



# Automated and Connected Vehicle Testing with TRC's New SMARTCenter

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# History of TRC

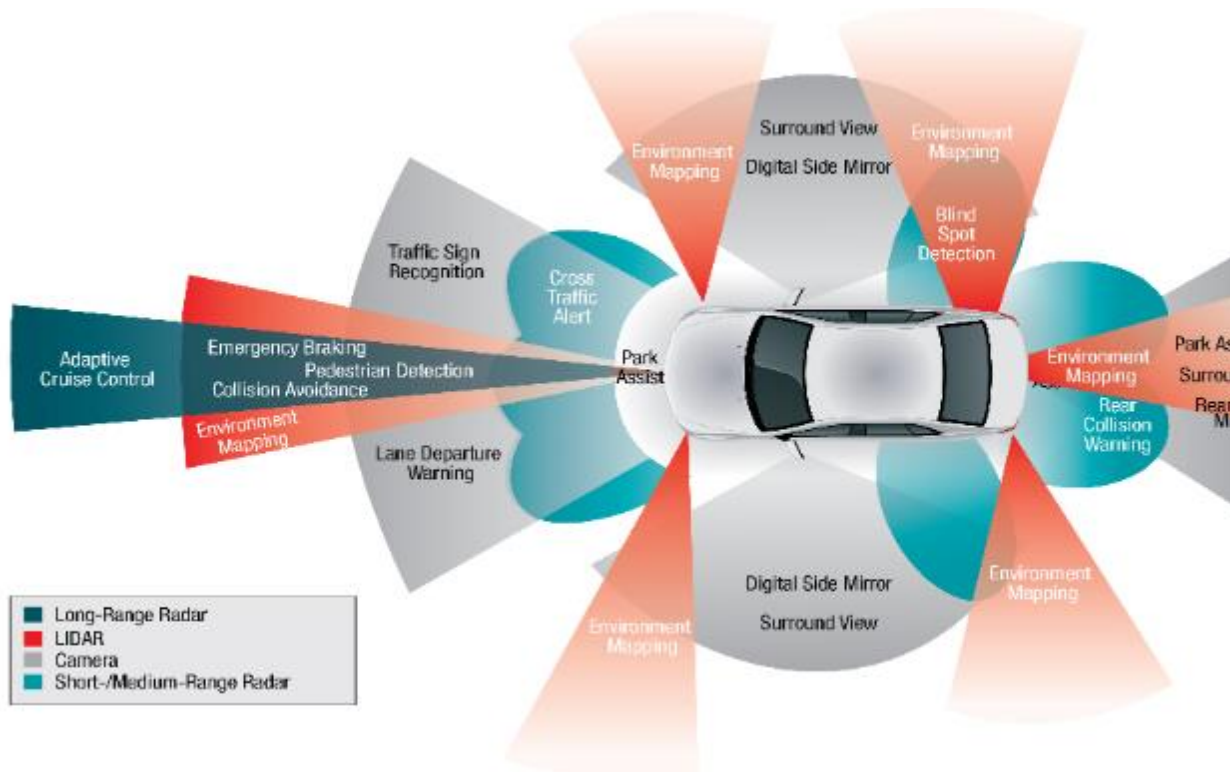


Dedicated July 10, 1974 by  
Governor James A. Rhodes

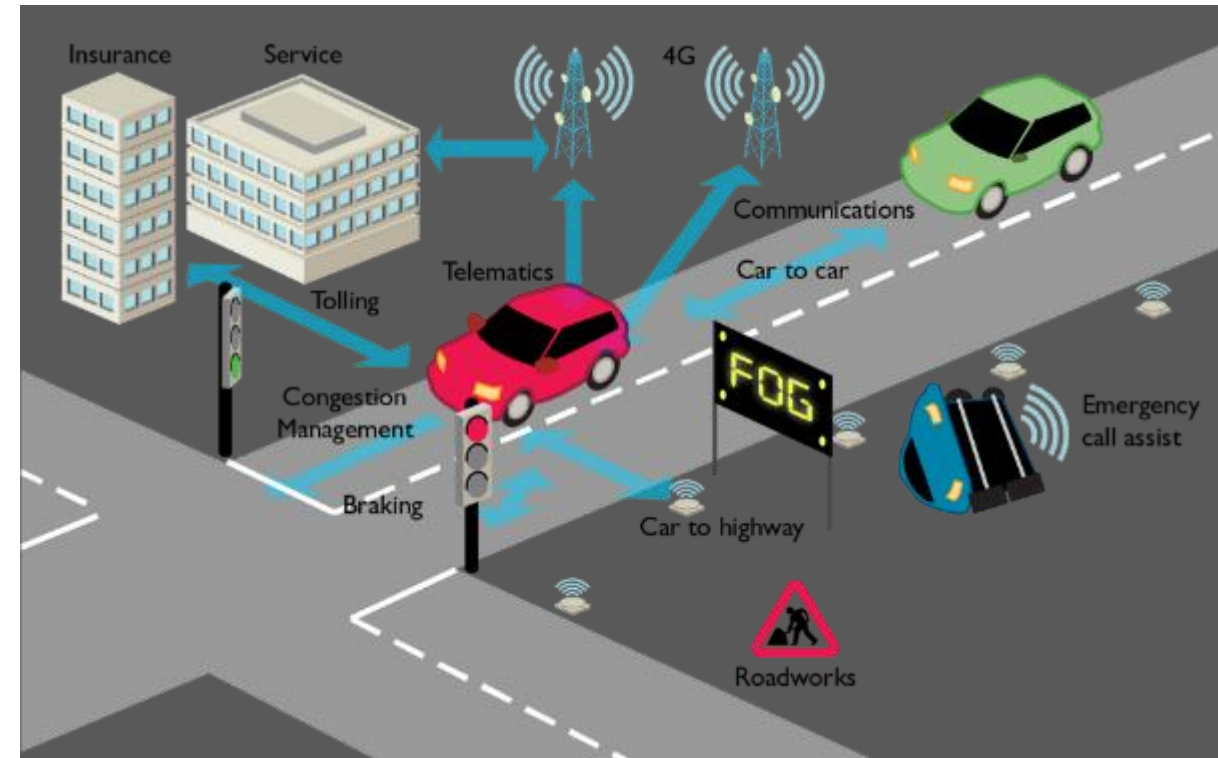
- Most comprehensive, independent proving ground in North America
- Operated by TRC Inc. an Ohio non profit (501c3)
- Affiliated entity of The Ohio State University
- Envisioned in the late 1960's for Economic Development to attract automotive jobs, investment, research & development
- Home to National Highway Transit Safety Authority's (NHTSA) only Vehicle Research & Test Center since 1976 - Only independent proving ground in the country with a government laboratory onsite

# Automated and Connect Vehicles

## Automated



## Connected



# History of Vehicle Technology

## 1950 – 2000

Cruise Control  
Seat Belts  
Antilock Brakes

## 2010 - 2016

Rearview Video Systems  
Automatic Emergency Braking  
Pedestrian Automatic Emergency Braking  
Rear Cross Traffic Alert  
Lane Centering Assist

## 2025+

Highway Autopilot

## 2000 - 2010

Electronic Stability Control  
Blind Spot Detection  
Forward Collision Warning  
Lane Departure Warning

## 2016 - 2025

Lane Keeping Assist  
Adaptive Cruise Control  
Traffic Jam Assist  
Self-park

# Recent Trends: Heavy Truck Platooning & Automation

- Truck platooning – connecting two or more trucks in a convoy - systems are becoming a global trend
- Closed highway conditions are ideal for automation
- Established OEMs and start-ups alike are testing new technologies

## Self-Driving Truck Hauls 40K Pounds Of Butter Across US



<https://www.pymnts.com/innovation/2019/self-driving-truck-hauls-40k-pounds-of-butter-across-us/>

# Recent Trends: Low-Speed Shuttles

## Columbus Pilots Self-Driving Shuttle



- Over 260 low-speed shuttles are planned or have been implemented around the world
- Transporting people and goods
- Introducing citizens to automated vehicles, many times for the first time



