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CASE STUDY: OHIO'S CONNECTED AND AUTONOMOUS VEHICLE TESTING ENVIRONMENT

The US33 Smart Mobility Corridor will be the longest, largest, and most comprehensive "autonomous-ready" testing environment in the nation—quite possibly the world.

By Luke Wadsworth,
RCDD, OSP, CDT

Across the country and around the world, the goals of the connected and autonomous vehicle (CAV) industry are to reduce risk and improve safety for the traveling public. Decreasing the number of crashes and fatalities on the public roadways is a universal goal that guides all visions for developing CAV systems and applications. Motor vehicle crashes caused an estimated 35,560 fatalities in 2018.[1] A study by the National Highway Traffic Safety Administration (NHTSA) showed that 94 percent of crashes are due to human errors.[2]

Ohio's Department of Transportation (ODOT), as well as many other transportation agencies, is looking to improve the safety and operational benefits of CAV technologies to meet its goal of enhanced safety through improved interaction between vehicles and the transportation infrastructure and environment. This improved interaction leads to improved mobility by increasing safety and reducing delays and congestion.

The autonomous or semi-autonomous vehicle makes up one component of the CAV environment. The long awaited self-driving vehicle is well on the way to becoming a reality. Roadways will soon be the stage for a revolution in the automotive experience. Auto manufacturers and tech companies across the globe are in a race to develop and produce a safe and economically viable autonomous vehicle. The success of CAV development is dependent on a well-equipped infrastructure.

The semi-autonomous vehicles already in development are utilizing a mix of wireless technologies and onboard ultrasonic, radar, image, and light detection and ranging (Lidar) sensor systems to drive the vehicle on the roadway. These location tracking and proximity sensing technologies combine two existing systems on some late model cars—traffic adaptive cruise control and a lane keeping system—into a more complete system that provides limited self-driving capabilities (Figure 1).

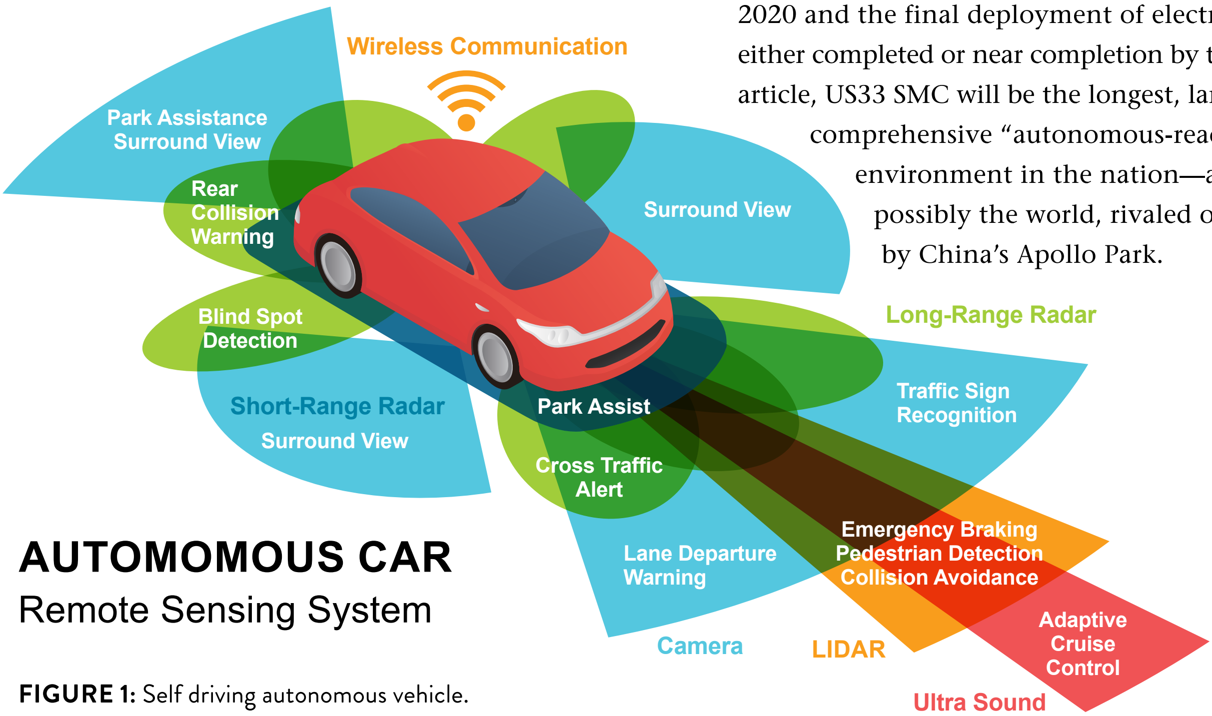


FIGURE 1: Self driving autonomous vehicle.

This self-driving ability is generally limited to larger county, state, and interstate roadways with better lane markings. The combination of these technologies is resulting in a variety of levels of automation. Manufacturers are integrating some level of automation into the vehicle systems of many new cars and trucks.[3]

CHALLENGES FOR CAV DEVELOPMENT

The U.S. Department of Transportation (USDOT) identifies various proving ground sites for testing autonomous vehicles.[4] These facilities represent a diverse cross section of the automotive and commercial vehicle manufacturing and testing industry.

A public roadway testing and research environment is essential to the development of CAV technologies. The variety of conditions such as weather, traffic patterns, and unexpected driving behavior on expressways and urban streets is often difficult to recreate at a mocked-up testing facility. Testing a connected vehicle's ability to transition from urban roadways to an expressway and back requires a merging of connectivity across these environments.

No single proving ground site thus far has been able to provide a comprehensive testing facility for developing CAV applications in both expressway and urban environments—until now. With Ohio's Smart Mobility Corridor (US33 SMC) completed in December 2020 and the final deployment of electronic systems, either completed or near completion by the time of this article, US33 SMC will be the longest, largest, and most comprehensive "autonomous-ready" testing environment in the nation—and quite possibly the world, rivaled only by China's Apollo Park.

