Strategic Growth Plan for Connected and Automated Vehicle Assets in Southeast Michigan

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Cover

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Introduction

Michigan is known worldwide for leading-edge research and manufacturing for the automotive and defense industries. Southeast Michigan (greater Detroit), in particular, is an established hub of industrial innovation, including in the high-tech, communication technology arena.

To better understand opportunities to enhance the region's connected and automated vehicle (CAV) environment and explore ways the defense and automotive sectors can achieve greater collaboration in this space, the Advance Michigan Defense Collaborative[1], through funding from a Department of Defense Office of Economic Adjustment Defense Industry Adjustment Grant, funded the Center for Automotive Research (CAR) to develop a plan to strengthen the region's CAV ecosystem. This Regional Plan for Connected/Automated Transportation Systems Assets and Initiatives contains key findings from three parts of the project: a benchmarking exercise that compares southeast Michigan with three other regions on a variety of CAV technology topics, maps of regional CAV assets, and a SWOT analysis. An initial version of this paper was released in July 2017. Given funds remained at the completion of the project, CAR worked with the client to identify a fifth benchmark location – Boston – and included it in this version of the report.

Methods

Different research methods were used for each portion of the project. These methods are described below.

Benchmarking

CAR's benchmarking effort compares the Detroit region to Seattle, Silicon Valley (California), Boston, and Pittsburgh—four regions that compete with Detroit for leadership in the development of CAV technology. The benchmarking effort highlights differences and similarities between the five areas and their CAV assets. It helps identify ways to improve southeast Michigan's standing as a hub for automotive development and manufacturing, primarily related to innovation in CAV technology. The comparison between these regions informs the analysis of the greater Detroit region's specific strengths, weaknesses, opportunities, and threats (SWOT).

To compare the five regions accurately, CAR chose to use the Combined Statistical Area (CSA), as defined by the U.S. Census,[2] as the logical geographic unit of comparison. The CSAs that encompassed the majority of each region are Detroit-Warren-Ann Arbor, Seattle-Tacoma, San

[1]Advance Michigan Defense Collaborative is part of Advance Michigan, and includes five participating organizations working specifically on this grant: Workforce Intelligence Network, Macomb/St. Clair Workforce Development Board, Macomb County, Michigan Defense Center, and Merit.

[2] Core based statistical areas (CBSAs), metropolitan divisions, and combined statistical areas (CSAs), July 2015. https://www.census.gov/geographies/reference-files/time-series/demo/metro-micro/delineation-files.html

Jose-San Francisco-Oakland, Boston-Worcester-Providence, and Pittsburgh-New Castle-Weirton (see the Appendix A for a detailed definition of these five CSAs).[3]

Southeast Michigan CAV Assets and Other Maps

For the asset maps, CAR researchers conducted a thorough review of major companies, non-profit organizations, and academic institutions that are active in the CAV space. This effort began with reviewing internal databases, generating an initial list of companies, and supplementing that list with web research. Once the organizations were cataloged, researchers developed a map to display where each entity is located visually. The organizations represented on this map were part of the thirteen counties of the Advance Michigan region, a federally designated Investment in Manufacturing Communities Partnership. This includes the Advance Michigan Governing Board and the Advance Michigan Defense Collaborative. Under these initiatives, the southeast Michigan (Advance Michigan) region consists of Clinton, Eaton, Genesee, Ingham, Lapeer, Livingston, Macomb, Monroe, Oakland, St. Clair, Shiawassee, Washtenaw, and Wayne. These counties encompass the major cities of Detroit, Pontiac, Lansing, Ann Arbor, and Flint. Additional maps with relevant information were created and analyzed as well.

SWOT Analysis

CAR interviewed representatives from a variety of companies and organizations to gather their views on the region's strengths, weaknesses, opportunities, and threats concerning the CAV ecosystem. Organizations were selected to represent different parts of the CAV value chain, including vehicle manufacturers, Tier 1 suppliers, smaller software suppliers, defense, and public sectors. From these interviews, CAR researchers developed a preliminary SWOT analysis, which was then supplemented with findings from the benchmark analysis. Some of the comments are viewpoints held by one or several individuals, thus are not necessarily representative of the entire industry.

Representatives from the following companies and organizations were interviewed:

- Argus Cyber Security
- Ford Motor Company
- General Motors
- Karamba Security
- Lear (from Arada acquisition)
- Michigan Automotive and Defense Cyber Assurance Team (MADCAT)
- Oakland County CAV Task Force
- Quantum Signal
- U.S. Army Tank Automotive Research, Development, and Engineering Center (TARDEC)
- Visteon

[3] Throughout the report, when referring to Detroit, Seattle, Silicon Valley, Boston, or Pittsburgh, the authors are discussing these CSA, as categorized in Appendix A.

Regional Strategic Plan

Southeast Michigan is known nationally and internationally as a CAV hub, with a vibrant ecosystem of companies, academia, test environments, and an engaged public sector at the local, state, and federal levels. That said, more communities and states are becoming aware of the economic development and improved mobility opportunities these technologies can offer and are developing their CAV clusters.

CAR staff has identified several action items that key stakeholders can take to better coordinate and align the region's CAV efforts to maintain southeast Michigan's leadership position in the CAV space. These actions are organized into five categories: Greater Collaboration, Regional Geographic Assets, Education and Workforce, Investments, and Marketing.

Greater Collaboration

One of the most impactful ways the region can improve the CAV ecosystem is via increased collaboration across a variety of areas.

Align Regional Leaders

The greater Detroit region has a history of poor cross-municipality collaboration. Other active areas in CAV technology have not had such an economically-limiting hurdle to overcome, and thus may be better positioned for regional economic development of this technology area. Detroit's regional cooperation is improving, but regional leaders still have ways to go. One way to help southeast Michigan move beyond its traditional, hyper-local approach is to identify an organization to coordinate cross-regional, collaborative efforts in advancing CAV assets in the region. Three of the most active counties in this space, Macomb, Oakland, and Washtenaw, each have their strengths which would be enhanced if they combined forces to make the region a much stronger CAV leader. As one interviewee noted, "If we align as a region, there's no one that can touch us."

Improve Auto and Defense Industry Collaboration

The automotive and defense sectors both stand to gain significantly from CAV technologies. At present, cybersecurity and platooning are important issues for both industries and could be a starting point for greater dialogue between them. This is especially true in the opportunity to share relevant use cases. Perhaps each industry could collaborate more in challenges geared toward solving common issues, akin to the Defense Advanced Research Projects Agency (DARPA) challenge.

Security clearance on the defense side is certainly a consideration, but with appropriate coordination, one that should be surmountable. As Betsy Freeman, former Department of Defense Deputy CIO for Business Process and System Review stated during a 2017 presentation, "It's time [for the auto and defense sectors] to stop dating and get married."[4]

[4] Business Wire. "Ascolta's Betsy Freeman Addresses "Cyber Sharing" at 2017 NDIA Cybersecurity Defense Sector Summit." March 6, 2017.

One way to encourage collaboration is to involve defense sector representatives in developing cybersecurity standards, such as through SAE International. Another potential collaboration forum is via Information Sharing and Analysis Centers (ISACs). ISACs are member-driven organizations that maximize the flow of information between critical private sector industries and the government. There are twenty-four such organizations, with one dedicated for automotive and two for defense, but none that work with both industries.

Defense research entities can also take advantage of testing facilities like MCity, a simulated urban and suburban test environment built on the University of Michigan campus, and the American Center for Mobility (ACM), a forthcoming, large test facility focused on testing, verifying, and certifying CAVs.

Increase Networking Opportunities

While there are a variety of conferences on the topic of CAVs, two things are lacking: more opportunities for start-ups/smaller companies to connect with larger ones, and more opportunities for the defense and auto sectors to interact. A solution is to host specific events targeted at connecting CAV start-ups with more established automakers, Tier 1 suppliers, defense companies, and support organizations. This type of networking may help to avoid a situation where, as one interviewee stated, “I’ve filled out information on screens, but don’t know where it went and never got to connect with a person.” Similarly, events centered on convening the defense and automotive industries around shared topics of importance – such as cybersecurity – would be very valuable.

Enhance the Start-up and Smaller Business Ecosystem

In addition to providing more opportunities for start-ups to network with established organizations, there are several ways to enhance the region’s start-up community.

Identify a Go-between

Identify a person or organization to act as a liaison between start-ups and scouts from established organizations. This person or organization would need to have keen knowledge of industry needs, as well as start-ups/smaller organizations capabilities, and be able to match them appropriately.

Central Information Source on CAV Events

Start-ups and smaller organizations could use assistance navigating the multitude of CAV-related events, and identifying which are the best opportunities, and the southeast Michigan CAV ecosystem could benefit from having a central information source on CAV events. For example, a platform like the State of Michigan’s Planet M could centralize and curate information about CAV-related events. By highlighting the most important events and emphasizing their focus area (general, specific theme, specific audience, etc.), companies could more easily decide which events would maximize their return-on-investment.

Capitalize on Regional Geographic Assets

There are two primary assets that can and should be utilized: 1) the region’s robust test environments and facilities and 2) its international crossings.

Test Environments and Facilities

Between the Michigan Department of Transportation’s (MDOT) various CAV test environments and the two, unique CAV facilities of MCity and the forthcoming ACM, southeast Michigan has a wealth of testing opportunities. Communities and public agencies can collaborate informally or set up

formal partnerships with companies to work together on testing and early deployment of CAVs. This holds true for both automotive *and* defense testing needs, especially as the defense sector could test technology in CAV testbeds just as automotive companies do. These public-private links will help maintain and even strengthen southeast Michigan's standing among select CAV testing sites, especially as the competition between testing sites at the national and international scale ramps up.

Border Crossings

Companies developing CAVs will need to ensure international interoperability of their technologies. Southeast Michigan communities and state agencies can capitalize on this need by emphasizing the state's unique geographic position. Communities can collaborate with companies or provide financial support to organize cross-border tests of automated vehicle technology or platooning on the Blue Water Bridge, the Detroit-Windsor Tunnel, the Ambassador Bridge, or the future Gordie Howe Bridge.

Southeast Michigan communities and state agencies can also increase their collaboration with their Canadian counterparts in Ontario, under the scope of the Michigan-Ontario Memorandum of Understanding signed in August 2016.

Education and Workforce

One of the greatest challenges to the region's CAV ecosystem is finding necessary talent. There are a variety of steps the region can take to help overcome this barrier.

Reinforce Links between Auto, Defense, and Education Institutions

Organizations like Macomb/St. Clair Workforce Development Board, Workforce Intelligence Network (WIN), and the Michigan Economic Development Corporation (MEDC) can continue efforts to encourage companies to accept more co-ops, apprenticeships, and internships, and to hire more of the state's graduates. Some methods to achieve these outcomes include:

- Organizing internship and job fairs with students and companies
- Mentoring programs where students can get career guidance from automotive professionals
- Sponsoring students' registration at industry events
- Organizing design jams, research project presentations, or hackathons like the SAE Battelle CyberAuto Challenge where students work on concrete projects alongside professionals; or competitions like Intelligent Ground Vehicle Competition, where companies can see students' work firsthand
- Encouraging more R&D partnerships between universities or community colleges and automotive companies

Strengthen the CAV-related Academic Offerings

The region is already strong in CAV offerings at educational institutions, but needs to develop a solid partnership between industry and academia to maintain this strength—especially in designing academic programs that meet industry needs. Educators can continue to work closely with industry advisors to ensure curricula are current, and that students are informed about the latest CAV technology developments. This collaboration could take the form of tech councils, which some

community colleges rely on heavily to ensure they are up-to-date on important industry trends. The region and state can also support community colleges in southeast Michigan to better align programs with industry and to develop programs for computer science, cybersecurity, information technology (IT)/data management, software/design, which are currently disciplines that do not have sufficient offerings. Additionally, academic institutions, economic development organizations, and other players can support programs that encourage and assist students in becoming entrepreneurs.

This suggestion also applies to supporting K-8th grade students, especially in supporting science, technology, engineering and mathematics (STEM) programs. It is important to spark early interest in these fields to help attract students toward STEM careers.

Provide Amenities or Incentives to Attract Highly-skilled Workers

Southeast Michigan needs to attract more job seekers with experience in software development, software engineering, system engineering, and cybersecurity. One way to do this is to offer loan forgiveness for graduates with these in-demand skills. Communities can also improve their residents' quality of life by offering diverse and affordable housing options, various transportation alternatives (mass transit, biking, walking, mobility services), and other urban lifestyle amenities.

Organize Job Fairs Dedicated to CAV Technology

Economic and workforce development organizations need to organize, support financially, or participate in job fairs that are specifically dedicated to CAV development. This sector is in great need of talent attraction, and it is not adequately covered by established events and recruitment channels.

Investments

Despite the many CAV-related amenities southeast Michigan offers to potential companies and investors, the region lags behind others in terms of investment dollars. There are a few strategies to improve the Detroit region's CAV investment attraction.