RIDE FOR FREE  
EVERYDAY



SELF-DRIVING VEHICLE  
WITH A HUMAN ON  
BOARD AT ALL TIMES



CARRIES UP  
TO 12 PEOPLE



WHEELCHAIR  
ACCESSIBLE

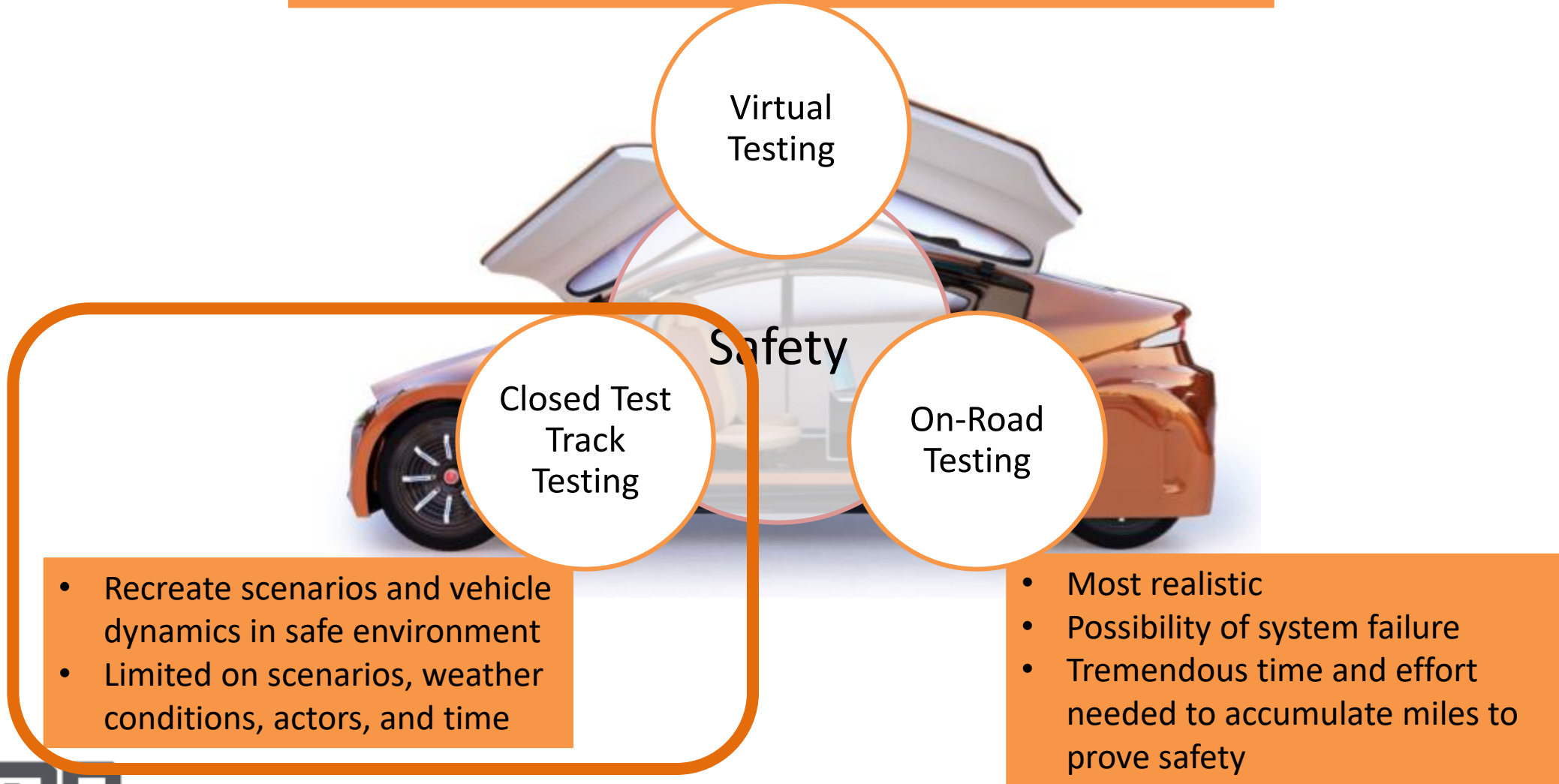


2 SHUTTLES

<https://smart.columbus.gov/get-involved/linden-leap#section-riding-is-easy>

# Ensuring Safety of Automated and Connected Vehicles

- Efficiently test thousands of scenarios and conditions
- Verification to real world testing



# Services



## Road Performance Evaluation

Dynamics  
Durability  
NVH  
Driver Training  
Fuel Economy  
Corrosion  
Events