BACKGROUND OF OHIO’S US33 SMART MOBILITY CORRIDOR PROJECT

The project area spanned Franklin, Union, and Logan counties, as well as the cities of Columbus, Dublin, and Marysville. “This project also tied into the Smart City Challenge won by Columbus, Ohio in 2016 when it beat 78 other cities nationwide. The USDOT pledged up to $40 million plus $10 million in private funding for Columbus to become the country’s first city to fully integrate innovative technologies—self-driving cars, connected vehicles, and smart sensors—into their transportation network.”[5]

The development of US33 SMC was a concerted effort of many regional players supported by the Council of Governments (COG) as shown in Figure 2.

The construction of US33 SMC was completed in three phases. Phases 1 and 2 were awarded as design-build contracts through ODOT. The phases were designated as follows: Phase 1 Primary Route and Phase 2 Local Route.

The requirements included in the design-build team’s (DBT) scope of work included the capacity and ability to design, install, and test the fiber duct system and fiber optic cable to complete the designated phase installation of the US33 redundant route fiber loop.

Other stakeholders for the project included three separate power utilities and several communication utility providers not only in the three cities, but also in Franklin, Union, and Logan counties. The design requirements for the project involved extensive coordination with all utilities and municipalities. The DBT was responsible for all records for public and private underground utilities included in the designed construction plans. Complete and comprehensive field surveys and subsurface investigations were used to document all existing underground utilities and identify proposed construction methods and locations.

Phase 3 was awarded as a traditional construction project with complete engineered plans. This phase included the placement of 61 poles along US33. Each pole location required a complete Intelligent Traffic System (ITS) cabinet and foundation structure, underground communications pathway tying the pole site into the Phase 1 cable and underground pathway for power service, all within the state’s right of way.

US33 SMC COG STRUCTURE

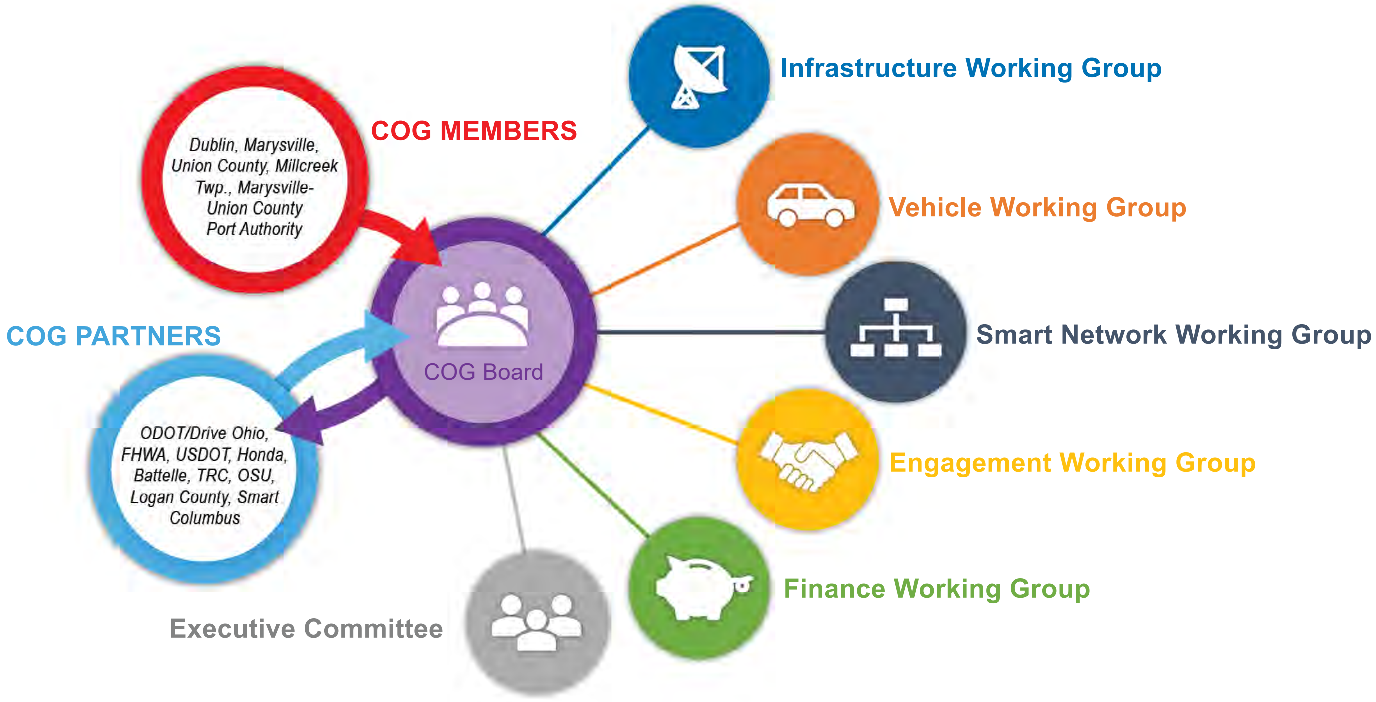


FIGURE 2: This collaborative group was key to the development of US33 SMC. Image is courtesy of the Union County Chamber of Commerce.

Providing power service to 61 new ITS sites along 35 miles of US33 spanning multiple municipalities in three counties was a daunting task to accomplish within the proposed schedule for construction of the Phase 3 segment of the project. Many of the roadside unit (RSU) pole locations were in remote areas along US33 with no existing power service in proximity to their ITS cabinets. The three local power utility providers were able to connect service to 30 of the ITS cabinets in proximity to existing service.