Increase Venture Capital Investment in Regional Companies

Silicon Valley, one of southeast Michigan's prime competitors in the CAV space, greatly outpaces the Detroit region's venture capital (VC) investments. One reason for this disparity is differences in how each region and industry perceive failure. Increasingly, the auto industry is becoming less failure-averse, and is recognizing the learning opportunities that can come from mistakes. Southeast Michigan needs to cultivate a greater risk-taking culture and better understand that knowledge can derive from failure. This cultural shift can help foster an environment in which people are willing to risk starting something new, which may in turn create a critical mass of start-ups with which VCs and other investment entities may engage.

The region also has a high commercialization gap, or the difference between R&D dollars spent and VC investment. This is actually a positive attribute when it comes to attracting VC, as it represents untapped investment opportunities. This fact could be marketed more among VC circles.

Leverage Regional Assets to Increase Investment

The region needs to attract greater corporate R&D investments in computer and electronic products, additional federal R&D funding from USDOT and DOD, as well as a larger share of foreign direct investment, to stay on top of the CAV sector. To do this, community and company leaders must remain engaged with federal-level decision makers to understand what their goals are, and translate those goals into actionable programs the Detroit region can work together to achieve.

Stimulate Patent Creation

Southeast Michigan players need to stimulate innovation and patent creation in several key CAV fields where the region is currently less strong (cybersecurity data management, intelligent transportation systems), in addition to emphasizing the region's strengths (vehicle design and testing and vehicle IT design). One method to achieve this is to offer incentives for patent-generation, and/or marketing recognition for companies whose employees generate high-quality patents.

Market Region Better

Through programs such as the State of Michigan's Planet M, the Detroit region can continue to market itself nationally and internationally as the place for connected and automated vehicle testing, research and development, business growth, network connections, and relatively low cost-of-living. Doing so may attract more start-ups to locate in southeast Michigan, leveraging the great concentration of automakers and suppliers located here and the opportunity to connect with them, and attract foreign direct investment from international companies that wish to invest here. Such marketing may also break the auto industry's stigma as being "old", and attract more students and other highly-skilled professionals to the industry.

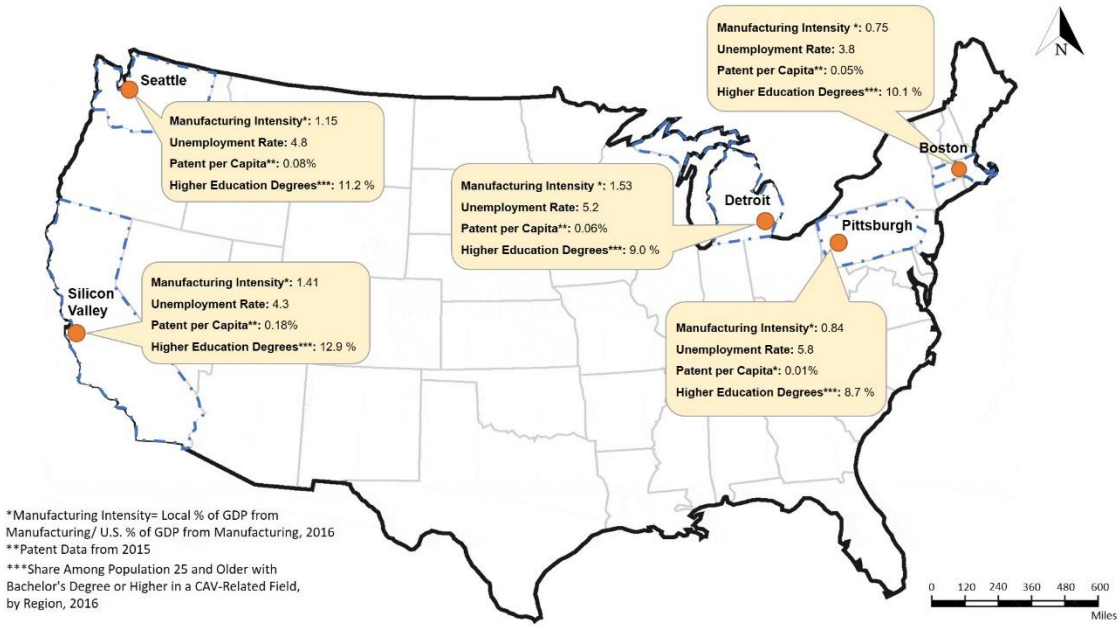
Economic development and talent attraction players can learn from research such as the Oakland County Skills Needs Assessment Project and the Workforce Intelligence Network Connected and Automated Vehicles Skills Gap Analysis and Cybersecurity Skills Gap Analysis in order to develop methods to attract professionals with key skills to the region.

Finally, as mentioned earlier, entities could promote the region's commercialization gap as a way to attract more VC.

Benchmarking Analysis

CAR researchers compared and contrasted five regions utilizing criteria that help define the regional CAV assets: industry presence, patents, talent, education, investments, legal and regulatory framework, governance and CAV strategy. Figure 1 displays a snapshot of key comparisons across the regions, and the subsections that follow present research findings in detail.

Figure 1. Benchmarking Comparison



The Detroit area has the highest manufacturing intensity relative to the four comparison regions, but this leadership might change due to ongoing trends in the automotive industry. Silicon Valley leads the regions in patents per capita as well as percent of population with higher education degrees. Detroit is comparable to Boston and Seattle in terms of patents per capita, but lags behind Seattle, Silicon Valley, and Boston in terms of percent of population with higher education degrees. Pittsburgh is lowest in this category.

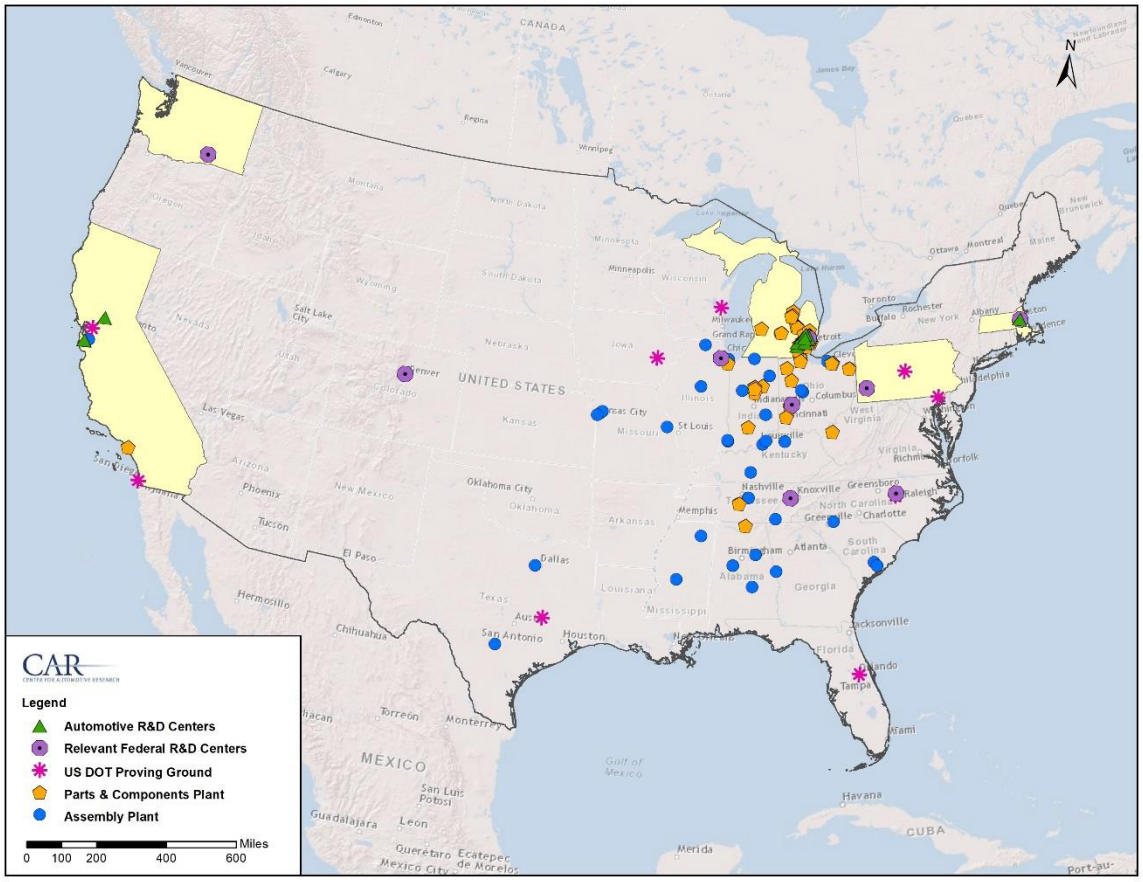
Demographics and Industry Presence Overview

Regional Analysis

Detroit, Boston, Pittsburgh, Seattle, and Silicon Valley, all have influential ties to both manufacturing and technology industries, though the specific industries and connections vary.

Figure 2 demonstrates an overall view of the automotive industry and CAV related facilities (U.S. DOT proving grounds, and research and development centers) in the country. The five regions analyzed in this report are highlighted, and the following sections discuss industry presence and a demographic snapshot of each.

Figure 2. Automaker Industry Footprint and Relevant National R&D Centers, 2017



From a demographic perspective, each region was compared across the following categories: total population, unemployment rate, age distribution, and share of CAV-related degrees by residents living in the region. Figure 3, Figure 4, and Figure 5 provide an overall comparison across the five regions in these demographic categories. For more detailed information by region, please see Appendix B.

Detroit

As the original birthplace of the North American automotive industry, the Detroit area remains a global hub for automotive manufacturing. The region is distinguished by manufacturing—with the highest manufacturing intensity (1.53) compared to the other regions (Silicon Valley – 1.41, Seattle – 1.15, Pittsburgh – 0.84, and Boston – 0.75). Automakers and suppliers have established hundreds of facilities in this area, including manufacturing facilities, headquarters, R&D centers, proving grounds and testing facilities. Many well-known companies, such as Fiat Chrysler Automobiles (FCA), Ford, and General Motors (GM), Daimler, Lear Corp., Delphi Automotive, BorgWarner Inc., and Federal-Mogul Corp,[5] have a headquarters, R&D, and a testing presence in this area. Additionally, Toyota, Nissan, Subaru, Mitsubishi, and Hyundai-Kia have R&D and design centers in the region. More recently, tech companies that are developing CAV technology, such as Uber and Waymo (Google), have announced they are opening facilities in the region, and GM's Maven start-up is headquartered in Warren.

[5] Automotive News, Top 100 OEM Suppliers, 2015

Increasingly, the Detroit area is seeking CAV testing facilities investments and infrastructure deployments. The State of Michigan has actively supported the industry by backing projects relating to development and adoption of autonomous vehicles, and these are primarily concentrated in southeast Michigan. The American Center for Mobility, funded by the Michigan Strategic Fund and designated as a U.S. DOT national proving ground, will be a 335-acre test facility at the historic Willow Run plant in Ypsilanti, Michigan. The Center is currently under construction, but is planning a focus on testing, verification and certification of connected and automated vehicles. Another CAV testing center in this region is MCity, a simulated urban and suburban environment built on a 32-acre site at the University of Michigan that opened in July 2015. Detroit is the leading region for testing and deploying infrastructure enabling vehicle communication (vehicle-to-vehicle and vehicle-to-infrastructure communication through Dedicated Short Range Communication, or DSRC), with both the Southeast Michigan Connected Vehicle Environment and the Ann Arbor Connected Vehicle Test Environment. Finally, around 20 companies have received a state license to test CAV technology on public roads, and the city proper is hosting pilot tests of May Mobility's automated shuttle. Figure 19 in the Southeast Michigan Asset and Other Maps section shows the southeast Michigan'.

The attraction of highly skilled talent to Detroit is crucial. The total population of the Detroit-Warren-Ann Arbor CSA in 2016 was over 5.3 million people, the third highest among the benchmarked regions; Silicon Valley ranked first with a total population of roughly 8.7 million people and Boston was second with a total population of roughly 8.0 million people. The majority of the population in Detroit is under 45 years old (56 percent) and roughly 32 percent are between the ages of 20 to 44. The Detroit region's talent pool has a strong engineering background; over 146,000 residents of the Detroit area ages 25 and older have an Engineering bachelor's degree. On the other hand, more than 51,000 individuals hold bachelor's degrees in Computers, Mathematics, and Statistics, compared to over 238,000 individuals in Silicon Valley. Overall, 9.0 percent of Detroit area residents over 25 years old hold a bachelor's degree in Computers, Mathematics and Statistics, Engineering, or Science and Engineering Related Fields.[6]

Boston

The Boston area hosts several world-renowned academic institutions, and these universities, Harvard and the Massachusetts Institute of Technology (MIT) in particular, are often the initial home to many of emerging startups in the area. Graduates from these well-known universities have made great strides in CAV technology development, either within established technology companies or by starting their own companies, as is the case with nuTonomy and Optimus Ride.

From an industry perspective, the Boston area is more active in the research and technology development side of CAVs rather than heavy manufacturing activities. Not surprisingly, Boston has the lowest manufacturing intensity rate of the other benchmarked regions (0.75). Some automakers and Tier-1 suppliers like Toyota and Bosch, for example, have R&D centers in the area to keep up with the latest research coming out of the prominent, local universities. Other large, high-tech companies, including General Dynamics, Draper, and Amazon Robotics, also have offices there.