## Laboratory Evaluation

Passive Safety  
Emissions  
Fuels & Lubes  
Radio Antennae  
Aero-Acoustics



## Advanced Mobility

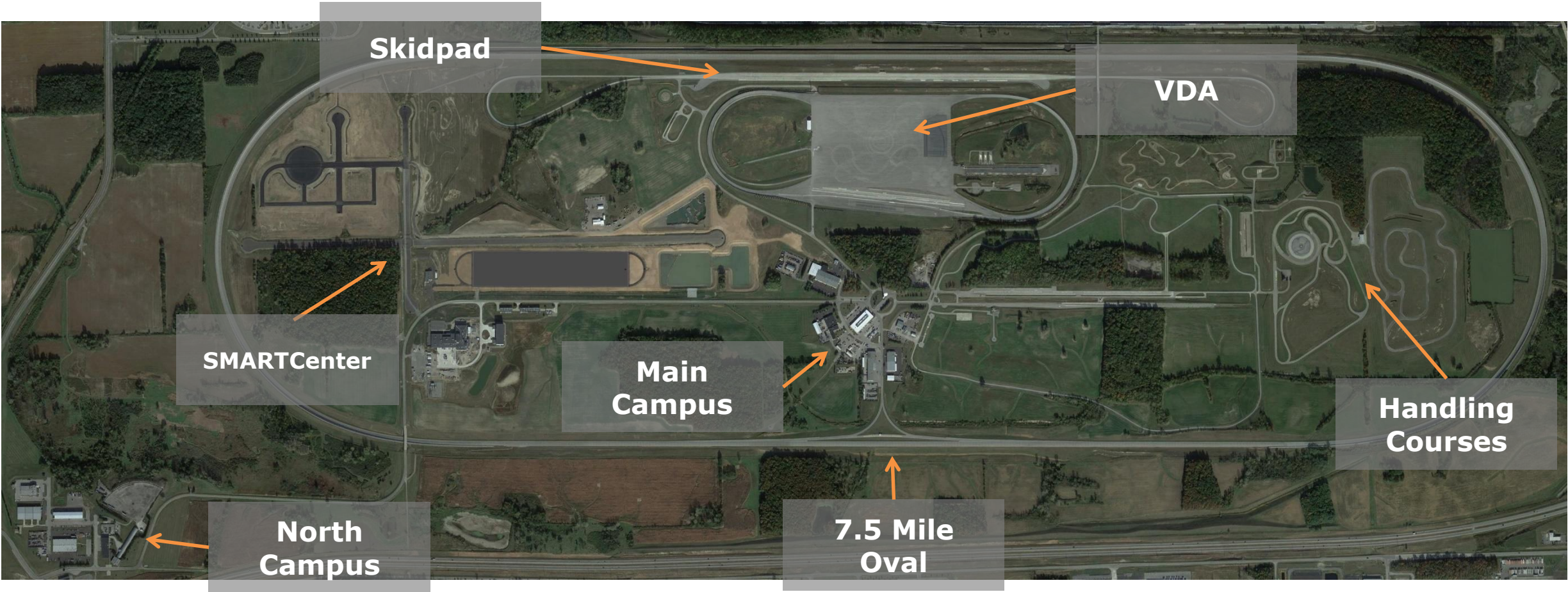
Driving Automation  
Connectivity  
Driver Assistance  
Test Scenario Development  
AV Crashworthiness  
Vehicle-Infrastructure Testing  
Electronics Reliability  
HiL Simulation



## Technical Services

Research Scientists  
Engineers  
Statisticians  
Analysts  
Technicians

# Facility Highlights





# Smart Mobility Advanced Research & Test Center

**\$45 million** in funding from ODOT, JobsOhio and The Ohio State University

**Inputs:** Facility design developed and evolved through five years of users/stakeholder meetings including inputs from NHTSA

**Function:** Support a wide variety of AV/CV testing in a safe, controlled and repeatable environment



# Facility Highlights



# Intersection



# Urban Area



# Vehicle Dynamics Area



# Control Building



# SMARTCenter Features

## Dedicated AV/CV Test Facility

Confidential and secure area designed specifically for AV/CV testing with large run-offs

## High Speed Intersection

Six lanes wide, tractor trailer sized turnaround bulbs, suitable for high speed testing of passenger and commercial vehicles

## Traffic Signals

Flexible intersection configuration, advanced traffic control system, variable signage, multiple traffic detection systems, integrated with V2X infrastructure

## Urban Network

Diverse set of roadways and intersections, circular vehicle dynamics area for simulation of roundabouts and other intersections, suitable for lower speed testing and environments