Ohio's Department of Transportation accepted a proposed plan to extend power within the right of way from 14 of these service locations. This proposal required extensive coordination through the design, planning, and construction of the Phase 3 segment of the project. Many of the poles installed on the project included additional ITS traffic management electronic equipment, such as high-resolution traffic cameras and traffic monitoring devices. The RSU poles located near interchanges were 50 feet (15 m) tall for additional field of view over roadway structures, and 40 foot (12 m) poles were installed along most of the unimpeded US33 roadway.

The location of the RSU poles was engineered to provide continuous wireless coverage for the Direct Short Range Communications (DSRC) signal along all parts of the US33 SMC. The signal range for DSRC typically reaches over a half mile with high levels of link consistency. The DSRC signal was designed to perform in a high mobility setting with low latency performance for V2I, V2V, and V2X communications. Handling fast information exchanges and changing environments with rapidly changing obstructions at highway speeds is critical for reliable transmission of roadside safety messages (RSMs).

A study by the National Highway Traffic Safety Administration (NHTSA) showed that 94 percent of crashes are due to human errors.

Furthermore, US33 SMC decision makers chose a blown cable system versus traditional cable pulling as the primary method of installation, with the exception of some wireless pole applications where it was easier to pull short length cables.

WHY A BLOWN/AIR-JETTED CABLE SYSTEM?

Conventional cabling through which optical fiber cable is pulled by large work crews into innerduct or mesh ducts and into conduit is the most well-known installation method within the ICT industry. The other two methods are blown cable and blown fiber systems.

Many in the ICT industry often mistakenly refer to blown cable and blown fiber systems synonymously as "blown fiber or air-blown fiber," which has caused some confusion about which installation system is being addressed. The term "air-blown fiber" and the various ways it can be written (e.g., air blown fiber) is a protected U.S. registered trademark of a blown fiber system manufacturer, so the use of that term can only be used by or with permission of that manufacturer.

It is important to emphasize that these two systems are distinctly different technologies and fiber installation methods. Unlike blown cable systems, blown fiber systems use optical fiber bundles, rather than cables or micro cables, which are blown into empty tube cables for the formation of the fiber pathway infrastructure.

Sometimes the upfront costs of the initial duct infrastructure installation are higher when comparing blown cable to traditional cable pulling, but it depends on many variables associated with a project.Once the blown cable duct or micro duct fiber pathway is completed, then the benefits of a blown cabling system begin. It is also important to understand that blown cable systems can vary considerably per manufacturer and can provide different types and quality of ducts, maximum cable fiber counts, blowing techniques, blowing speeds, and equipment. No two blown cable systems are exactly alike. The same holds true for blown fiber systems.

The following information is typical for many blown cable systems:

A key distinction between traditional cabling and blown cabling is that the initial installation of the micro duct infrastructure is the only time that there will be physical disruption to the OSP and buildings for optical fiber projects. Because it takes only two installers to blow micro cables behind the scenes in telecom rooms, for example, there is no need to ever re-enter the micro duct infrastructure, walls, or ceilings. With the physically nondisruptive blown cable system, upgrades, any moves, adds, or changes (MACs), fiber path rerouting and other fiber-related projects can be done anywhere and at any time, discreetly out of view of employees and visitors.

One of the major benefits of adopting a blown cable system is the typical 2-installer installation, which can save significant time and labor costs. For example, to add a new fiber run approximately 3,000 feet (915 m) in an already laid micro duct infrastructure, it generally would take two installers approximately 30 minutes to blow the micro cables at a typical speed of 150 feet (46 m) per minute. This would require four or more installers taking many hours or possibly a day to pull the optical fiber cable.

Because any type and count of micro cables can be blown in and out of the modular and reusable duct infrastructure undamaged, there is no end to the fiber and bandwidth life cycles. Some blown fiber systems may make the above claims as well.

For its blown cable system, the US33 SMC decision makers chose an air-jet solution with a 7-way duct (Figure 3) for ease of installation and significant scalability with a capacity of up to 3,024 fiber strands when using the selected 432-fiber count OSP non-armored singlemode micro cable (Figure 4).

For additional information about OSP blowing installation technologies and comprehensive best practices for all outdoor installs, refer to BICSI's *Outside Plant Design Reference Manual (OSPDRM),* 6th Edition.

