunities, such as businesses, or charging locations, with the increase of electric vehicles.


Source: Peter Frei


Source: Bloomberg

33 Smart Mobility Corridor

The Smart Mobility Corridor is an ambitious initiative created to make a hub of smart technology research and development. The corridor itself is currently about 35 miles of highway, crossing Franklin, Union, and Logan county. The corridor starts near the City of Dublin and connects all the way to Honda's North America Campus. One of the most exciting components of the corridor is the installation of 432 strands of fiber optic, which will allow the high-speed transfer of large amounts of data. This will allow researchers and companies to have access to an immense amount of data for testing. The initiatives surrounding the corridor truly are groundbreaking, putting this section of Central Ohio on the cutting edge of transportation technology.

Automotive Ecosystem

Along the 33 Corridor section of US 33 lies nearly 70 automotive related companies and businesses. Having a cluster of industry creates a vibrant ecosystem of development. This cluster creates a draw in both business and talent. This is exactly what is needed for an area on the cutting edge of smart mobility research and development.

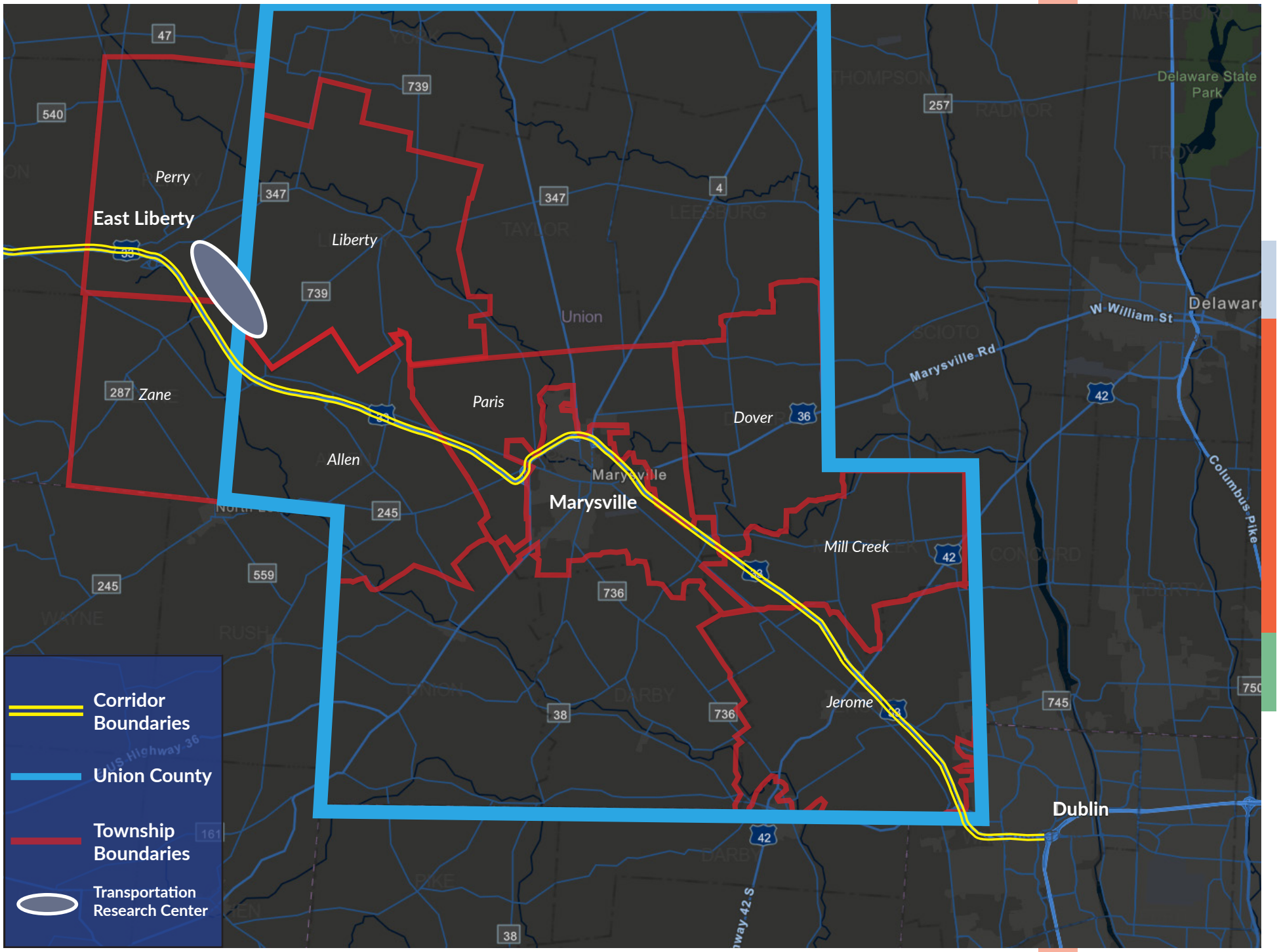
AV/CV Testing Ground

The heart of the 33 Corridor project is the collaborative atmosphere between organizations such as The Ohio State University, DriveOhio, the Ohio Department of Transportation, and local municipals. Together there has been an investment into the funding of fiber optic networks, highway sensors, and fleet testing. These technologies are an important step in autonomous and connected vehicle research.

Multi-Jurisdictional

The corridor is overseen by a council of governments, who review, evaluate, and make recommendations on the development of the 33 Corridor. The NW 33 Innovation Corridor Council of Governments is currently comprised of the City of Dublin, the City of Marysville, Union County, and the Marysville-Union County Port Authority.

Source: Marysville-Union County Port Authority


Perry
East Liberty
Liberty
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Zane
Paris
Dover
Allen
Marysville
Mill Creek
Jerome
Dublin
Delaware State Park
W William St
Marysville Rd
Columbus Pike
Corridor Boundaries
Union County
Township Boundaries
Transportation Research Center

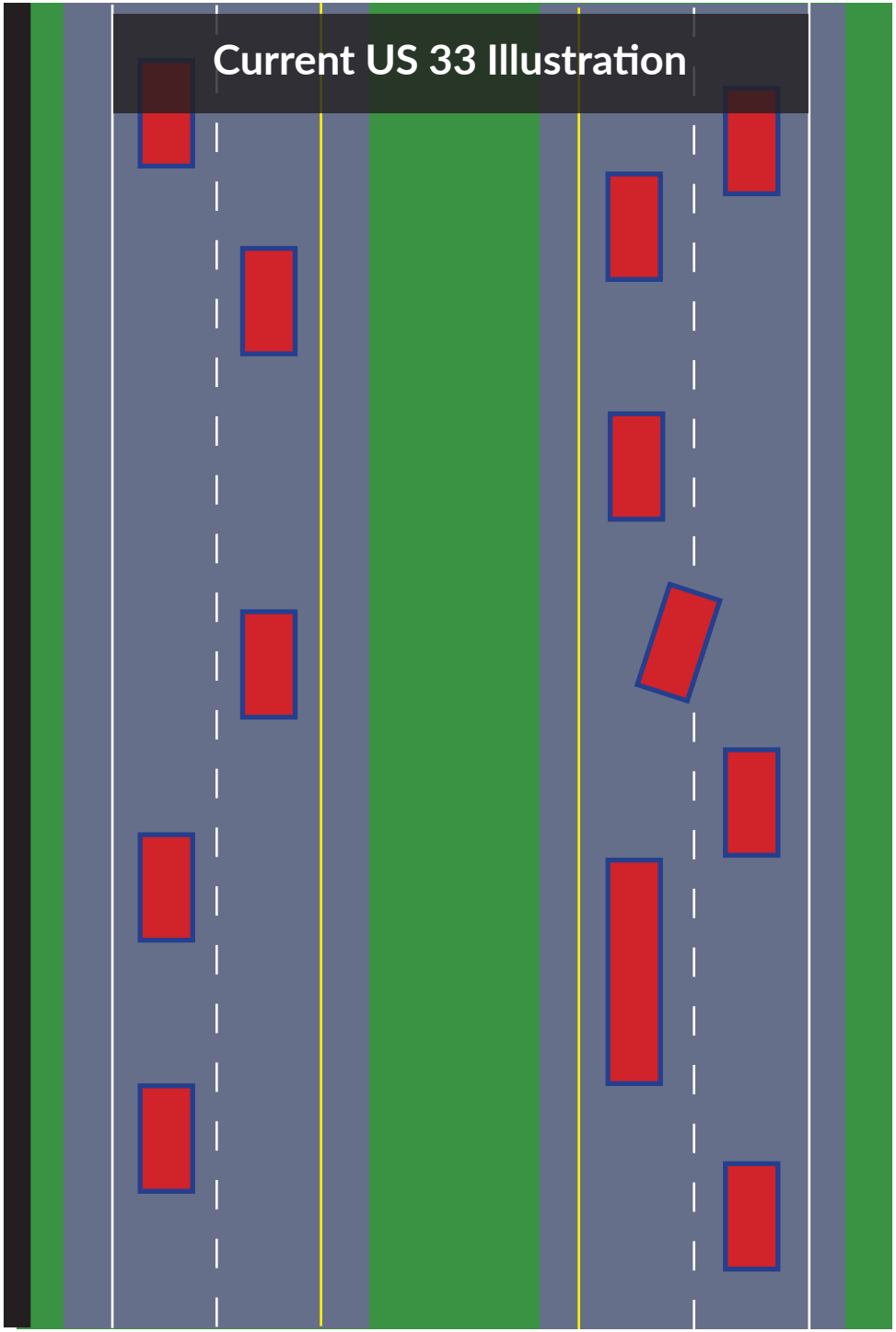
How might autonomous vehicles look along 33?