The Boston CSA also hosts a great number of software and technology development companies, such as Google, Facebook, IBM, Akamai Technologies, PTC, Iron Mountain, Veracode, Agero, Carbon Black, Rapid7, CarGurus, SimpliSafe, CyberArk, Sybotic, Acquia and Black Duck Software. These are only a few examples companies in the region that are working on software development, cybersecurity, artificial intelligence, internet of things (IoT), data management and mobility solutions.

[6] Source: U.S. Census

Recently, some active transportation technology firms have made noticeable achievements in CAV technology. nuTonomy is a MIT spinoff startup that develops software for CAVs. On October 2017, Delphi acquired nuTonomy, investing $400 million in the company. Optimus Ride Inc. is another MIT spinoff which is working on electric CAVs. Recently, nuTonomy and Optimus each announced plans to test and develop driving automation technology on public roads in the Boston area.[7] In addition to city streets, the Boston CSA include Devens, a former military base, which some local officials are considering using as a vehicle test bed.

In addition to producing important scientific research, the Boston area's academic institutions play a key role in educating the workforce for CAV activities. In 2016, 10.1 percent of population older than 25 years old who live in this region and have a bachelor's degree in Engineering, Computer, Mathematics and Statistics, or Science and Engineering related degrees.[8]

Pittsburgh

Like Detroit, Pittsburgh is located in a region whose economy has long relied on a robust industrial sector. Currently, Pittsburgh is working to push its economy forward by focusing on new technologies, though, manufacturing remains an important part of this region's economy. Many well-known manufacturing companies are located in the region, including Alcoa/Arconic, Bosch, PPG Industries, and U.S. Steel.

Several major technology companies, such as Google, Apple, Facebook, IBM, and Uber, have offices in the Pittsburgh area. In 2015, Uber hired about 40 researchers and scientists from Carnegie Mellon University, and opened the company's Advanced Technologies Group in Pittsburgh to focus on the development of automated vehicle technology. The following year, Uber announced it was building a test track and testing facility at the city's Almono development. Pittsburgh is also home to artificial intelligence startup Argo AI, a company in which Ford has invested $1 billion. Argo AI is also planning to place satellite offices in southeast Michigan and Silicon Valley.[9]

Pittsburgh continues to create and grow as an innovative center. It has allowed Uber to test automated vehicle technology on its streets since May 2016, the city is collecting and distributing data for users and creating a map for residents (Burgh's Eye View application), and it is investing in the Internet of Things (IoT).[10]

Due to a long period of deindustrialization, Pittsburgh has struggled to retain a younger workforce. In 2016, the Pittsburgh area's total population was about 2.6 million, with the majority of individuals between the ages of 20 to 44 (30.5 percent) slightly ahead of individual between the ages of 45 to 64 (28.7 percent). In total, 8.7 percent of Pittsburgh area residents over 25 years hold a bachelor's degree in Computers, Mathematics and Statistics, Engineering, or Science and Engineering Related Fields—the lowest percentage across all five regions.[11] That said, recently, an increasing

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[7] Enwemeka, Zeninjor. "2 Boston Companies Move to Put Passengers in Self-Driving Cars." WBUR. December 1, 2017. http://www.wbur.org/bostonomix/2017/12/01/boston-self-driving-car-passenger-pilots

[8] Source: U.S. Census

[9] Isaac, M. and Neal E. Boudette. "Ford to Invest $1 Billion in Artificial Intelligence Start-Up." The New York Times. February 10, 2017. https://www.nytimes.com/2017/02/10/technology/ford-invests-billion-artificial-intelligence.html

[10] State Tech Magazine. March 2017. http://www.statetechmagazine.com/article/2017/03/pittsburgh-building-technology-focused-government accessed April 2017.

[11] Source: U.S. Census

number of younger individuals are heading to Pittsburgh due to its growing tech industry and the region's mobility services deployments.[12]

Seattle

Historically, Seattle has been known for its aerospace industry leadership, largely due to the concentration of Boeing's commercial airliner business in the region. More recently, however, other global companies, such as Microsoft, Amazon, Google and Facebook, have also located in the Seattle area.

The Seattle region hosts a number of large automotive and transportation technology firms and initiatives, including:

- Inrix (traffic data analytics), Xevo (ex UIEvolution, artificial intelligence and IoT company), AirBiquity (software telematics), and Kymeta (satellite communications).
- Several carsharing (car2go, ReachNow, and Zipcar) and ridehailing (Uber, Lyft) companies operate in the region, and ReachNow's headquarters are in Seattle.
- Microsoft, headquartered in Redmond, Washington, is developing artificial intelligence, machine learning, and quantum computing applications that can be used for connected car solutions. Microsoft is working with Ford, Toyota, Volvo, and the Renault-Nissan Alliance.
- Amazon, headquartered in Seattle, announced a partnership with Ford in 2016 to work on vehicle connectivity solutions.

Since February 2016, Waymo (the current name for Google parent company Alphabet's automated vehicle company) has been testing its automated vehicles in Kirkland, a suburb of Seattle. The company chose this location because the local climate gives the opportunity to test how its automated vehicles function in rainy conditions.[13] Kirkland, Washington had been courting Google to host the company's self-driving car testing for four years.[14] In addition, the tech-friendly city houses Google's third-largest engineering center that employs more than 1,000 people working on Google+, Cloud, and Chrome. Google first came to Kirkland in 2004, and doubled the size of its campus there in 2016.

The tech industry continues to boost Seattle's economy; in the first quarter of 2016, 75.9 percent of area commercial leases came from the technology industry, totaling 2.1 million square feet of office space.[15] These companies locate in Seattle to access the region's high quality and large labor force, as well as a relatively lower cost of living compared to other west coast locations (such as Silicon Valley).

Over the past few years, the Seattle area has evolved into a major engineering hub for technology companies due to its large skilled labor pool.[16] In 2016, Seattle had a total population of over 4.6 million, with the majority of the population between the ages of 20 to 44. About 11.2 percent of

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12 Carpenter, M. and Deborah M. Todd. "The Google effect: How has the tech giant changed Pittsburgh's commerce and culture?" Pittsburg Post-Gazette. December 7, 2014. http://www.post-gazette.com/business/tech-news/2014/12/07/Google-effect-How-has-tech-giant-changed-Pittsburgh-s-commerce-and-culture/stories/201412040291

13 Lerman, R., "Google is testing its self-driving car in Kirkland." *Seattle Times*, February 3, 2016 http://www.seattletimes.com/business/technology/google-is-testing-its-self-driving-car-in-kirkland/

14 McFarland, M., « How a Seattle suburb wooed Google's self-driving cars to town" Washington Post, February 4, 2016 https://www.washingtonpost.com/news/innovations/wp/2016/02/04/how-a-seattle-suburb-wooed-googles-self-driving-cars-to-town/?utm_term=.71de4728c6b8

15 JLL. June 2016. http://jllcampaigns.com/jlltechspec/articles/west-coast-tech-companies-move-seattle, accessed April 2017.

16 JLL. June 2016. http://jllcampaigns.com/jlltechspec/articles/west-coast-tech-companies-move-seattle, accessed April 2017.

individuals over the age of 25 living in this region have a bachelor degree in CAV related majors (4.5 percent in Engineering, 3.0 percent in Mathematics and Statistics and 3.7 percent in Science and Engineering-related degrees).[17]

Silicon Valley

Silicon Valley, California is known as the technology hub of the United States, with hundreds of technology firms located there. By far, more technology companies are located in Silicon Valley than in the other benchmarked regions. On the other hand, Silicon Valley has far fewer manufacturing facilities, R&D centers, and headquarters for manufacturing companies than are present in southeast Michigan. In that respect, Silicon Valley is more comparable to Seattle, Pittsburgh, and Boston. In recent years, automakers such as Ford, Daimler, Nissan, Honda, Volkswagen, and BAIC have opened offices and R&D centers in Silicon Valley to take advantage of its startup culture, hire talented engineers, and work with technology giants such as Apple, Google, and Intel. In 2016, 26 automakers had offices in Silicon Valley, up from ten in 2010.[18] Though small compared to the R&D centers these automakers have in Michigan, Germany, or Japan, these facilities have rapidly risen to prominence due to their work on automated driving and in-car computing.

In addition to being one of the largest CAV development regions, Silicon Valley is also known as a testing location. Waymo first started testing its automated vehicle prototype in Mountain View, California in 2009. Currently, 30 companies are testing automated vehicle technologies on public streets in California, including automakers (Volkswagen, Mercedes Benz, Tesla, BMW, Honda, Ford, Nissan, Subaru), suppliers (Delphi, Bosch, Valeo), tech companies (Waymo/Google, Apple, NVIDIA Corporation, GM Cruise, Zoox, Drive.ai), and electric car companies (Faraday Future, Wheego Electric Cars, NextEV USA).[19]

GoMentum Station is the most important testing ground for connected and automated vehicles in the Silicon Valley CSA. Located at the decommissioned Concord Naval Weapons Station,[20] and owned by the Contra Costa Transportation Authority, the site was designated one of the ten U.S. DOT national automated vehicle proving grounds in January 2017. The 5,000-acre facility features 20 miles of abandoned roads, bridges, tunnels, railroad crossings, and other infrastructure. The facility has been used by Honda, Apple, and others.[21]

Finally, there are a number of new mobility concepts and companies that started in the Bay Area including, ridehailing (Uber, Lyft), microtransit (Chariot), and ridesharing (Commutr, Waze carpool).

With roughly 8.7 million inhabitants, Silicon Valley also has a large, highly skilled talent pool. Overall, 13.6 percent of Silicon Valley residents over 25 years hold a bachelor's degree in Computers, Mathematics and Statistics, Engineering, or Science and Engineering Related Fields —the highest percentage across all five regions.[22]

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[17] Source: U.S. Census

[18] Autotech Council http://www.autotechcouncil.com/media/271981/20164-ac_membershipbrochure-v2.pdf , accessed February 2017.

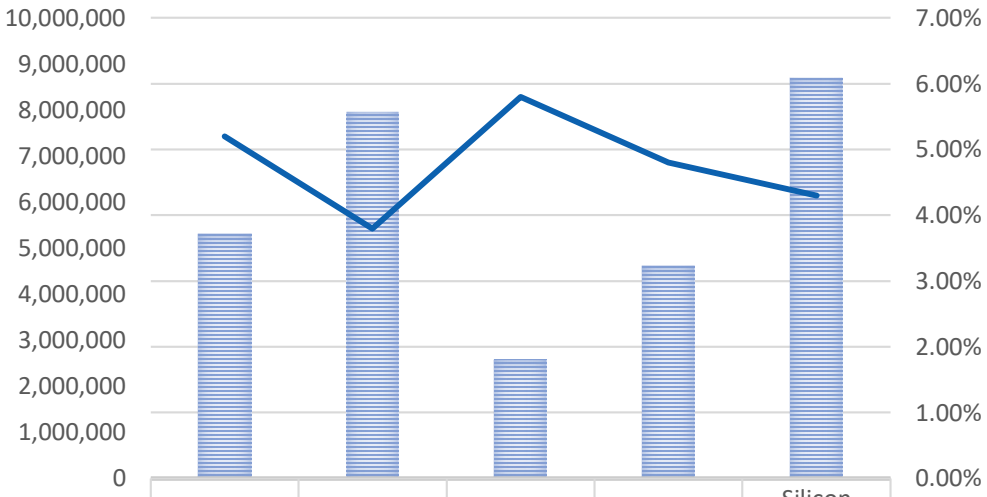
[19] California DMV, https://www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/testing, accessed February 2017.

[20] GoMentum Station. http://gomentumstation.net/ accessed February 2017.

[21] Alex Heath. "Inside the abandoned military base where Apple wants to test its top-secret car." *Business Insider*. August 14, 2016.