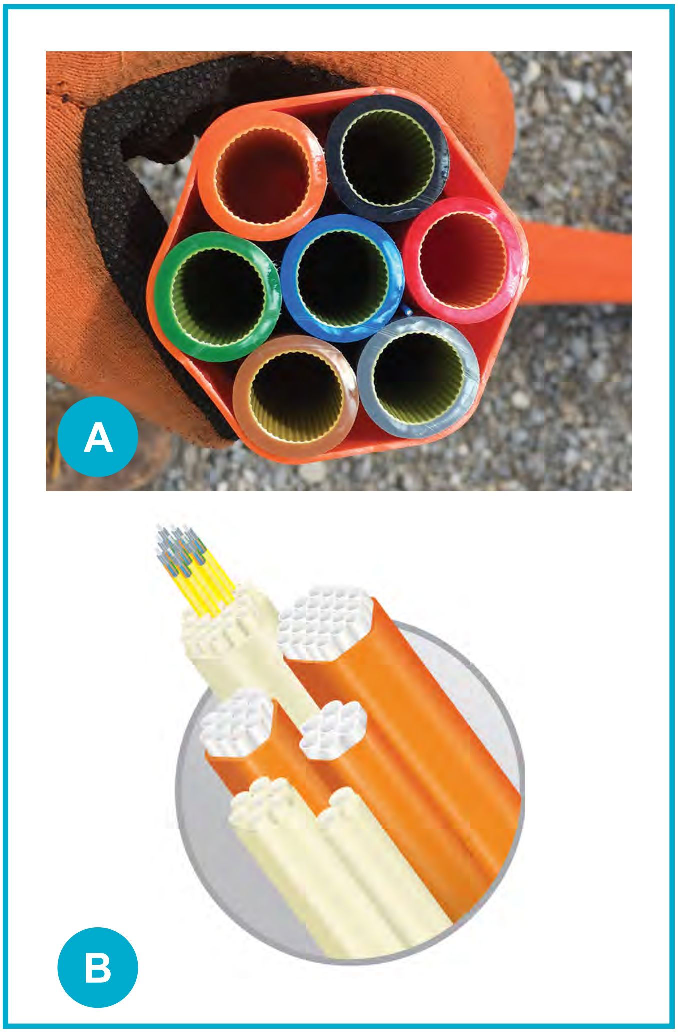


FIGURE 3: (A) Shown is the 7-way duct, consisting of 7 individual micro ducts (22 mm outer diameter, 16 mm inside diameter) bundled under one over-sheath used in the US33 SMC project. It replaces the need for installing traditional conduit and innerduct used in traditional cable pulling.
(B) 2-way, 4-way, 7-way, 19-way, and 24-way micro duct configurations are available.[6]

FIGURE 4: OSP 432-fiber GR-20 compliant LM-series singlemode micro cable, which is under a ½ inch in diameter due to the 250-micron fiber strands.[7]

INSTALLATION HIGHLIGHTS FOR THE SMART MOBILITY CORRIDOR—PHASES 1 AND 2

As shown in Figure 5, the project location is a regional CAV testing environment that includes 35 miles of US33 four-lane limited access highway, small city environments in Dublin and Marysville, and the world-class Transportation Research Center (TRC) in East Liberty, located in Logan County. This mix of open road highway, urban streets, and private off-road testing facilities gives US33 SMC a significant advantage over other proving ground sites. Within the US33 SMC, CAV systems and applications can be tested and analyzed in virtually any environment with few exceptions. Ohio's typical climate provides testing opportunities in dry, wet, warm, and cold winter environments. Columbus, Dublin, and Marysville provide a wide range of urban roadway environments.

The TRC is a notable and integral part of US33 SMC in its own right. Set on 4,500 acres, it is the nation's largest independent vehicle testing facility serving approximately 66 neighboring automotive companies. The TRC conducts virtual testing of vehicles and vehicle systems in a research building and lab environment and provides many other services including:

- An NHTSA research center
- 24-7 testing with 4,500 acres of road, courses, and trails
- 7.5-mile test track with traffic intersections up to six lanes wide
- 50-acre vehicle dynamics testing area
- 540-acre Smart Center allowing testing of CAVs
- Real life traffic scenarios

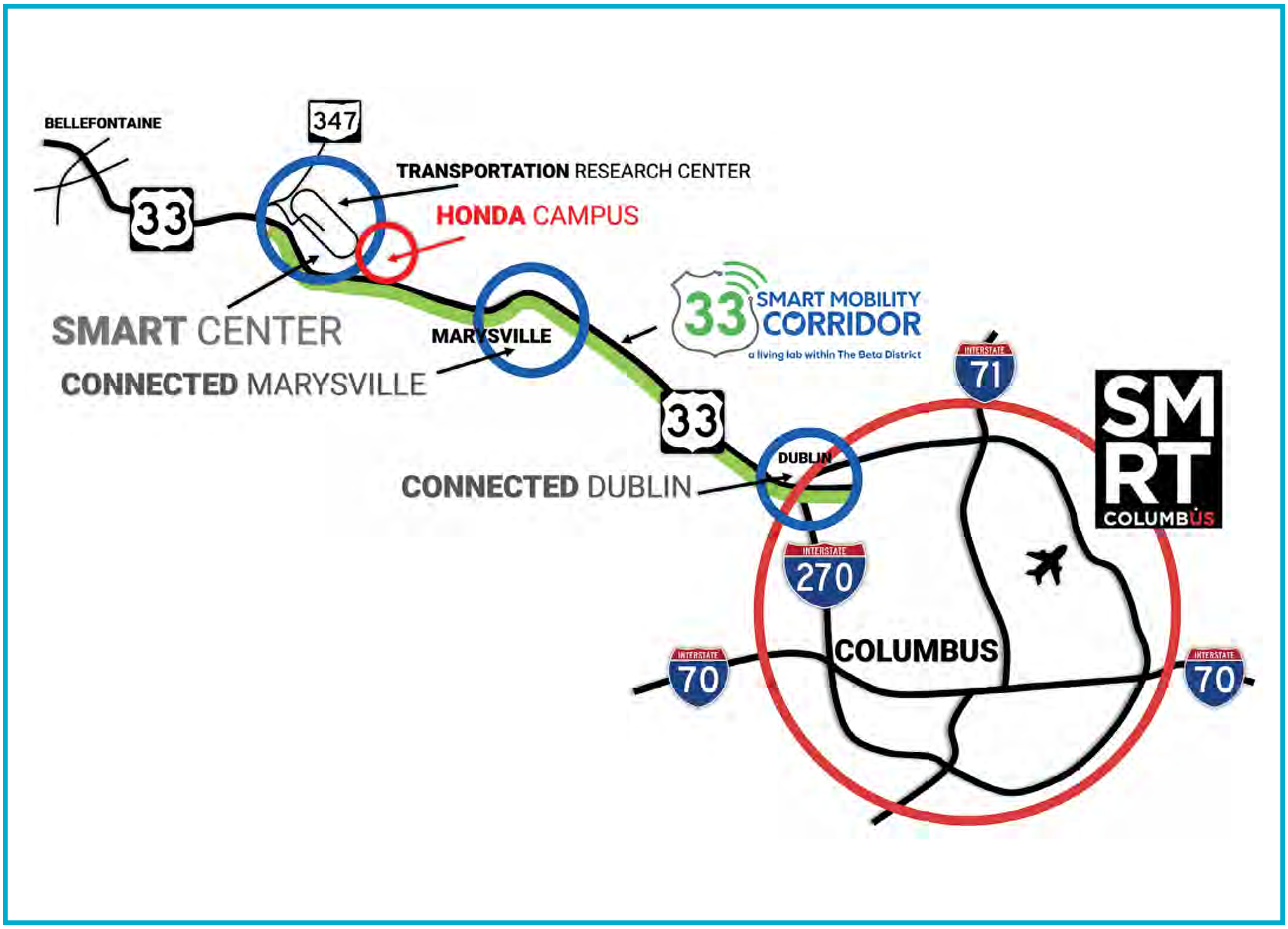


FIGURE 5: US33 SMC project area overview. Image is courtesy of the Union County Chamber of Commerce.