## Control Building

10,200 ft<sup>2</sup>, centralized control and coordination of testing, vehicle prep and calibration work bays, Advance Mobility office

## Support Infrastructure

Power distribution and fiber network, facility monitoring cameras, weather station, conduit pathways

## V2X communications

DSRC, C-V2X and high speed wireless communications covering the entire site, smart traffic controllers



# Testing Tools

**NHTSA SSV**



**Soft Car 360**



**Pedestrians - Adult and child**



**RAEB Post and Pillar**



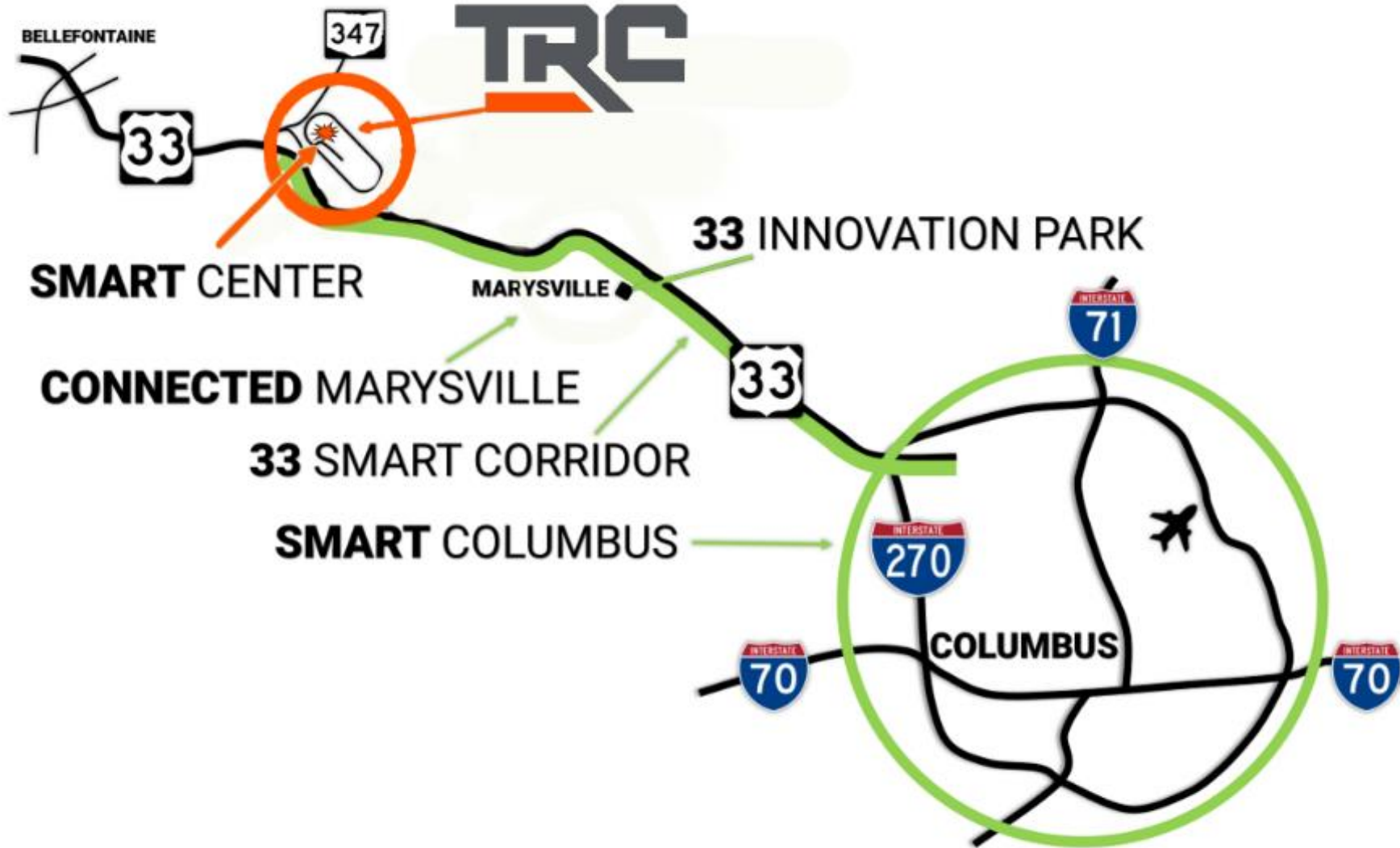
**Deer**



**Bicycle and Motorcycle**



# Ohio's Smart Ecosystem



# Ensuring Safety of Automated and Connected Vehicles

- Efficiently test thousands of scenarios and conditions
- Verification to real world testing