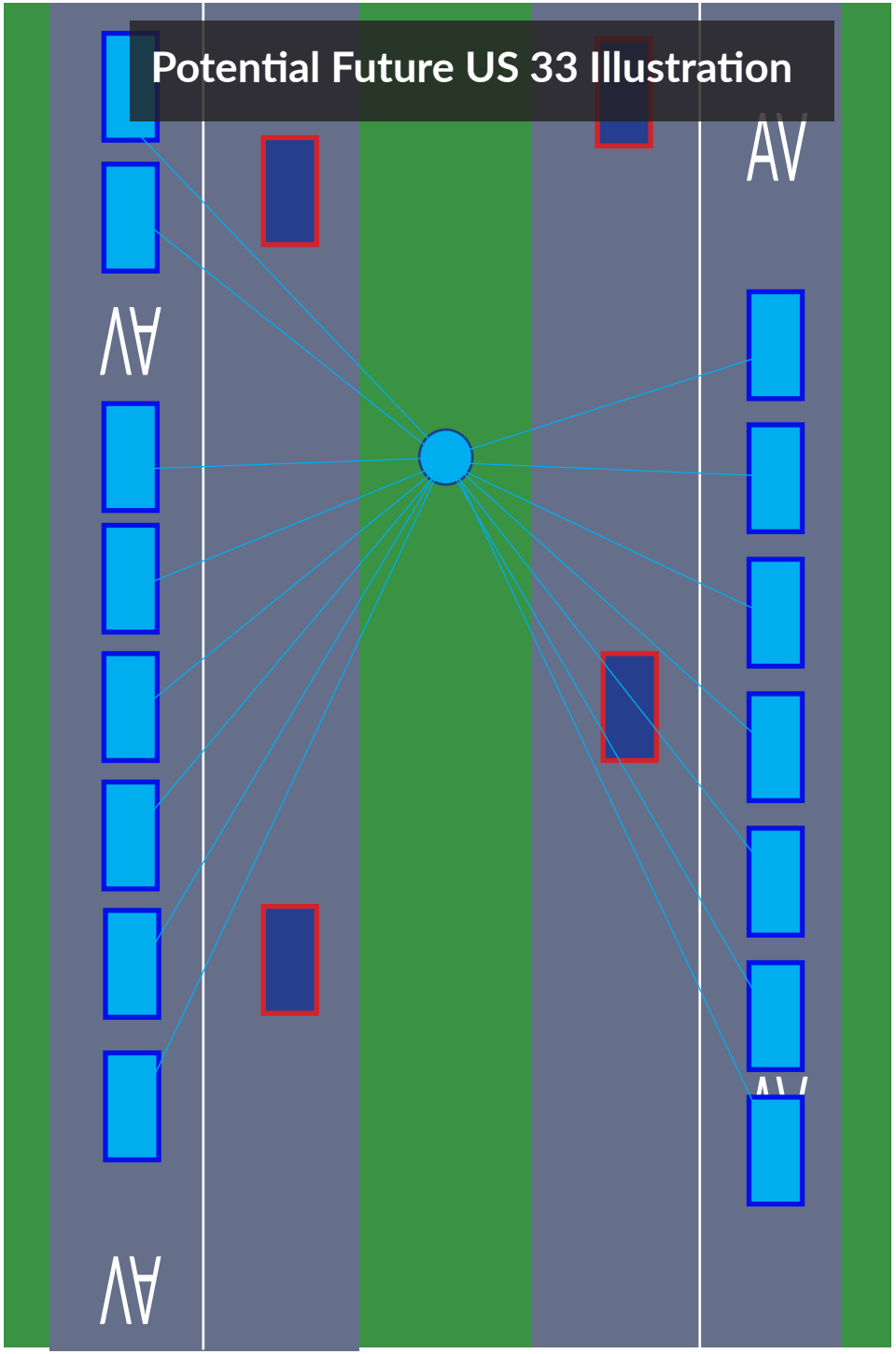
Envisioning how autonomous vehicles will look along the 33 Corridor is important. In the not so distant future drivers will be traveling alongside autonomous vehicles, and knowing what this entails will smooth any transitions. A potential illustration gives some ideas to how AVs along the highway might function. Within this illustration are a few critical systems that will eventually be deployed.