FIGURE 6: The main distribution frame (MDF) is in the MDC, which is a large commercial office building. The MDC occupies the 3rd floor in this building. Image is courtesy of the Union County Chamber of Commerce.

Installing a redundant backbone loop began with the construction of the Primary Route (Phase 1), mostly along the shoulder of US33 from the Metro Data Center (MDC) in Dublin, shown in Figure 6, to the TRC in East Liberty (Figure 7).

Both the Phase 1 and Phase 2 backbones were cabled as home runs between the MDC and TRC locations. The Local Route (Phase 2) followed a parallel path to US33 on various state and county roads, as well as passing through the center of the city of Marysville and parts of the city of Dublin.

The US33 Telecom Building in Figure 7 serves as a small data center. It has two rooms and 19 data cabinets for current and future network and electronics to run the CAV systems. There will be more optical fiber connections to this building in the future.

FIGURE 7: Shown is the aerial view of the massive TRC campus. Circled is the US33 Telecom Building shown larger in the right-hand image. It is the termination location for the Phase 1 and Phase 2 cabling backbone infrastructures.
(Photos provided with permission and courtesy of TRC Inc.)

Accomplishing the Redundant Backbone with Air-Jetted Cabling

The high-capacity 7-way duct, featuring 7-22mm outer diameter/16mm inner diameter micro duct fiber pathways (Figure 8), was direct-buried along the roadside within state-owned right of way access using a combination of directional drilling and vibrate plowing methods (Figure 9).

FIGURE 8: Shown is a 1600-foot (488 m) reel of 7-way duct (left). Notice the 7 micro duct optical fiber pathways (right).

FIGURE 9: In addition to directional drilling, vibrate plowing methods were used to install the 7-way duct.

The duct was placed between 32-inch round underground concrete pull boxes (PBs) spaced at a maximum of 1,500 feet (457 m) in rural areas and 750 feet (229 m) in urban areas. Also, 48-inch round pull boxes were used for micro cable splicing locations during construction and placed in strategic locations for future connectivity to the singlemode 432-fiber strand OSP non-armored micro cable. The duct was delivered on 1600-2000-foot reels to match the spacing between the PBs on the project.

The micro cable was placed in preparation for air-jetting, which is the manufacturer's term for its blowing installation method (Figure 10).

FIGURE 10: Shown are several thousand feet of micro cable ready to be air-jetted through the 7-way duct.

At the sending end, compressed air was injected into a sealed micro duct through which the micro cable would be air jetted (Figure 11). The micro cable was pushed into the sealed micro duct by the air-jet equipment's spinning drive wheels that were controlled and monitored for pressure and traction. The compressed air carried the micro cable through the micro duct minimizing friction to extremely low levels that allowed the micro cable to be air-jetted several thousand feet at a time.

FIGURE 11: The air-jetting equipment set-up.

> *Once the blown cable duct or micro duct fiber pathway is completed, then the benefits of a blown cabling system begin.*

The micro ducts had initially been designed and manufactured with a ribbed interior wall to reduce friction by limiting contact with the 7-way duct jacket, allowing the micro cable to be carried at high speeds by compressed air. Specialized jetting lubricants were also used to reduce the drag and friction even more.

The 432-strand micro cable was shipped on 20,000-foot (6096 m) reels. Phase 1's fiber run was approximately 200,000 feet (60,960 m) and, therefore, used 10 reels of micro cable. Phase 2 required approximately 235,000 feet (71,628 m) and used 12 reels of cable.

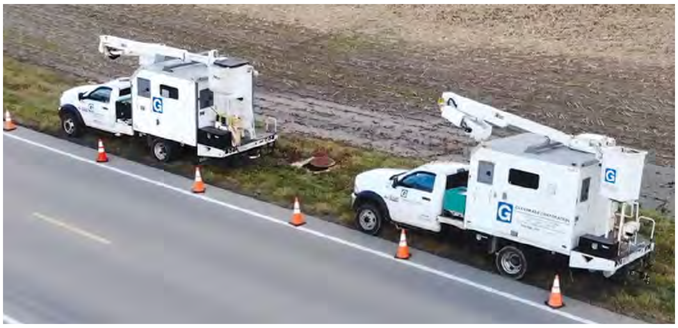


FIGURE 12: Fusion splice trucks.

In total, 10,368 fusion splices were required to connect all 22 reels of micro cable together with fusion spliced factory-terminated 12-fiber MPO connectors on to the ends of both cables at the TRC's telecom building and the MDC's MDF room.

For this installation, only one of the seven micro ducts was used, leaving six empty micro duct fiber pathways for future expansion. Once a micro duct is cabled, there is no need to ever re-enter the duct, since any MACs, rerouting, and trouble shooting can be done at the TRC and MDC.

CONNECTING WIRELESSLY—PHASE 3

The automated control systems on autonomous vehicles are inherently dependent on current information about the roadway environment in which they are traveling (Figure 13).

Wireless communication to self-driving cars is provided through a network of roadside unit (RSU) radios that support the Vehicle-to-Infrastructure (V2I) communications as well as Vehicle-to-Vehicle (V2V) and Vehicle-to-Anything (V2X). The V2I is an increasingly complex system of hardware, software, and firmware on both the vehicle through the on board unit (OBU) and the RSU. Together, these provide a wireless bi-directional exchange of communication between the vehicle and the infrastructure.