[22] Source: U.S. Census

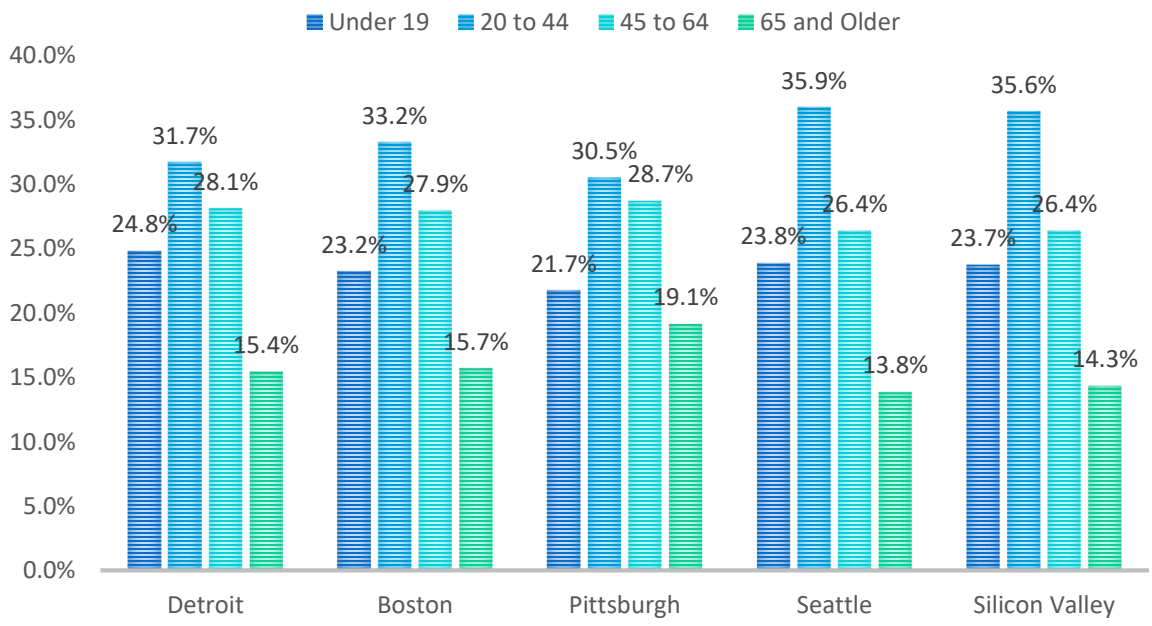
Figure 3. Total Population and Unemployment Rate, by Region, 2016



	Detroit	Boston	Pittsburgh	Seattle	Silicon Valley
Total Population	5,318,653	7,950,338	2,582,661	4,622,318	8,692,393
Unemployment Rate	5.20%	3.80%	5.80%	4.80%	4.30%

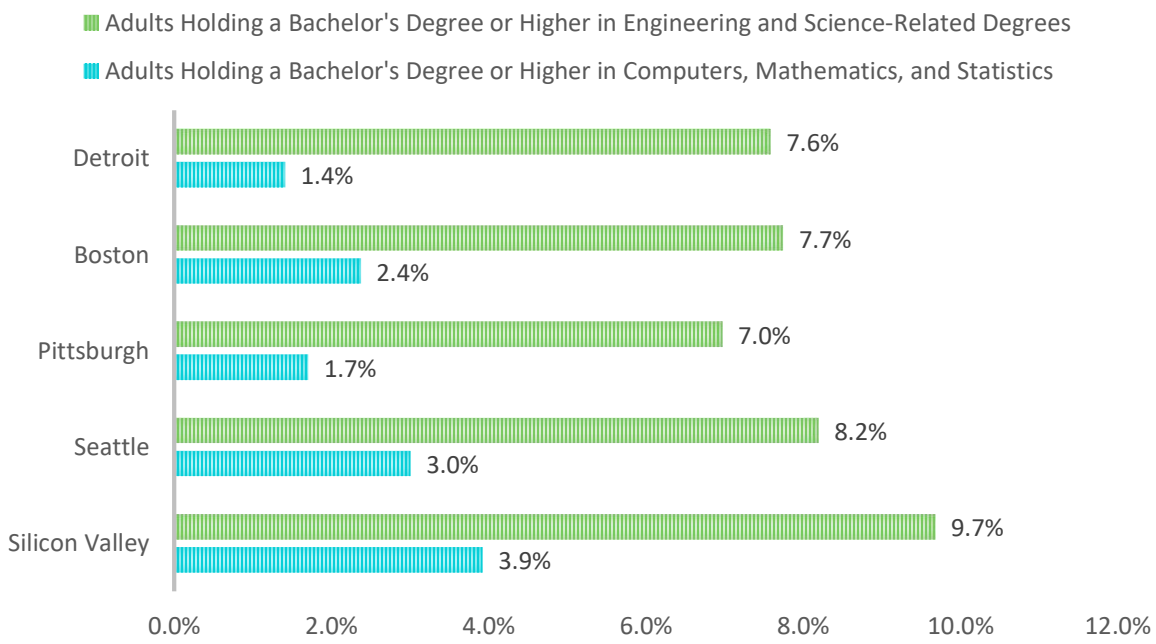
Sources: U.S. Census; Bureau of Labor Statistics

Figure 4. Age Distribution, by Region, 2016



Source: U.S. Census

Figure 5. Share Among Population 25 and Older with Bachelor's Degree or Higher in a CAV-Related Field, by Region, 2016



Source: U.S. Census

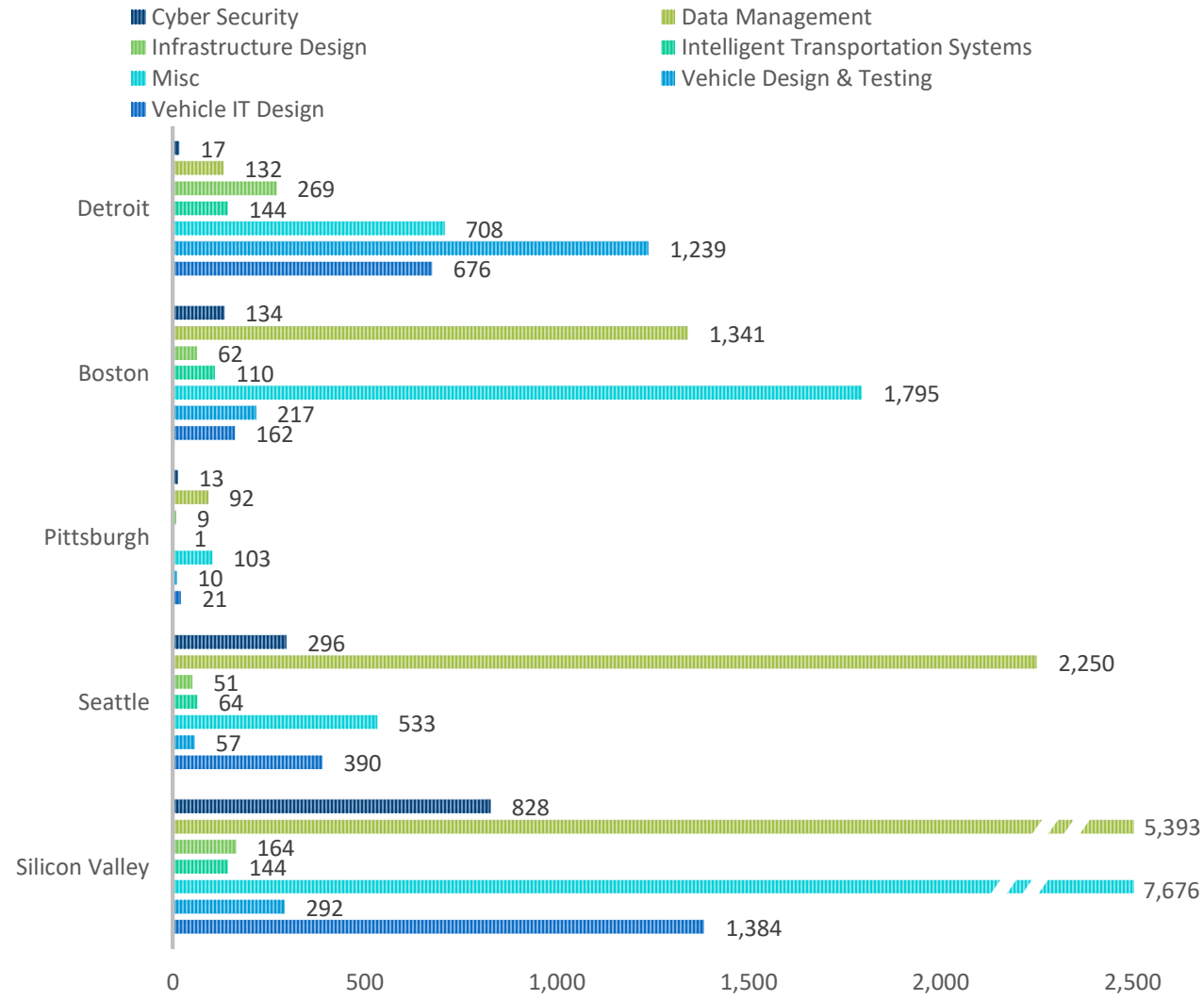
Patents

Tracking the number of granted patents by technology can provide a measure of a region's innovation activity.[23] The technology classes relevant to CAV technology were combined into seven different categories: cybersecurity, data management, infrastructure design, intelligent transportation systems, vehicle design and testing, vehicle IT design, and miscellaneous. Figure 6 below compares the five regions in the categories.

[23] Because the U.S. Patent and Trademark Office base regional patent counts on the residence locations of the first-named inventors at the time of the grant as opposed to where the location of the inventive activity is taking place, these numbers can differ slightly. However, the U.S. Patent Classification System breaks technology patents into 475 classes.

Data Source: U.S. Patent and Trade Office, Patenting In U.S. Metropolitan and Micropolitan Areas Breakout by Technology Class, 2000-2015.

Figure 6. Number of Patents by Region, 2015



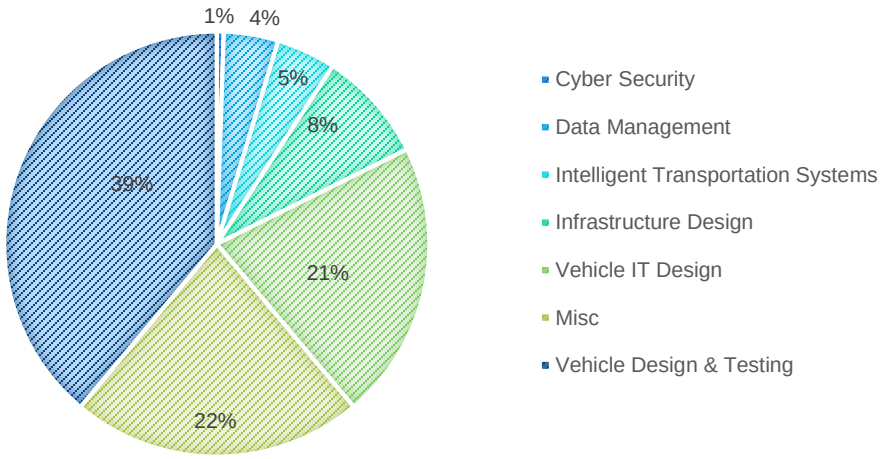
Source: U.S. Patent and Trademark Office

By far, Silicon Valley is the leading region of the five benchmarked areas in terms of technology patents (both by absolute total —over 15,000— and per capita —0.18 percent) in 2015. Data Management and Miscellaneous categories account for more than 80 percent of Silicon Valley's technology patents for 2015. The Data Management category includes technology classes related to data processing; for example, database and file management, generic control systems or specific applications, and coded data generation or conversion. The Miscellaneous category includes technology classes that are relevant to CAV technology, but do not fit in the other six categories; for example, electrical communications, metal fusion bonding, optics measuring and testing. Intelligent Transportation Systems account for the smallest number of patents in Silicon Valley relative to the other categories. Intelligent Transportation Systems includes technology classes such as electrical transmission or interconnection systems, and inter-program communications or inter-process communications. Both Silicon Valley and Detroit have more than 140 patents in this last category, Boston trails behind with about 110, and both Seattle and Pittsburgh have fewer than 65 patents. Also, compared to all the regions, Silicon Valley leads in number of patents related to Vehicle IT Design, with over 1,300 filed.

Boston holds a distant second in the absolute number of patents with more than 3,800 in 2015. This being said, on a per capita basis, Boston falls behind both Seattle and Detroit with 0.05 percent. The majority of Boston's patents fall into two categories – Data Management (35 percent) and Miscellaneous (46 percent). Compared to the other regions, Boston falls in the middle of each category.

Seattle (3,600) and Detroit (3,100) are roughly equivalent in terms of the number of patents in 2015 —about 0.06 to 0.08 percent per capita. Even though the two totals are similar, the types of patents differ significantly. Seattle had more than 60 percent of its patents granted in 2015 allocated to the Data Management category. The smallest categories (less than 2 percent) were Infrastructure Design, Vehicle Design and Testing, and Intelligent Transportation Systems. Detroit was strongest in Vehicle Design and Testing (leader in patents across all regions), Miscellaneous, and Vehicle IT Design, three categories representing more than 80 percent of the Detroit region's total patents granted for 2015. Cybersecurity was the smallest category for Detroit, making up only 0.5 percent of its 2015 total technology patents.[24] The largest absolute number of patents in the Cybersecurity category was in Silicon Valley, with over 800. Figure 7 below shows Southeast Michigan's breakdown of patents by category for 2015.

Figure 7. Southeast Michigan Patents, 2015



Source: U.S. Patent and Trademark Office

Pittsburgh had the lowest number of patents, roughly 250 patents or 0.01 percent per capita in 2015. Almost 80 percent of Pittsburgh's technology patents fell into the Data Management and Miscellaneous categories. The smallest category for Pittsburgh, 0.4 percent, was Intelligent Transportation System patents.

[24] Source: U.S Patent and Trademark Office

Talent

Comparing the 2016 employment levels in transportation equipment manufacturing[25] and computer systems design and related services employment[26] reveals different profiles of the five regions. These talent profiles are explored in more detail below, but for the specific employment breakdown within each region, please reference Appendix D.