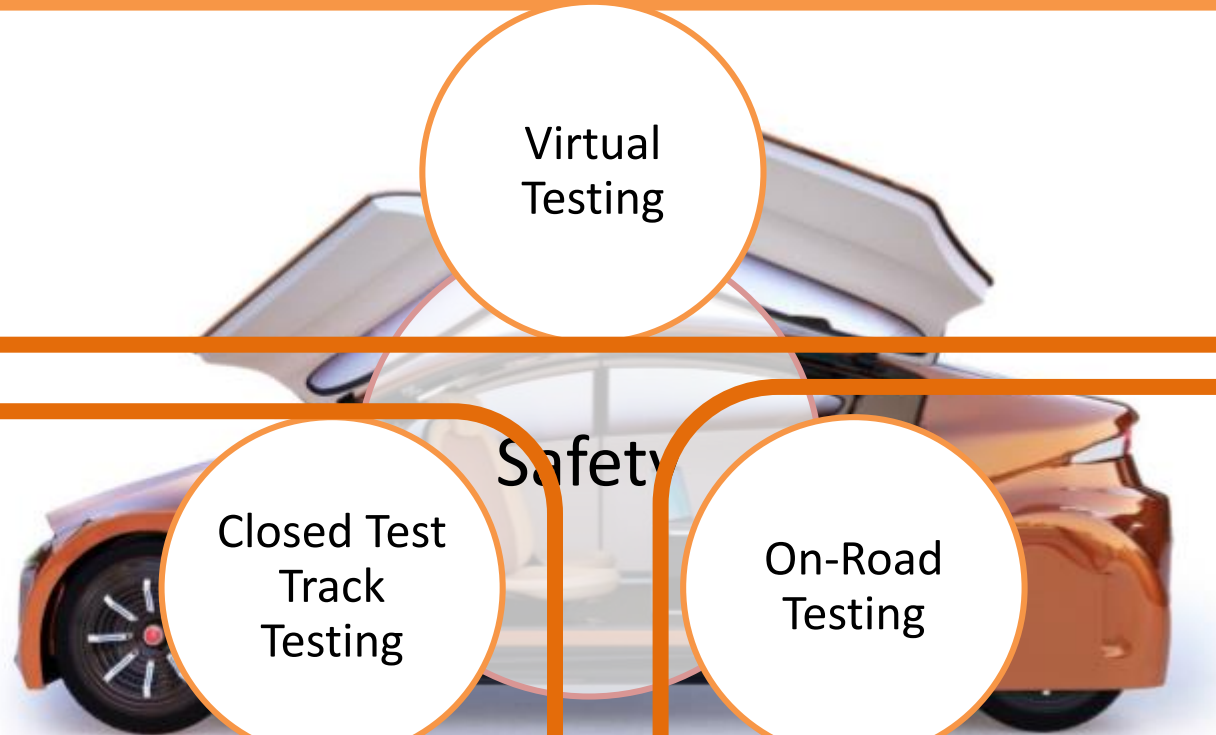
Virtual Testing

Closed Test Track Testing

- Recreate scenarios and vehicle dynamics in safe environment
- Limited on scenarios, weather conditions, actors, and time

On-Road Testing

- Most realistic
- Possibility of system failure
- Tremendous time and effort needed to accumulate miles to prove safety



# R.O.A.D.M.A.P. Project

- Goal of the project is to evaluate performance of currently available driving automation systems in rural environments to enable planning and improvement
  - Understand EV ownership and travel
  - Deployment of an EV shuttle on a rural route
  - Procure EV taxi service
  - Deploy a Level 2 vehicle on rural roads to understand how the vehicle navigates different environments
- Share best practices, lessons learned, and infrastructure recommendations