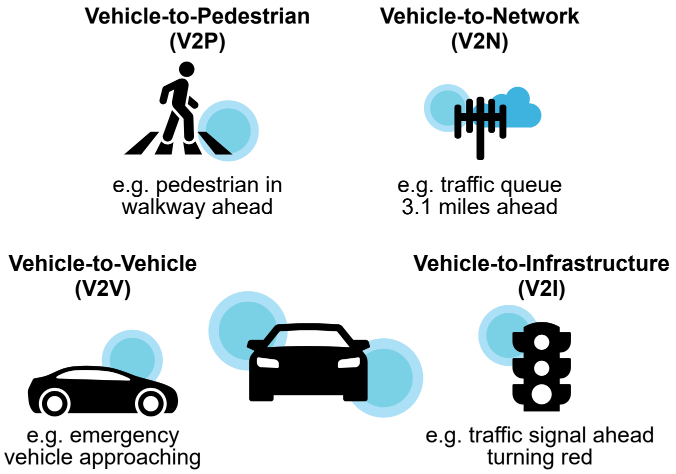


FIGURE 13: Examples of communication networks.

The wireless connectivity to vehicle traffic on US33 was provided through a network of 61 poles installed as Phase 3 along the shoulder of US33 with RSUs mounted 25 feet (8 m) above the road surface. Wireless connectivity for local traffic in Dublin and Marysville was provided through 33 RSUs mounted on existing infrastructure at signalized intersections.

The electronics and all connectivity for each RSU unit along US33 is situated in a pole mount or ground mounted ITS cabinet at the base of each pole (Figure 14).

Each ITS cabinet was connected to the Phase 1 and Phase 2 singlemode micro cable by a smaller count fiber cable (24 and 48-fiber strands). Multiple fiber pairs were used through the ITS cabinets to provide a "daisy-chain connectivity" sequence to protect the system from complete coverage loss resulting from the failure of any one RSU cabinet system.

The placement of the RSU poles was designed to provide continuous wireless connectivity to test vehicles on US33 from the US33/I-270 Interchange to the TRC near East Liberty, with OBU radios using Dedicated Short Range Communications (DSRC).

CAV growth in the coming years is expected to increase at a rate of at least 25.2 percent annually.

FIGURE 14: An RSU pole with ground mounted ITS cabinet.

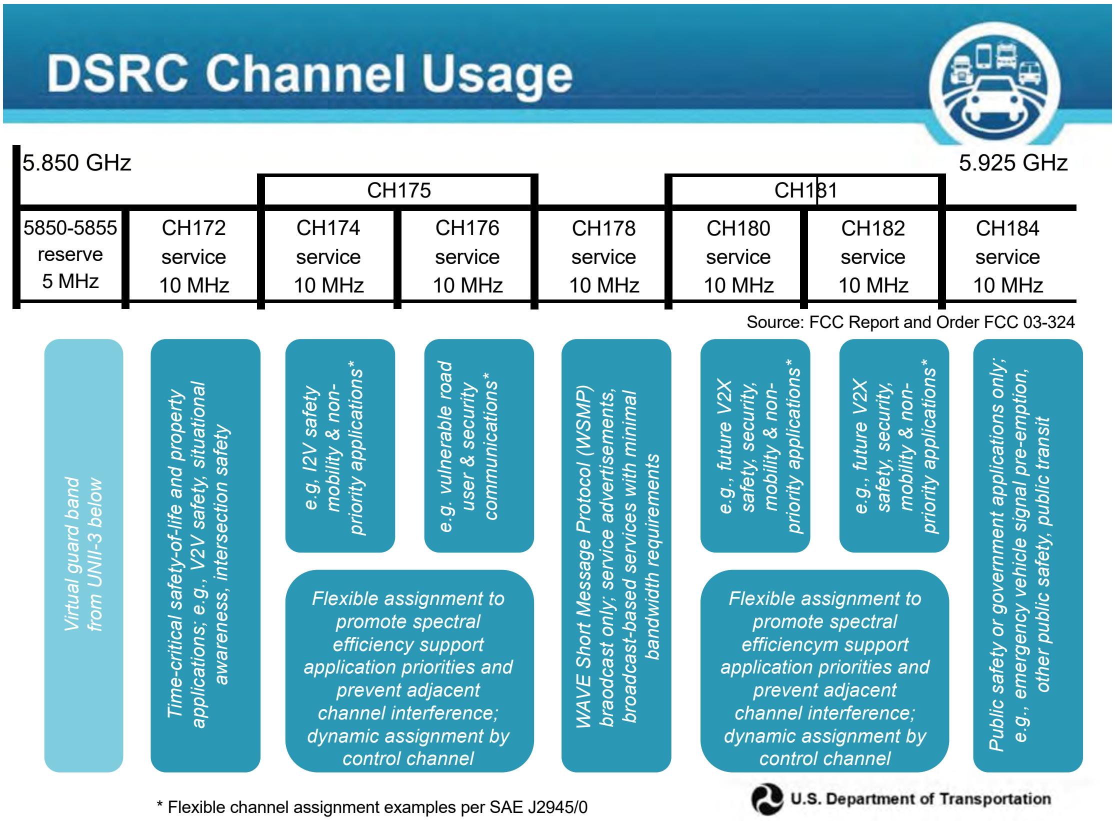
The DSRC uses IEEE 802.11p in the 5.9 GHz band and is specifically designed for automotive use. A dedicated spectrum of 75 MHz in the 5.9 GHz band was allocated for ITS, specifically for the development of DSRC. Seven 10 MHz channels have been designated with a 5 MHz band as a buffer to the adjacent bands in the lower frequency.

This allocated bandwidth is optimized for maximum cyber security and has a large base of interoperable solutions. The DSRC technology has been standardized and widely tested for V2I, V2V, and V2X applications for more than a decade.