Transportation Equipment Manufacturing

Seattle and Detroit are comparable in terms of number of transportation equipment manufacturing employees—both by total population and per capita ratios. In absolute numbers, the Seattle and Detroit regions have the most employees in transportation equipment manufacturing, at 138,915 and 114,958, respectively. These numbers dwarf those of Boston, Silicon Valley and Pittsburgh, at counts of 13,043, 11,354 and 1,959, respectively. On a per capita basis, Seattle (3.0 percent) has a higher concentration of transportation equipment manufacturing employees compared to Detroit (2.2 percent). However, this employment sector is significantly more important in these two regions than in Boston (0.2 percent), Silicon Valley (0.1 percent), and Pittsburgh (0.1 percent).

Computer Systems Design and Related Services

Silicon Valley has the most computer systems design and related services (CSD) employees at 171,604. Silicon Valley's total employment in CSD is two times greater than that of the Boston region, which is a distant second at 85,316. Seattle's 81,972, Detroit's 37,389, and Pittsburgh's 14,517 follow. Per capita, Silicon Valley remains a leader at nearly two percent of its population employed in this space. In Seattle, CSD employees represent close to two percent. In Boston, CSD employees equal a little over 1 percent of its population, while in Detroit and Pittsburgh they stand at 0.7 percent and 0.6 percent, respectively.

Education

As technology advances, the need for highly skilled individuals becomes more necessary in the labor market. Therefore, a region's educational strengths and diversity of offerings are important factors to gauge the potential for future advancement in CAV technology. Currently, out of total bachelor degrees in each region for 2016, the share of CAV-related degrees[27] range from 22.1 percent (Boston) to 28.5 percent (Silicon Valley).[28] Appendix C shows regional educational offerings in detail. According to several recent studies released in southeast Michigan, as well as interviews CAR conducted with key individuals in the automotive industry,[29] there are about 20 top

[25] The NAICS code for Transportation Equipment Manufacturing is 336. This category comprises the subcategories of Motor Vehicle Manufacturing, Motor Vehicle Parts, Aerospace Product and Parts Manufacturing, and Military Armored Vehicle, Tank, and Tank Component Manufacturing, among others.

[26] The NAICS code for Computer Systems Design and Related Services is 5415. This encompasses programming, software design, computer systems design, and data-processing facilities, among several others.

[27] CAV-related degrees include the following fields: Computers, Mathematics, Statistics; Engineering; and Science and Engineering-Related.

[28] Source: U.S. Census

[29] CAR took these skills and gathered information on relative programs and course offerings at universities, community colleges, and trade schools in each of the four regions. In addition, CAR reached out and worked with several community

skills and specific jobs in high demand related to CAV technology as shown in Figure 8 below. These skills include software development, information security analysis, computer system engineering, coding, artificial intelligence expertise, app development, cybersecurity, software engineering, and others as Figure 8 shows.

Figure 8. CAV Talent Needs in Southeast Michigan

**Note: Skills mentioned across all three sources*

Sources: CAR Research; Oakland County, Michigan Skills Needs Assessment Project; WIN CAV Skills Gap Analysis

Universities

Boston has the greatest number of universities compared to the other regions with a total of over 50 that offer CAV-related programs. The majority of these universities lie in the Boston-Cambridge-Newton Metropolitan Statistical Area (MSA), about 65 percent. A few well known universities in the Boston CSA include Harvard, Massachusetts Institute of Technology (MIT), Boston University, University of Massachusetts Boston, Northeastern University, University of Massachusetts Amherst, and Brown University. Among these universities, MIT is very active in exploring different areas of autonomy, from developing artificial intelligence software for underwater vehicles to study the impacts of CAVs on cities by creating a 3D augmented reality model, and multifunctional drones which can fly and drive. MIT AgeLab is working closely with Toyota Collaborative Safety Research Center (CSRC) to decode the complexity of urban environment traffic by developing hardware prototypes and software systems that can be integrated into cars to detect everything about the

colleges in southeast Michigan to gain more insight into possible future plans for CAV-related courses or programs being offered.

state of the driver and the external environment. Boston University's Robotic Lab is researching ground and air autonomous vehicles systems.

The majority of programs offered at Boston universities are as follows: engineering, math, and computer science. Boston leads the regions in programs offered in relation to cybersecurity, but is only slightly ahead of the Pittsburgh region. For a better look at the types of programs offered in each region, please refer to Figure 9 below.

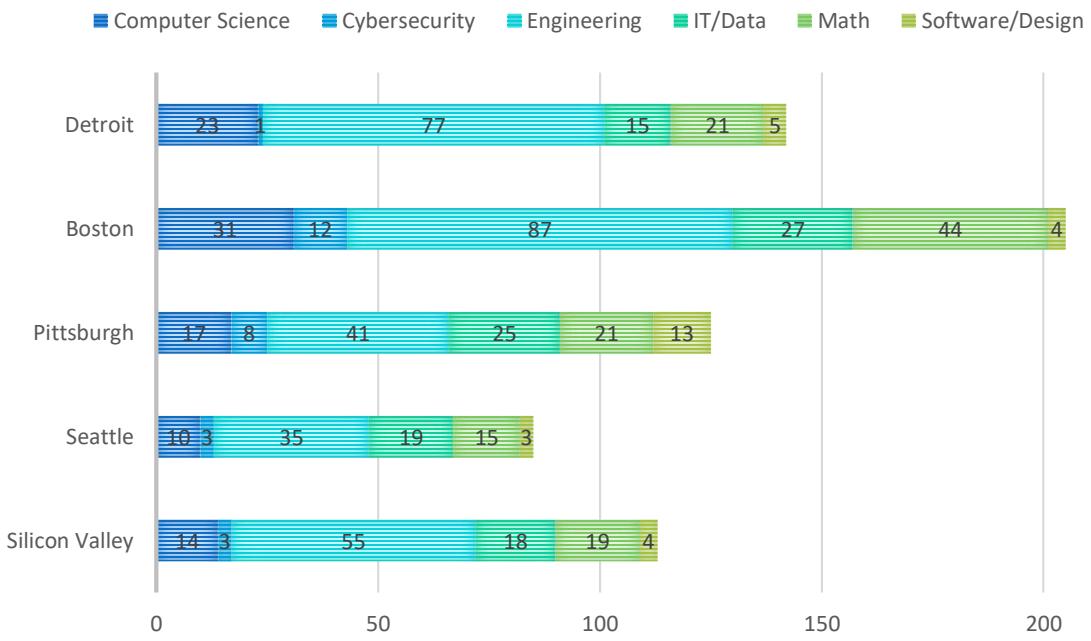
Silicon Valley has 21 universities that offer CAV-related programs and about 60 percent of these schools fall into the San Francisco-Oakland-Hayward MSA. This region is home to Stanford University, one of the institutions at the forefront of automated vehicle development. Stanford has formal research partnerships with Toyota and Volkswagen. In 2005, a team led by Stanford's Artificial Intelligence Laboratory (SAIL) won the DARPA Grand Challenge. Another key university is University of California - Berkeley, which is home to eight research institutes in the fields of transportation and engineering. UCB's institutes tackle the technology, human factors, and policy angles of CAV development. The majority of programs offered at Silicon Valley-area universities are in engineering, math, and IT/data. In addition, the region hosts significant programs in electrical engineering, computer systems engineering, robotics engineering, information technology, and big data analytics.

The Detroit region has 20 universities, with more than half located in the Detroit-Warren-Dearborn MSA. The University of Michigan is the leading institution in academic CAV research. Its Transportation Research Institute (UMTRI) was a key partner in the Ann Arbor Connected Vehicle Safety Pilot Model Deployment (SPMD), and now manages the Ann Arbor Connected Vehicle Test Environment. The UM Mobility Transformation Center (MTC), a partnership with private companies, supports CAV R&D and manages the MCity test bed. The University of Michigan also has a close research partnership with the Toyota Research Institute (TRI). Detroit area universities offer a large number of engineering programs including computer, industrial, manufacturing, software, and systems. The Detroit region's universities offer the greatest number of engineering programs compared to the other regions. Specific IT programs such as data, software development, and cybersecurity are available at certain universities in the region, but are not as prevalent.

In the Pittsburgh area, sixteen universities have programs related to CAV technology. Most of these schools are located in the Pittsburgh MSA. The Pittsburgh region is best known for Carnegie Mellon University (CMU), which has been contributing to AV technology development for the last 30 years through several research labs including the National Robotics Engineering Center (NREC). CMU's Tartan Racing led the team that won the 2007 DARPA urban challenge. Overall, the Pittsburgh region has several universities that offer programs related to IT/data, cybersecurity, and software/design. Pittsburgh universities are second behind the Boston region in cybersecurity programs. Some other programs offered include information systems, cyber forensics and information security, coding, and software development.

With a total of fifteen, Seattle has the fewest number of universities offering CAV-related programs compared to the other regions. The University of Washington is involved in CAV research through its work on human factors, intelligent transportation systems, and data analytics. Other Seattle area universities offer programs related to engineering, IT/data, and math.

Figure 9. Number of University Programs in CAV-Related Fields, by Region, 2017



Sources: University Websites (Accessed June 2017)

Community Colleges

Over 85 community colleges with CAV-related programs were analyzed across the benchmark regions. Silicon Valley (35) had the largest number of community colleges with CAV programs, followed by Boston (20), Seattle (15), Detroit (10) and Pittsburgh (7). For all five regions, the programs reviewed included computer science, cybersecurity, engineering, IT/data, math, software/design, and automotive. Figure 10 below displays the breakdown of the programs by region. At 225 programs, Silicon Valley leads in the number of programs offered in all programs except engineering (Boston leads with 50 programs offered) and cybersecurity where it offers the same amount of programs as Boston (11). The programs with the largest number of offerings in Silicon Valley are in the automotive (53), IT/data (44), and software/design (36) categories. Examples of programs include automotive technology (engine performance, chassis technology, drivetrain technology, and electronics), computer information systems, and computer programming.

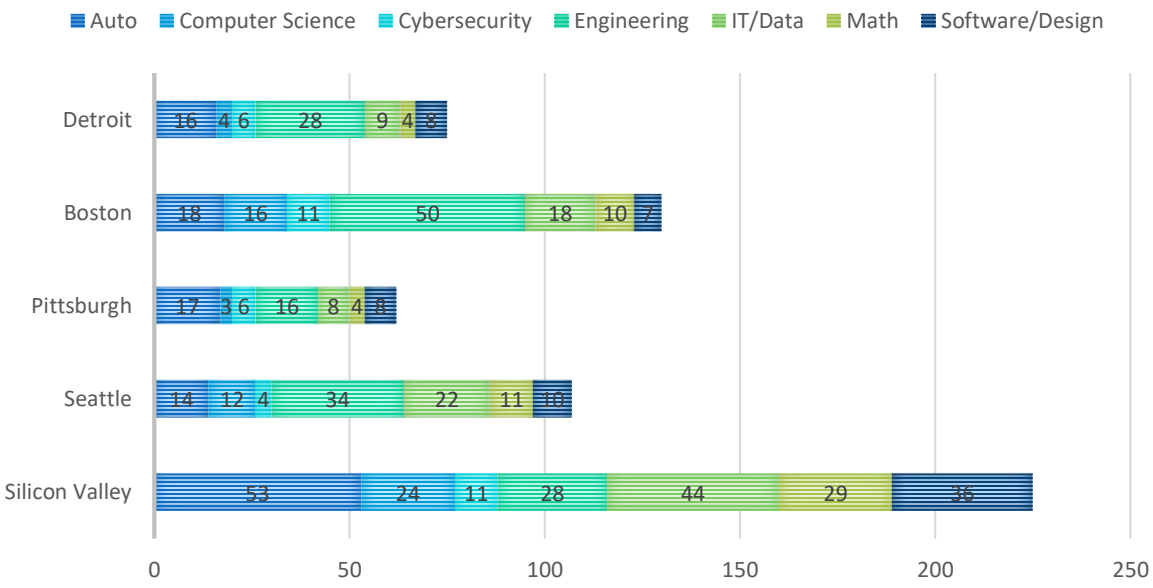
The Boston region offered the largest amount of engineering programs (50) compared to the other regions. Programs include civil, computer and electrical, engineering graphics and design technology, and mechatronics. Seattle is comparable to the Boston area in most categories except cybersecurity, where the region has the smallest number of program offerings (4). Seattle outranks Boston in IT/data, math, and software/design categories.

Detroit (75) and Pittsburgh (62) are both behind the other regions in terms of the number of CAV programs each region's community colleges offer. Both regions have many automotive and engineering programs, but the remaining categories (computer science, cybersecurity, IT/data, software/design) have fewer than ten programs in each.