DSRC

AV/CV Vehicle

Unconnected Vehicle





Platooning

Autonomous vehicles will have the capability to stack closely to each other while they are traveling. This highly increases the efficiency of traffic on the highway.

Highway Markings

Solid lines better allow sensors and cameras mounted on autonomous vehicles to read roadways.

Dedicated Lanes

As both human drivers and autonomous vehicles begin to share the roadways, it will be the smoothest option to dedicate a lane specifically for AV cars. This will reduce the chances of any hazardous situations.

DSRC's

To facilitate connections with the infrastructure, DSRC devices will be located along the Corridor. These will share information with vehicles, such as road conditions, speed limits, and many other factors.

Sites of Comparison

Looking toward other areas in the country and world for comparison is a vital part to continuing growth. In the field of transportation technology this is especially true. The locations that have been selected to compare the area around the 33 Smart Mobility Corridor are due to their similar position toward AV/CV testing and business. It is always to the benefit of one's own region to look to see what works best, as well as what doesn't. This comparison analysis is based upon economic research of Nevada, Michigan, and Central Ohio by Ady Advantage.

Source: Torc Robotics


Source: University of Michigan

Nevada

Focus on AV/CV technology that improves traffic efficiency and safety.

Implemented connected infrastructure along Las Vegas Strip.

First state to enact policy related to AV/CV. Policy related to regulations on AV/CV testing similar to that of Ohio.

Research from Nevada's universities on AV/CV technology is poorly marketed.

Drone research that works in conjunction with AV/CV is a strong component of universities. DriveOhio has taken a strong step toward following this path with its three year drone pilot program along the 33 Corridor.

Source: AP Photo/John Locher

Michigan

Currently the largest competitor with Central Ohio in the AV/CV industry. Direct competition with Ann Arbor and Detroit for industry related businesses.

Public/private partnerships have been an effective tool in this region in terms of research, testing, and economic attraction.

Very comparable educational institutions with Central Ohio. These institutions are valuable assets toward the production of skilled engineers and AV/CV knowledge.

Encourages an entrepreneurial ecosystem around the Ann Arbor area. Focal point from the state to encourage economic development toward smart mobility businesses and technology.

Extensive resources for entrepreneurs, including incubators, accelerators, smart city contests, and venture/angel funding to help development.

"M-City" is a valuable asset for testing of AV/CV technology.


Source: University of Michigan

Connected Marysville

The goal of Connected Marsyville is to test connected vehicles in a real world setting with real world drivers. The project plans to equip all 27 traffic signals in Marysville with DSRC radios and 1,200 vehicles with On Board Units, devices that communicate from the car to infrastructure. This combination will allow the vehicles to be connected with the infrastructure of the city. The aim of this project is to test cutting edge smart technology in an environment that can be found anywhere in the US. The proximity to the 33 Corridor and the density of Marysville make it the perfect candidate. This project truly is ambitious, with no other city in the world having a fully connected system yet.