The OBU allows CAV vehicles to communicate with other CAV vehicles, as well as the electronics at the RSU poles (the CAV infrastructure). Through the OBU, DSRC broadcasts basic information, such as location, heading, and speed to the surrounding vehicles and infrastructure 10 times every second in a secure anonymous manner. Surrounding RSUs will receive this data and respond with broadcast for travel information messages (TIMs) and RSMs. Safety-related messages on limited access highways include curve speed warning, reduced speed warning/lane closure, and ramp wrong way warnings. Safety-related messages for local and urban streets will include red-light violation warning, pedestrian crosswalk warning, and railroad crossing warning. Surrounding vehicles receiving the message from the transmitting vehicle will estimate any risk through collision avoidance and other safety applications.

Driver privacy is maintained during transfer of information with no unique data about the vehicle included. All three RSU units meet the U.S. Department of Transportation FHWA 4.1 specification for communications to vehicles, data security, and GPS reception for time of day and location.[8]

Currently, most of the electronics have been installed in the ITS cabinets. Ohio Department of Transportation technicians are working with the RSU system integrators to test and resolve any equipment issues; equipment includes the RSU antennas on the 61 poles and the network electronics in the ITS cabinets. This trouble-shooting and system startup will be completed or near completion at the time of this article.



DSRC Channel Usage

5.850 GHz — 5.925 GHz

		CH175			CH181		
5850-5855 reserve 5 MHz	CH172 service 10 MHz	CH174 service 10 MHz	CH176 service 10 MHz	CH178 service 10 MHz	CH180 service 10 MHz	CH182 service 10 MHz	CH184 service 10 MHz
Virtual guard band from UNII-3 below	Time-critical safety-of-life and property applications: e.g., V2V safety, situational awareness, intersection safety	e.g. I2V safety mobility & non-priority applications*	e.g. vulnerable road user & security communications*	WAVE Short Message Protocol (WSMP) broadcast only; service advertisements, broadcast-based services with minimal bandwidth requirements	e.g., future V2X safety, security, mobility & non-priority applications*	e.g., future V2X safety, security, mobility & non-priority applications*	Public safety or government applications only; e.g., emergency vehicle signal pre-emption, other public safety, public transit
		Flexible assignment to promote spectral efficiency support application priorities and prevent adjacent channel interference; dynamic assignment by control channel			Flexible assignment to promote spectral efficiencym support application priorities and prevent adjacent channel interference; dynamic assignment by control channel		

Source: FCC Report and Order FCC 03-324

* Flexible channel assignment examples per SAE J2945/0

U.S. Department of Transportation

TABLE 1: Shows channel assignments for current applications and pending designations.

PROJECT RESULTS

Construction and cable placement cost savings using the 7-way micro duct in place of traditional 4 x 2 inch conduits resulted in approximately 12 percent savings for the construction of the fiber loop. As noted, there would only be three additional 2-inch ducts using the conven-tional method as opposed to having six additional micro ducts with the 7-way duct system.

It requires approximately half the installation time than traditional HDPE and pulled-cable practices. The air-jetted cable installation gives ODOT the ability to rapidly install additional micro cables for added connectivity at any time. The air-jetting cable installation can be as high as 10,000 feet per day (Table 2).

4 x 2" Conventional Install vs. 7-Way OD/ID 22/16				
	Conventional		Micro Technology	
	4x2 inch SDR11 432 SMF Fiber Cable	Cost $/ft	7-way 432 SMF Micro Cable	Cost $/ft
Conduit	4 each 2-in SDR11	$3.20/ft ($0.80/ft)	7-way Duct 22/16	$3.68
Fiber Cable	432 Non-armored	$4.19/ft	432 SMF Micro Cable	$3.31
Material Cost		**$7.39**		**$6.99**
Conduit Installation	Boring 4 x 2-inch Conduits	$11/ft	Boring 1 x 2.6-inch OD 7-way	$9.95/ft
Fiber Installation	Pulling	$1.35/ft	Blowing or Jetting	$0.58
Total Cost		**$19.74**		**$17.52**
Construction Cost for new UG conduit and fiber (Phase 1 & 2 totals)	Approximately 385,000' of new conventional UG conduit and 432 Fiber	385,000' x $19.74 = $7,599,900	Approximately 385,000' of new UG 7-way micro duct and 432 Fiber	385,000' x $17.52 = $6,745,200
Note: Initial construction cost for conventional provides only 3 additional ducts for future cable placement as opposed to 6 future ducts in the 7-way micro duct.				
Note: Cost for installing additional cables on the US33 SMC with air-jetting as opposed to conventional pulling results in approximately 57 percent labor savings.				

TABLE 2: Case study cost comparison details.

Another benefit of the micro duct system is the isolated pathway for each cable within the 7-way duct. Conventional UG duct systems are typically designed for multiple cable installs in each conduit. This traditional system potentially puts existing cables at risk each time a new cable is added.

Ready access to the redundant loop 7-way fiber duct at the selected PB locations provides ODOT with the flexibility to expand and provide dedicated optical fiber cable pathways for end users. The US33 SMC is home to over 66 companies working in automotive manufacturing, research and development and transportation logistics. In total, there are over 250 companies which will now have access to the redundant fiber loop route (Figure 15).

The 432-strand ODOT backbone singlemode micro cable can provide full redundant connection security for access to either the MDC or the TRC. Separate pathways for the Phase 1 and Phase 2 micro cable provides virtually 100 percent uptime security and protection.

FUTURE OPPORTUNITIES

The development of safety applications for urban environments including pedestrian safety, intersection and crosswalk safety, turn warnings, and weather alerts will contribute to the continued implementation of CAV technologies in new vehicle manufacturing. The US33 SMC will also provide an infrastructure for development of other technologies that will benefit CAV systems and contribute to improved automotive design processes that integrates the CAV applications and capabilities into all vehicle systems. Examples include Wi-Fi hotspots for travel time applications and LTE cellular backhaul for data upload/download abilities.