Discussions with several community colleges in southeast Michigan highlighted some key differences among schools. The location of the school is significant; the further away from CAV activity, the less likely it is that CAV-specific programs will be offered in community colleges. A few colleges mentioned that at present, there is not sufficient demand to provide CAV-specific

curriculum in every community college throughout Michigan. On the other hand, community colleges closer to automotive companies are actively pursuing CAV-related technology programs and course offerings—through partnerships, grants, outreach to communities, and updating/adding new curriculum—in order to meet the demand for these talent needs. As an example, for the past five years, the Center for Advanced Automotive Technology (CAAT)—a National Science Foundation-funded Advanced Technology Education Center that is a partnership between Macomb Community College and Wayne State University—has held a conference to provide information on advanced technology needs (CAV, lightweight materials, and powertrain electrification) to educators, government officials, and other key stakeholders.[30] The 2017 CAAT Conference primarily focused on CAV-related technology, and the theme of the conference was, "Driverless Cars, but What is Driving the Workforce?"[31] Additionally, Washtenaw Community College's (WCC) Advanced Transportation Center uses an interdisciplinary approach to merge three areas: intelligent transportation systems, lightweight materials manufacturing, and advanced automotive service and repair. WCC continues to add new, upgrade current, and completely rewrite outdated programs due to the constant advancement in technology throughout the automotive industry. For example, WCC's automotive services program has added four new high-technology vehicles, test equipment, and DSRC[32] communication technologies. These purchases were funded, all or in part, by the State of Michigan Community College Skilled Trades Equipment Program.[33]

Figure 10. Number of Community College Programs in CAV-Related Fields, by Region, 2017



Sources: Community College Websites (Accessed June 2017)

Skill Trade/Technical Schools

About 40 trade and technical schools are located in the five regions, and these schools provide over 140 programs related to CAV technology. Pittsburgh and Seattle have the highest number of

[30]Sources: http://autocaat.org/About_CAAT/CAAT_Conference; Community College Interviews

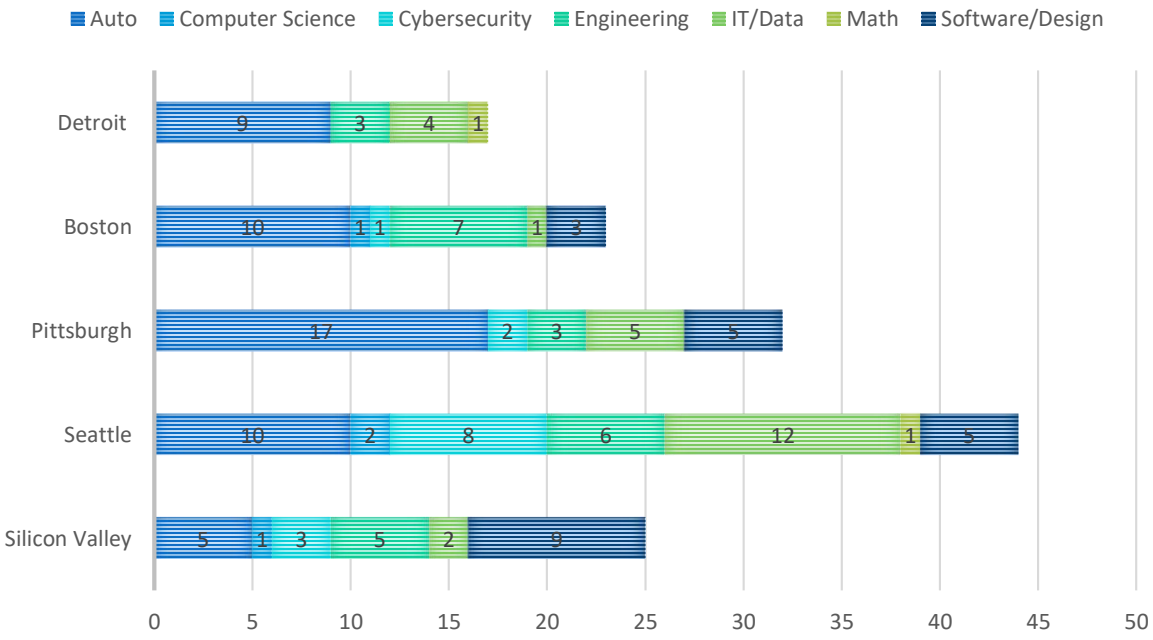
[31] CAAT Conference, April 2017

[32] (V2X) Dedicated Short Range Communications transmitter/receiver at the nominal FCC frequency of 5.9 GHz

[33] Community College Interviews

skill trade/technical schools. Detroit, Silicon Valley, and Boston are comparable to one another and not far behind the leaders, as shown in Figure 11. Seattle's trade and technical schools lead in program offerings in computer science, cybersecurity, and IT/data. Silicon Valley leads in software/design programs, Pittsburgh leads in automotive-related programs, and Boston leads in engineering programs. More than half of the programs Detroit technical schools offer are in automotive-related programs. Some frequent programs across most of the regions are computer networking and information systems security, information technology, some form of engineering (computer, electronics, mechatronics, industrial, and systems), and computer aided drafting.

Figure 11. Number of CAV-Related Skilled Trade/Technical Programs, by Region, 2017



Sources: Skilled Trade/Technical School Websites (Accessed June 2017)

Investments

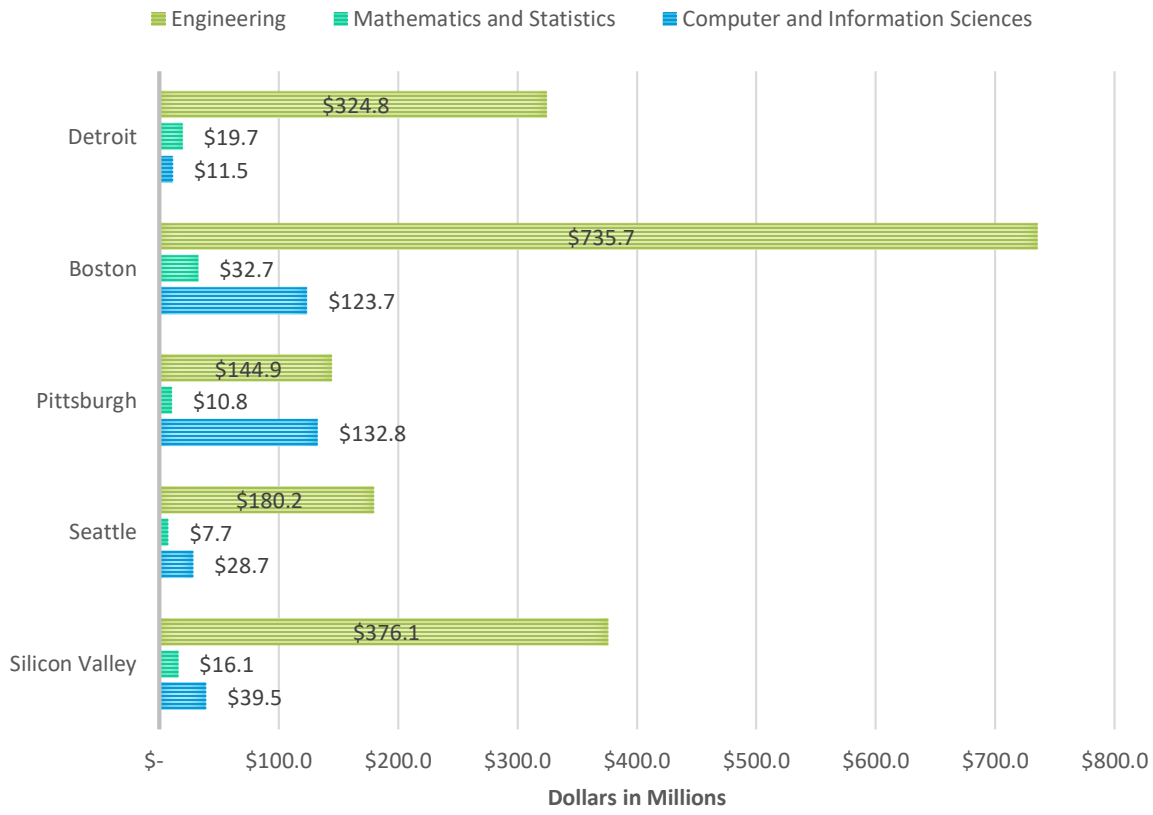
Comparing R&D expenditures and venture capital investment in the five regions helps to understand each region's future growth potential, as well as the start-up viability for innovative, new companies in the CAV sector.

University R&D Expenditures

Investing in R&D is essential for companies, institutions, and regions to remain innovative and competitive. In terms of higher education R&D expenditures in the fields of engineering, computer and information sciences, and mathematics and statistics, the Detroit region ranks third among the five areas with $356 million spent in 2016. Boston leads this ranking, with $892 million spent by universities and colleges, followed by Silicon Valley ($431 million). The Pittsburgh and Seattle

areas are in fourth and fifth place, with investments totaling $288.4 million and $216.5 million respectively, see Figure 12.[34]

Figure 12. Higher Education R&D Expenditures, by CSA and R&D Field, 2016



Sources: National Science Foundation

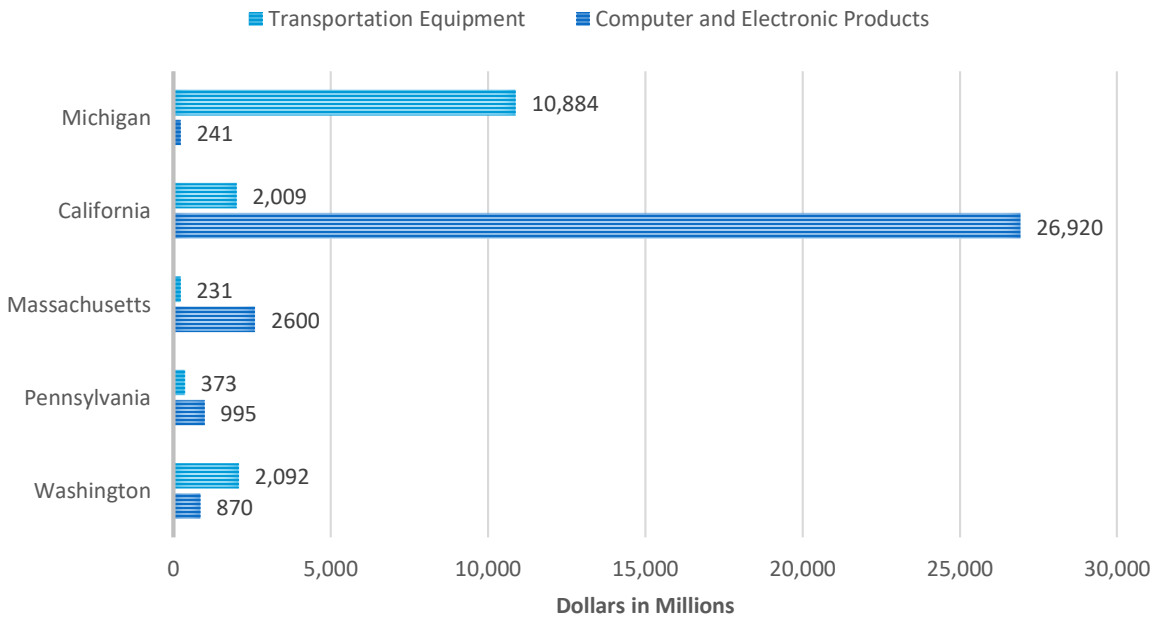
Industry R&D Expenditures

Figure 13 shows Michigan companies dedicated over $10.8 billion for R&D related to transportation equipment in 2013, more than five times the amount spent by companies in Washington ($2 billion) and California ($2 billion). Pennsylvania is a distant fourth, with $373 million invested in transportation equipment R&D. Boston region companies come in last $231 million invested in R&D. It is also relevant to look at R&D for computer and electronic products, since tech companies are increasingly positioning themselves in the automotive sector, and drawing on research in their core business area to develop CAV technologies. California is the clear leader in this respect, with over $26.9 billion in company computer and electronic R&D investments. Businesses located in the four other benchmark regions have far lower computer and electronics R&D expenditures. Companies spent $2.6 billion on computer and electronic R&D investments in Massachusetts, $995 million in Pennsylvania, $870 million in Washington, and only $241 million in Michigan. This comparison reveals that despite being a leader in transportation equipment R&D, the Michigan

[34] Data Source: National Science Foundation, National Center for Science and Engineering Statistics, Higher Education Research and Development Survey, FY 2016, Table 70.

business ecosystem is clearly lagging behind in computer and electronics R&D – a critical area that could give Michigan an edge in the development of CAV technology.[35]

Figure 13. Domestic R&D Paid for and Performed by Private Companies, by State and R&D Field, 2013



Sources: National Science Foundation

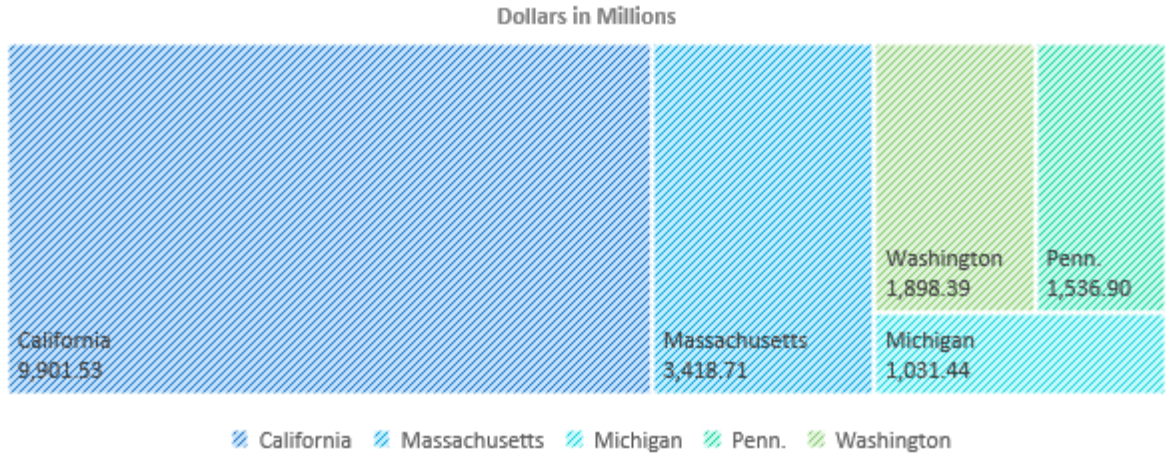
Federal R&D Expenditures

Among the five states compared, Massachusetts attracted the most U.S. Department of Transportation (USDOT) R&D funding, averaging $63 million per year between 2010 and 2015, see Figure 14. California came in second with $31.5 million per year, with Michigan close behind ($28.1 million). Pennsylvania ($19 million per year) and Washington ($12.5 million per year) rank fourth and fourth. California received the most Department of Defense (DoD) R&D funding, averaging $9.9 billion a year between 2010 and 2015. Massachusetts comes in second, with $3.3 billion a year on average. Washington ($1.8 billion), Pennsylvania ($1.5 billion), and Michigan ($1 billion) lag far behind on this metric, with more than five times fewer DoD R&D obligations committed than California.[36]

[35] Data source: National Science Foundation, National Center for Science and Engineering Statistics, and U.S. Census Bureau, Business R&D and Innovation Survey, 2013, Table 30.