Source: Marysville-Union County Port Authority


Source: Marysville-Union County Port Authority

Source: Marysville-Union County Port Authority

Source: 33innovationpark.com

Source: 33innovationpark.com

Source: 33innovationpark.com

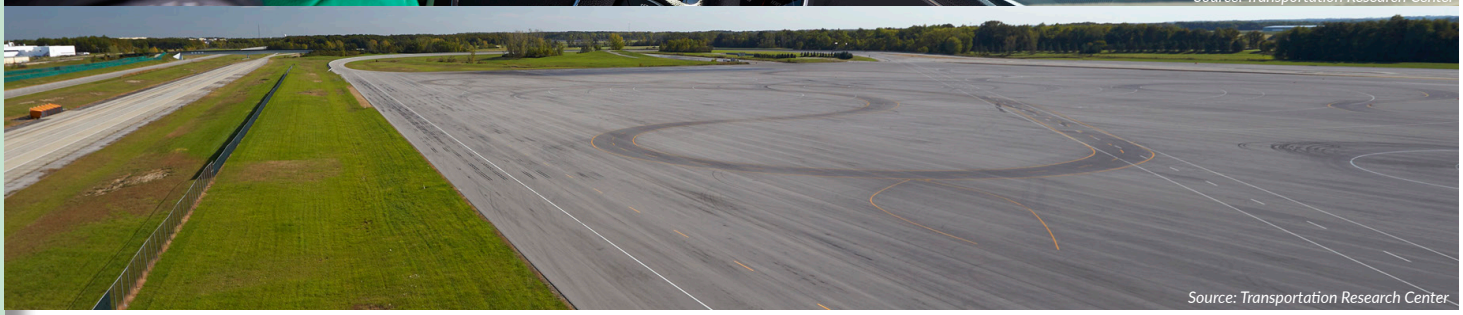
33 Innovation Park

The 33 Innovation Park is a master-planned business park located along the 33 Smart Corridor. The purpose of such is to attract businesses in industries such as smart mobility, advanced manufacturing operations, and innovative technologies. It is an incredible advantage for these businesses to be clustered among like-minded individuals or companies. Economic development heavily revolves around identifying the competitive advantage of one's area, and doing everything to build on this advantage. Attracting and retaining some of the best talent in these fields of technology is the best way to accomplish this.

TRC

Located on the Union and Logan County line, lies the largest independent vehicle test facility and proving grounds in the entire United States. The Transportation Research Center, or "TRC" for short, is a 4,500 acre complex of every driver scenario imaginable. Here cars are tested on things such as durability, emissions, or crash worthiness. TRC also plays a large role in research and development of smart mobility. Governor John R. Kasich broke ground on July 9th for the new SMARTCenter, a state of the art facility focused on testing autonomous and connected vehicle technology. Here autonomous vehicles will be able to be tested safely in as close to real world conditions as possible. To have such an advanced facility right in the backyard of the 33 Corridor is an immense asset.

Source: Transportation Research Center


Source: Transportation Research Center

What role does TRC play in the regional smart mobility ecosystem?

"TRC plays a number of roles within the smart mobility ecosystem. TRC's primary role is to provide a safe closed course environment for pre-deployment testing of new automated and connected vehicle and infrastructure technologies. TRC also serves as an independent body for assisting in the development of new guidelines, regulations and certifications."

What impact do you feel projects such as the 33 Innovation Corridor and Connected Marysville will have on development in the area in the coming years?

"These projects are likely to attract various technology companies to the area because of the media attention and deployment opportunities."

What can communities in the Central Ohio area do to best prepare themselves for the future as it relates to autonomous and connected vehicle transportation?

"Communities should look to invest in supporting infrastructure such as high speed fiber optic networks and ensuring high bandwidth cellular coverage. These types of infrastructure are important for many autonomous and connected vehicle applications."