Technology is making automotive travel a far more personalized experience. This is feeding consumer demand for an ever increasing interactive in-vehicle experience. Non-traditional automotive companies including those involved in software development, memory chip development, and big tech, as well as internet providers and communication service providers, are collaborating with traditional industry auto manufacturers to offer an optimum connected vehicle experience.

33 SMART MOBILITY CORRIDOR - AUTOMOTIVE CLUSTER

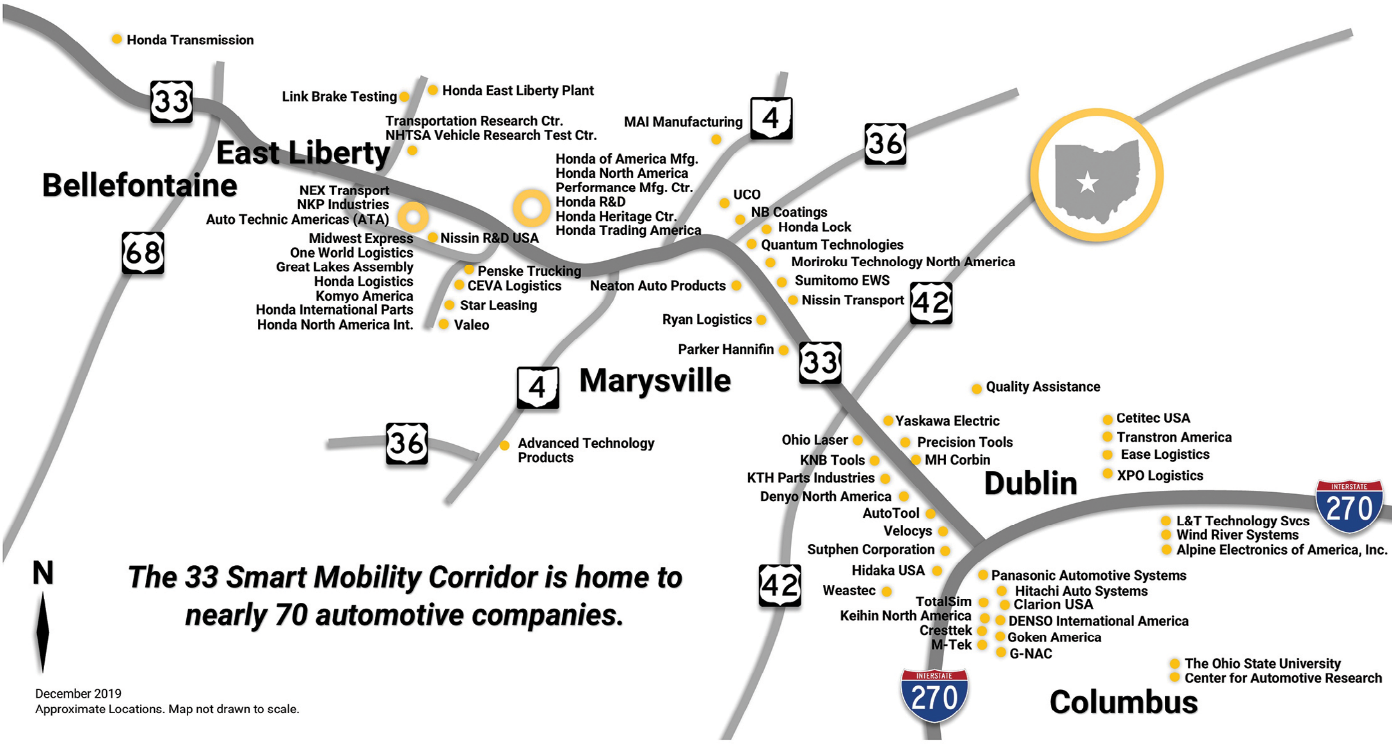


FIGURE 15: Map of automotive and transportation related companies within the SMC. Image is courtesy of the Union County Chamber of Commerce.

This will lead to ongoing development of new applications for public safety, traffic control and maintenance, vehicle maintenance and safety, as well as new channels of commerce with electronic payment for parking, tolls, and commercial advertising.

CAV growth in the coming years is expected to increase at a rate of at least 25.2 percent annually.[9] Investment in this growth will engage all stakeholders in an effort to transform automobile manufacturing into an interactive personalized mobility industry. There are other factors that are contributing to the investment in an increasingly connected infrastructure. For example, funding for testing and development of truck platooning technologies and driverless trucks is a major initiative for the trucking industry. Truck platooning is a method of linking two or more trucks in a convoy using connective technology and automated driving systems. This technology holds great promise for improved safety, improved fuel economy, and reduced environmental impacts. Moreover, there is a large-scale plan to unite Ohio, Pennsylvania, Michigan, and Indiana into the Smart Mobility Corridor. These future opportunities will rely on solid planning, designs, and the innovative infrastructures that only skilled ICT designers, product managers, contractors, and installers can provide.

CONCLUSION

The deployment of an air-jetted micro duct cabling system was ideal to meet the goals and needs of the US33 SMC project because of the distance, dynamic nature, and future expandability required, which will help ensure that the Smart Mobility Corridor is successful as one of the world's largest CAV testing environments.

Because the increased cost of the initial infrastructure installation can be more expensive with air-jetted and other blown cable systems, traditional cabling may be better suited for more static network projects that require minimal expansions and MACs. Ultimately, it is up to customers to choose which option is best, but it is important for ICT professionals to educate those customers about available technologies.

From a project management perspective, large projects like US33 SMC often extend over several years. Maintaining active and relevant participation from all stakeholders, including ICT designers, installers, contractors, and integrators, is of critical importance.

Large projects demand hard work and dedication, but it is also very exciting and professionally gratifying to devote one's BICSI credentials to the fast-paced evolution and advancement of smart/intelligent mobility technologies, which are changing the ways of transportation worldwide.

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