[36] Data source: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development, FY 2015, 2014, 2013, 2012, 2011 (Table 103), and 2010 (Table 85).

Figure 14. Federal DOT and DOD Obligations for R&D, by State, 2010-2015 Annual Average

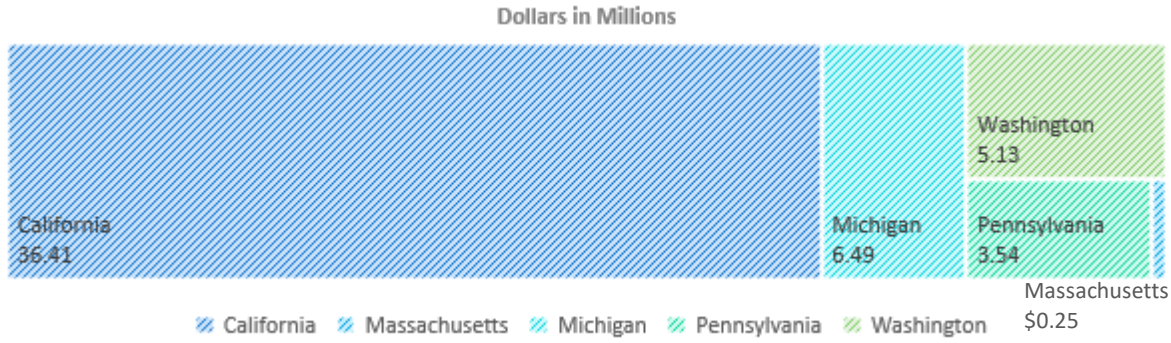


Sources: National Science Foundation

State R&D Expenditures

California also leads in terms of state government expenditures for transportation-related R&D, averaging $36.4 million (93 cents per capita) a year between 2010 and 2016. Michigan allocated $6.4 million, six times less than California in absolute terms, but also less per capita, at just 65 cents. Finally, state agency transportation-related R&D expenditures totalled $5 million (71 cents per capita) in Washington, $3.3 million (26 cents per capita) in Pennsylvania, and $0.2 million (4 cents per capita) in Massachusetts – shown below in Figure 15.[37]

Figure 15. State Government Expenditures for Transportation-Related R&D, by State, 2010-2016 Annual Average



Sources: National Science Foundation; U.S. Census

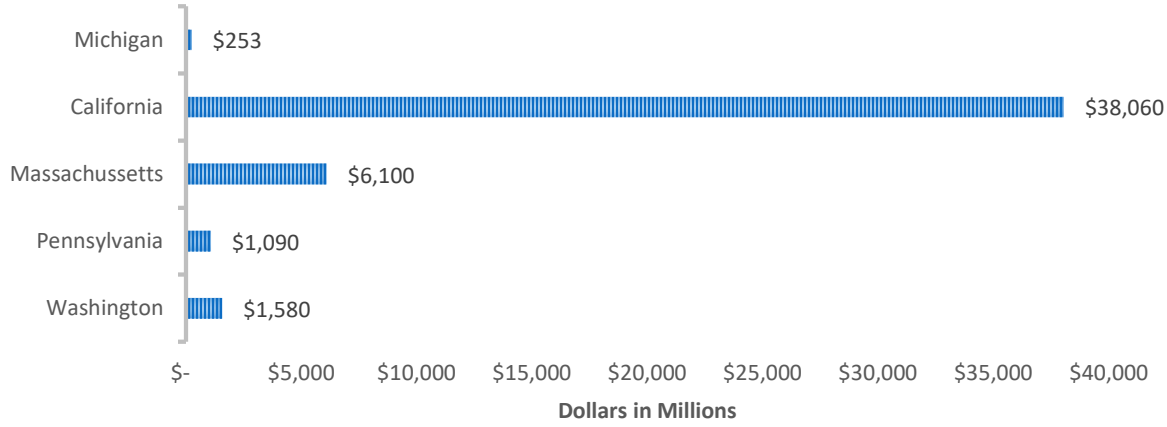
Venture Capital

Venture capital (VC) is often an important source of funding for CAV start-ups and small companies that do not have access to equities markets. Figure 16 displays VC funding at the state level, and it is clear California companies by far attract the most venture capital investments across all five regions. In 2016, California firms attracted $38 billion in VC funding, whereas firms from

[37] Data source: National Science Foundation, National Center for Science and Engineering Statistics, Survey of State Government Research and Development, FY 2009-2016, Table 13.

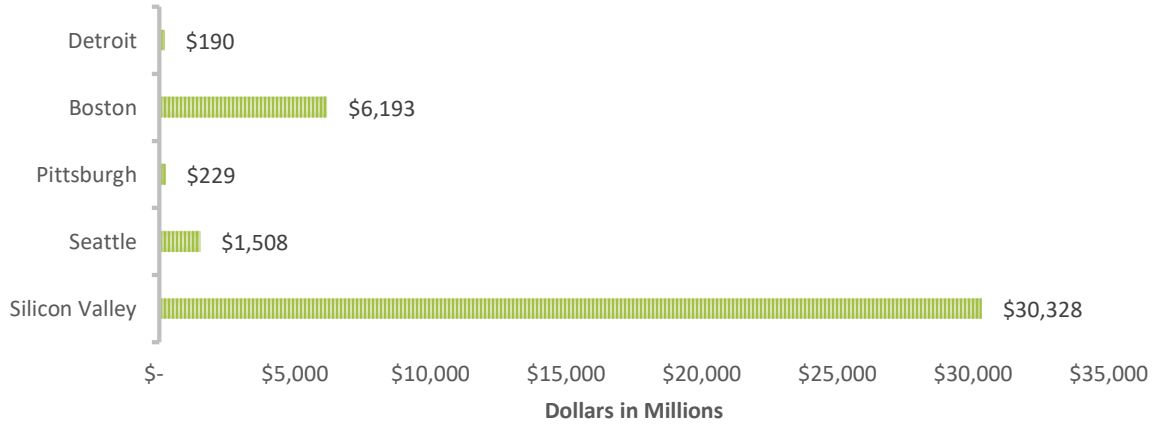
Massachusetts received $6.1 billion, Washington start-ups received $1.5 billion, and Pennsylvanian businesses brought in $1 billion in VC funds. Michigan companies ranked last, receiving only $253 million in VC funding in 2016.[38] The situation is similar at the regional level; in 2016, Silicon Valley companies secured $30.3 billion, outpacing Boston ($6.1 billion), Seattle ($1.5 billion), Pittsburgh ($228 million), and finally Detroit ($190 million) as shown in Figure 17.[39]

Figure 16. Venture Capital Investment, by State, 2016



Source: National Venture Capital Association

Figure 17. Venture Capital Investment, by CSA, 2016



Source: National Venture Capital Association

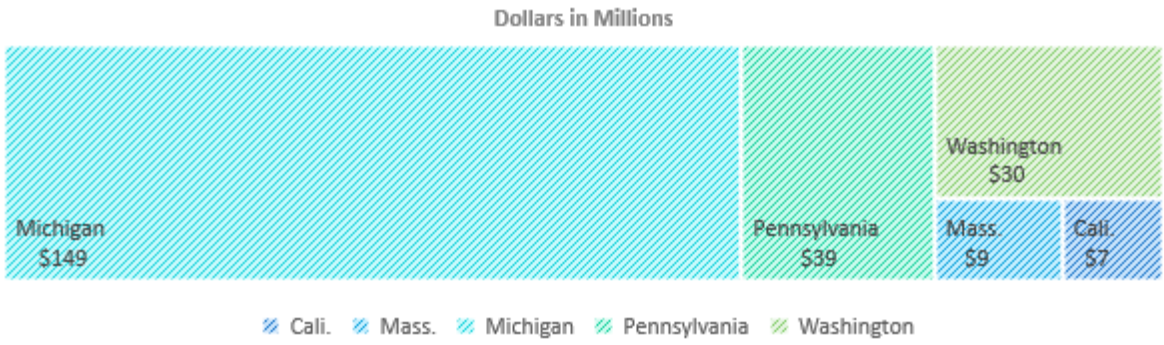
The difference between Detroit and Michigan, on the one side, and the other regions, especially Silicon Valley, is stark. The Michigan Venture Capital Association stresses that the commercialization gap, defined as the dollar amount spent for R&D per $1 of venture capital investment, is largest in Michigan ($149 in R&D for each $1 in VC). In contrast, the

[38] Data source: National Venture Capital Association, Ecosystem Dashboard, Venture Capital Activity by State in 2016, https://nvca.org/research/ecosystem-dashboard/ , accessed in December 2017.

[39] Data source: National Venture Capital Association, Ecosystem Dashboard, Venture Capital Activity by Metropolitan Statistical Area (MSA) in 2016, http://nvca.org/research/ecosystem-dashboard/, accessed in December 2017.

commercialization gap is $39 in Pennsylvania, $30 in Washington, $9 in Massachusetts, and just $7 in California, see Figure 18.[40]

Figure 18. Commercialization Gap (Dollars of R&D Spent per $1 of Venture Capital Investment), by State, 2016



Source: National Venture Capital Association

Legal and Regulatory Framework

Regional and state laws surrounding CAVs vary considerably across the five regions studied for this analysis. Details on each region follow.

Detroit

Michigan allows CAV driving on public roads when they are registered with special license plate called an 'M-plate'.[41] While this establishes a procedure for recognizing CAVs, details on testing activities in the State are not well known because M-plate holders are not required to disclose details on their testing. Normally-registered vehicles may also be used to test automated vehicle systems on public roads as long as federal safety standards are not compromised. In 2016, the state updated legislation to remove a prohibition on consumer use of automated vehicles, thus allowing use of such vehicles by the broader public as long as the vehicles comply with current safety standards.[42]

Boston

Massachusetts has not passed any law specific to automated vehicles or adopted formal regulations. However, Governor Charles Baker issued an Executive Order "To Promote the Testing and Development of Highly Automated Driving Technologies."[43] The Order convened a special working group on autonomous vehicles headed by the Massachusetts Department of Transportation (MassDOT). The main task of the group will be to advise the legislature regarding

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[40] Data source: Renaissance Venture Capital Fund, based on survey data from National Science Foundation, National Center for Science and Engineering Statistics, and Michigan Venture Capital Association.

[41] Steven Gursten. "Driverless cars can now be legally road-tested in Michigan, but who's liable when a driverless car causes a crash?" MichiganAutoLaw.com. Jan 6, 2014.

[42] Melissa Burden. "Snyder signs new Michigan self-driving law." *The Detroit News.* Dec 9, 2016.