Jennifer Richter-Dunn, *TRC Executive Assistant*

Source: Karen Kasler


Source: DriveOhio

DriveOhio

The Future of Smart Mobility

DriveOhio

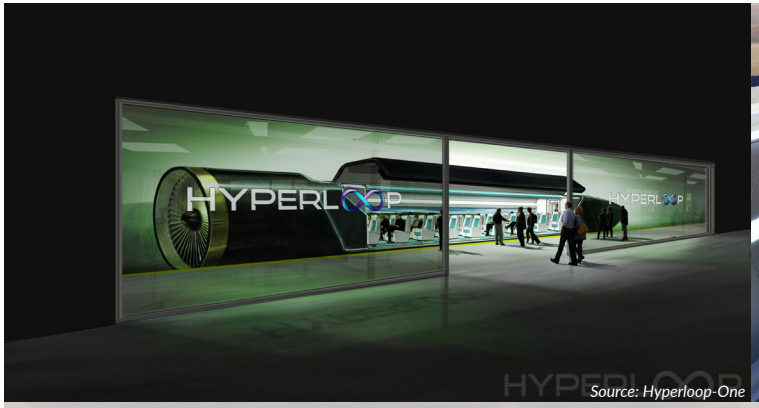
DriveOhio is an initiative of the Ohio Department of Transportation to collaborate between the public and private sector in regards to smart mobility. Companies that are interested in testing autonomous and connected vehicle technology are able to contact DriveOhio in order to be suited to the perfect location for their testing. On the left Governor John R. Kasich can be seen signing an executive order allowing for autonomous cars to be tested on Ohio roads. Furthermore, DriveOhio has just launched a pilot program for testing of Unmanned Aeria Systems, also known as drones, along the 33 Smart Mobility Corridor. This three year study is focused on researching drones as a tool for traffic management.

SMART Columbus

Smart Columbus was formed through the awarding of a $50 million in grant funding. This grant funding is aimed at improving the lives of Columbus residents through the implementation and advocation of new transportation technologies. The term “smart city” can seem that of a buzzword in media, but its an important movement meant to push toward a better environment for the people and businesses of a city. To the right some of the main goals and focuses of SMART Columbus can be seen. Improving mobility through the use of autonomous vehicles being a long term goal. This increased mobility is meant to assist the undeserved areas of Columbus, giving them access to healthcare, services, and employment.

Source: Smart Columbus

Hyperloop Initiative



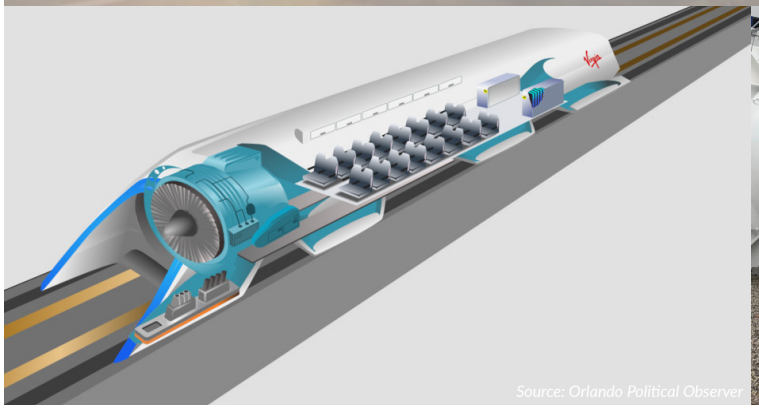
Source: Hyperloop-One


Source: Inverse

When it comes to transportation news in the past year it has been impossible to miss seeing headlines filled with *Hyperloop*. Much like autonomous vehicles, this is an exciting new technology that gives a glimpse into what the future of travel could look like. This technology is similar to the jump from travel by horse to by car, or from travel by train to by plane. The technology works similar to how pneumatic tubes are used at banks to send parcels. The project has entered its next phase, an environmental impact study. While exciting, the reality of being able to travel to Chicago in 29 minutes is still an incredibly long time away, but that doesn't mean one can't imagine what this leap in transportation could bring.

Source: Hyperloop-One

Source: Hyperloop-One


Source: Orlando Political Observer

Source: MORPC

Acknowledgements

Hunter Rayfield Creator
Dave Gulden Scope/Editing
Brad Bodenmiller Scope/Editing

LUC Regional Planning Commission
Union County Commissioners
Transportation Research Center
NW 33 Corridor Council of Governments

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