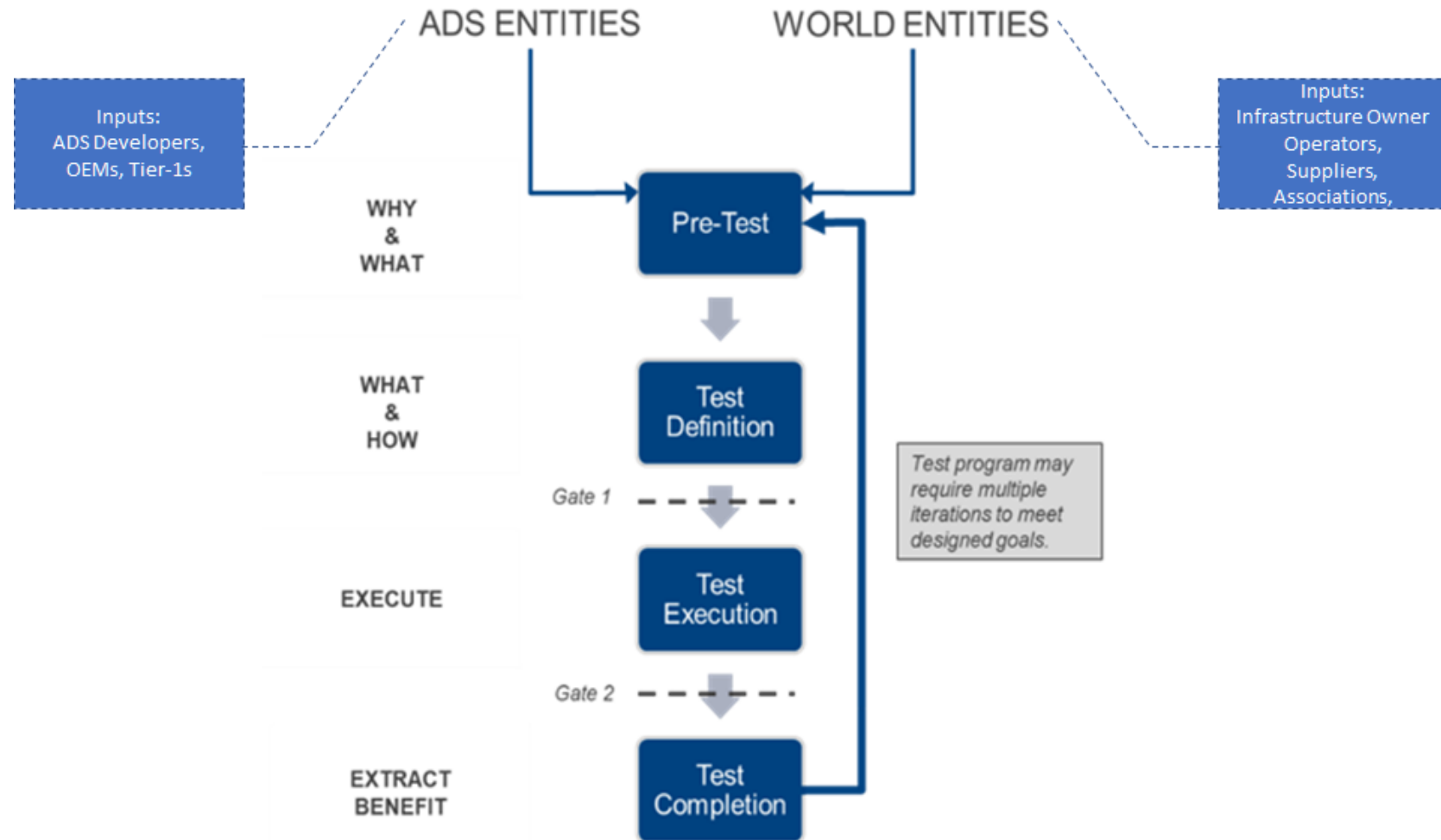


A graphic for the R.O.A.D.M.A.P. project. At the top, the acronym "R·O·A·D·M·A·P" is written in large, white, serif font on a green background. Below it, the full name "Rural Open Access Development Mobility Action Plan" is written in a smaller, white, sans-serif font. The graphic is divided into three sections: a map of Athens, Ohio, showing a red route and numbered points; a photograph of a gravel road with a traffic cone; and a photograph of a dirt road with yellow markers.

# ADS FRAMEWORK Project

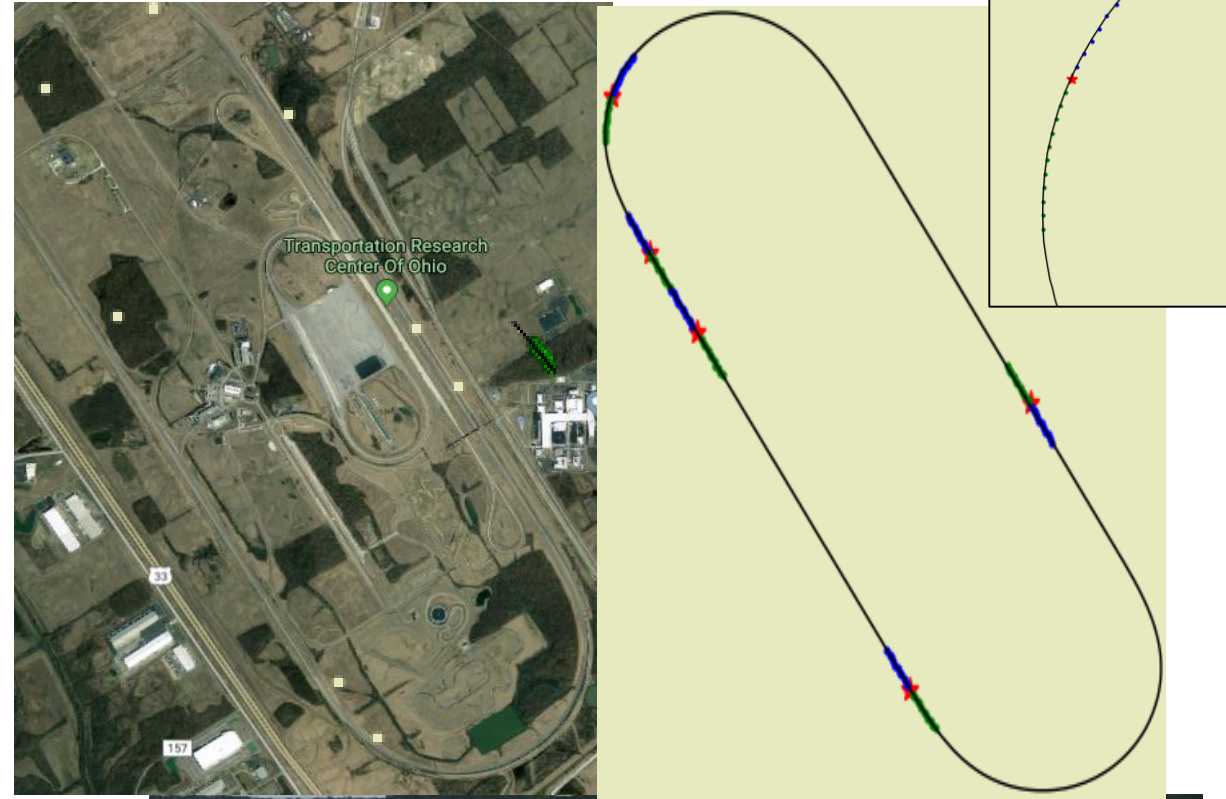
- Partnered with Battelle Memorial Institute for a FHWA project.
- Project develops an ADS/Roadway Testing Evaluation Framework
- Foster collaboration between the varied stakeholders of automated driving including ADS companies and infrastructure entities
- Collaboration also ensures safe deployment of these vehicles on our roadways

*Battelle and TRC Inc. are developing a Collaborative Test Framework for FHWA to help ADS and Roadway entities structure testing and evaluation programs..  
The information is designed to enable safe testing and deployment of ADS on our nation's roadways.*



# ARPA-E

- Combination of closed-test track testing and simulation to improve fuel efficiency of an automated and connected vehicle
- Goal of 20% fuel economy improvement
- Use of SPaT (Signal Phase and Timing) messages to create virtual environments in the real-world
- Combined our high speed test track with SPaT messages of traffic signals and intersections to understand how a connected vehicle can respond to these environments



# Warning Systems Projects

## Work Zone Warning

- Use connected vehicle technology to alert both the driver and construction workers
- Research focused on ensuring that alerts were timely and accurate

## Rail Crossing Warning

- Similar to Work Zone, use connected technologies to warn driver of upcoming rail crossing
- Understand effect of vehicle size and other factors on the system

## Summary

- Automated and connected vehicles are on their way
- Key to ensuring a smooth deployment and adoption relies on a comprehensive testing approach
- TRC's SMARTCenter is a tool in ensuring automated vehicle safety that can be combined with simulation and on-road testing for a holistic safety assurance

# STAY CONNECTED



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**Transportation  
Research  
Center Inc.**



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