[43] Mass.gov, Executive Order No. 572, by His Excellency Charles D. Baker, Governor. "To Promote the Testing and Deployment of Highly Automated Driving Technologies." October 20, 2016.

any legislation necessary to "protect the public welfare."[44] The Order further established that the working group and MassDOT will issue guidance to municipalities to allow testing activities. The Order specifies that such guidance must include a process by which MassDOT must approve companies prior to testing, and obtain a memorandum of understanding (MOU) between the testing company, MassDOT, and any municipality or agency whose roadways would be used.[45]

Very recently, Massachusetts has shown increasing interest in regulating new mobility innovations. For example, ride-hailing services (TNCs) will be subject to a new 5-cent per ride fee.[46] Potentially more impactful, the legislature has introduced a bill that would impose a per-mile fee on automated vehicles, require them to be zero-emission vehicles, and disallow them from travelling over a mile without a human inside. Automated vehicle developer, nuTonomy, has strongly opposed this bill.[47]

The City of Boston led the Go Boston 2030 initiative that produced a Vision and Action Plan in 2017 with specific projects and policies to be implemented over the next 5, 10, and 15 years. The plan includes an Autonomous Vehicle Policy, supports on-street testing of CAVs, and encourages shared electric automated vehicle business models.[48] With respect to on-street testing, the City espouses a flexible approach to the permitting process, understanding that not everything can be known up front, and treats the testing plan as a living document.[49]

Pittsburgh

Pennsylvania does not specifically regulate automated vehicle technology, and has never proposed to do so. Despite this, Pittsburgh is one of the most high-profile locations for CAV development due to the presence of Uber and CMU. Pittsburgh city government has a close relationship with Uber, and the Mayor's office actively assisted Uber by fast-tracking zoning and licensing of its research center. City government also helped encourage the Pennsylvania state government to accommodate Uber's core ridehailing business—particularly in the larger Philadelphia market.[50, 51] The mayor's office even went so far as to assist Uber in recruiting drivers,[52] highlighting the especially-close relationship between the company and City government.

Pittsburgh gained notoriety as a center of CAV development when Uber announced "self-driving Uber" rides would serve randomly selected, public passengers.[53] However, Uber's test vehicles are not more technically advanced than any other prototype automated driving systems being tested, as both a professional driver and an engineer supervise the cars as they operate in automated mode. While there is no obvious way to compare Uber's CAV technology to competitors, the

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[44] Ibid.

[45] Ibid.

[46] David Ingram. "Massachusetts to tax ride-hailing apps, give the money to taxis." *Reuters*. Aug 19, 2016.

[47] Dylan Martin. "Why a Proposed Mass. Bill Could 'Snuff Out' Autonomous Vehicle R&D." *BostInno.* Jan 26, 2017.

[48] Boston Transportation Department, 2017. Go Boston 2030 Vision and Action Plan, s.l.: s.n.

[49] Interview with Kris Carter, Co-Chair of the Mayor's Office of New Urban Mechanics, City of Boston. December 6, 2017.

[50] Colin Deppen. "How Pittsburgh became Uber's Kitty Hawk: Gov't emails reveal the promise, pitfalls of alliance." *Penn Live.* Dec 28, 2016.

[51] Rick Claypool; Robert Weissman. *Disrupting Democracy: How Uber Deploys Corporate Power to Overwhelm and Undermine Local Government.* Public Citizen. Washington, D.C. May 2016.

[52] Ibid note 50.

[53] Mark Harris. "Passengers in Uber's self-driving cars waived right to sue for injury or death." *The Guardian.* Sept 26, 2016.

promotion has created the impression that Uber and Pittsburgh are leaders in the global effort to commercialize self-driving vehicles.

Silicon Valley

Of the five regions benchmarked for this study, California's CAV regulations are the most elaborate and detailed. For testing purposes, a manufacturer must receive a permit from the DMV, it must submit an accident report in the event of a crash, and it must submit an annual report detailing the times test-drivers disengaged the autonomous mode to retake control of the vehicle.

Commercial deployments of autonomous vehicles are treated differently than test deployments. California's latest draft for self-driving commercial cars, dated September 2016, outlined a regulatory framework, but was widely criticized among both private and public entities as being too restrictive.[54] As such, the California DMV has yet to adopt a final set of regulations, and the timeline for doing so remains unclear.

Seattle

The State of Washington does not currently have any legislation or regulation specific to automated vehicles. Washington's state legislature considered CAV bills in 2013[55] and 2015,[56] but both efforts died in the transportation committee without coming to a vote. Following a House Technology and Transportation Committee briefing regarding CAV technology in December 2016, Rep. Zack Hudgins remarked, "this is a new frontier in many ways. We should be asking questions before we develop policy."[57]

The City of Seattle has not shown any interest in regulation. Both the city and the state appear to have a *wait-and-see* approach to regulating the rollout of CAV technology. Nevertheless, this delay does not imply inaction, as Seattle has shown a willingness to become involved in the regulation of other innovative transportation models. Specifically, the City of Seattle passed a first-of-its-kind law that would allow drivers for transportation network companies (TNCs), such as Uber and Lyft, to engage in collective bargaining.[58] Also, Seattle has a bicycle helmet law that many have blamed for the city's failure to sustain a bike-share program.[59] While there are no existing local regulations that would affect the deployment of CAV technology, industry might be hesitant to choose Seattle as a test market due to this history of regulatory actions.

Governance and CAV Strategy

Each region has different efforts aimed at enhancing its CAV ecosystem. Michigan has the most structured public-private governance for CAV technology thanks to two groups: the Michigan CAV Working Group, created in 2010 as a forum for dialogue, and the Council on Future Mobility, created in 2016, to provide policy recommendations. Pennsylvania has similarly created an Autonomous

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[54] Brian Fung. "Federal officials take aim at California's plan for self-driving cars." *The Washington Post.* Nov 15, 2016.

[55] WA HB 1649 of 2013.

[56] WA HB 2106 of 2015.

[57] John Stang. "Washington state lawmakers grapple with coming wave of self-driving vehicles." *GeekWire.* Dec 1, 2016.

[58] Nat Levy. "Seattle's landmark Uber union law set to go into effect as city releases final rules." *GeekWire.* Dec 30, 2016.

[59] Daniel Beekman; Jessica Lee. "Seattle's Mayor Murray kills city-run bike-share program." *The Seattle Times.* Jan 13, 2017.

Vehicle Policy Task Force last year, and the Massachusetts Department of Transportation (MassDOT) sponsors a monthly working group on the topic. Each of the groups is developing policies and strategic priorities on CAV testing and pilot deployment. Despite industry activity in California and Washington, no public-private CAV-oriented forums exist yet in either of these states. Instead, tech and auto companies interact mainly in industry forums.

Detroit

The Council on Future Mobility was created in 2016 by the recent Michigan AV legislation package, and the Council met for the first time in March 2017. The Council provides the Michigan Governor and Legislature with recommendations regarding changes to state policy for CAV technology. The Council's 12 members represent the automotive industry, cities, counties, Michigan Department of Transportation (MDOT), universities, elected officials, and stakeholder groups.

The Michigan CAV Working Group was created in 2010 at the initiative of the Michigan DOT. Its members represent state agencies, federal agencies, local agencies, and private ITS and CAV technology companies. The working group holds quarterly meetings consisting of a combination of informative presentations on important topics (technical, policy, research, procurement opportunities), and interactive efforts designed to solidify Michigan's ITS and CAV leadership.

In 2016, the Michigan DOT and the Michigan Economic Development Corporation launched the Planet M platform, which aims to showcase Michigan's collective mobility efforts—in particular the technologies and services that enable people and goods to move around.

In 2016, the state of Michigan signed a memorandum of understanding (MOU) with the Province of Ontario, Canada, to increase the competitiveness of the region's automotive industry.[60] One of the primary efforts toward this collaboration is focused on technology advancement, such as connected and automated vehicle technology.

Michigan, along with Ohio and Pennsylvania, is part of the Smart Belt Coalition (SBC), an inter-state collaboration of public agencies and academic institutions. The SBC's goals include providing a forum for key transportation decision-makers, supporting testing and deployment of CAVs, sharing data for research and deployment of CAV, and seeking joint funding opportunities for large-scale transportation research and implementation projects.[61] Currently, the SBC is preparing a strategic plan that focuses on CAV applications in work zones, traffic incident management, and commercial freight. After several meetings in 2016, the SBC is seeking to formalize the partnership through a MOU in 2017.

Boston

To help capitalize on the large amount of robotics knowledge in the area, MassRobotics was created to incubate and provide a co-working environment exclusively for robotics start-ups. The independent, non-profit opened in February 2017, and includes expensive equipment many

[60] State of Michigan website. http://www.michigan.gov/snyder/0,4668,7-277--390461--,00.html. Accessed January 11, 2018.

[61] State of Michigan website, http://www.michigan.gov/som/0,4669,7-192-47796-402603--,00.html, accessed February 2017.

robotics start-ups require, such as oscilloscopes, 3D printers, and even an enclosed area for drone testing.[62] As of January 2018, the incubator has 27 companies in residence.[63]

One of MassRobotics' partners is the Mass Technology Leadership Council (MassTLC). MassTLC is a large, regional technology association, and one if its primary efforts is ensuring the region's talent pipeline is robust.[64] It also hosts many conferences and gatherings throughout the year to encourage networking and thought sharing.

MassDOT holds a monthly working group primarily focused around future legislation around automated vehicles. The group is primarily made of state government employees across several units of government, and participants discuss a variety of sub-topics of automated vehicles, such as liability, insurance, and infrastructure.

Pittsburgh

PennDOT created an Autonomous Vehicle Policy Task Force in 2016, and it held its first meeting in June 2016. The Task Force's goal is to shape Pennsylvania's approach to automated vehicles. The body also includes other state agencies (Department of Insurance, Department of Community and Economic Development, Pennsylvania State Police, and the Pennsylvania Turnpike Commission). Among the stakeholder representatives, the Task Force includes the Federal Highway Administration, motor vehicle associations (AAA, the American Trucking Association, Pennsylvania Motor Truck Association), universities (Carnegie Mellon University, University of Pennsylvania), the City of Pittsburgh, Pennsylvania Trial Lawyers Association, GM, SAE International, and Uber Technologies. Finally, the Task Force also includes legislative analysts from the House and Senate Transportation Committees. The Task Force is currently finalizing an Autonomous Vehicle Testing Policy.

The Pittsburgh Technology Council is a regional IT trade association that provides its 1,300 members business development, talent retention, government relations, and visibility services. Its members represent the tech sector from hardware and IT, to life sciences and application developers. The Council also organizes several industry networks: Advanced Manufacturing, Creative Industries, Entrepreneur Resource Center, IT, and Life Sciences.

Like San Francisco, Pittsburgh was also one of the seven finalist cities in the U.S. DOT Smart City Challenge. Leadership of the proposal consortium included: Allegheny County, PennDOT, Port Authority of Allegheny County, Pittsburgh Parking Authority, utility companies, university partners (UPenn and CMU), citizens and community stakeholders, industry partners (Uber, GM, Ford, Bosch, TomTom, Zipcar, IBM, Inrix, Savari, HERE, Cohda, Peloton).[65] Proposed actions included in the plan were real-time adaptive signal control with smart transit priority, and an automated shuttle network.[66]

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[62] Kolodny, Lora. "Boston's new hub, MassRobotics, is like a WeWork for robotics startups." *TechCrunch*. February 16, 2017. https://techcrunch.com/2017/02/16/bostons-new-hub-massrobotics-is-like-a-wework-for-robotics-startups/

[63] MassRobotics website. https://www.massrobotics.org/project/facilities-residents/. Accessed January 1, 2018.

[64] MassTLC website. http://www.masstlc.org/about-masstlc/. Accessed January 1, 2018.

[65] City of Pittsburgh Proposal, The Smart City Challenge, http://apps.pittsburghpa.gov/mayorpeduto/Smart_City_slides.pdf, accessed February 2017.

[66] City of Pittsburgh Proposal, The Smart City Challenge, https://www.transportation.gov/sites/dot.gov/files/docs/Pittsburgh%20Vision%20Narrative.pdf, accessed February 2017.

Seattle

Bellevue, Redmond, and Kirkland—three cities located east of Seattle—have formed the Innovation Triangle, a tech-oriented economic development alliance. The organization's website does not identify mobility or transportation companies located in the area, but companies listed in other categories are active or have expressed an interest in the CAV space (Google, Amazon, Inrix, Intel, and Kymeta).

The Cascadia Innovation Corridor is an initiative between the Province of British Columbia and the State of Washington. The two governments signed an MOU in September 2016 at a cross-border conference organized by the Business Council of British Columbia, the Washington Roundtable, and Microsoft. Some of the goals of the MOU are supporting innovation and collaboration in life sciences, clean technology, data analytics, high tech, and transportation.[67]

Silicon Valley

The Autotech Council was launched in 2012 by 50 Silicon Valley-based automotive industry executives. Participation has since grown to include automakers (FCA, Ford, Hyundai, etc.) Tier 1 (Bosch, Valeo, Magna, etc.), and Tier 2 suppliers, semiconductor companies, venture capital, and corporate venture funds. The goal of the Autotech Council is to speed better automotive innovations to market. Council members can discover innovations, grow their professional networks, and build partnerships.

Another industry association located in the Silicon Valley area is SEMI, serving the manufacturing supply chain for the Micro- and Nano-electronics industries. SEMI has served its members and the industries it represents for more than 40 years, and its global headquarters are in Milpitas, California.

While San Francisco was one of the seven finalists in the U.S. DOT Smart City Challenge, the city's proposal was unsuccessful. However, some of the partnerships initiated through the application process may continue, and could bring more smart mobility solutions to fruition. The Smart Cities application partnership was led by the San Francisco Municipal Transportation Agency (SFMTA), and included area transit agencies, research and data partners (UC Berkeley, MIT Media Lab, Waze, Zendrive), new mobility providers (Zipcar, Motivate, Uber, Lyft, Chariot), and automotive companies (BMW, GM, Ford, Tesla, Zoox, Bosch).[68] The overall goal of their proposal was to deploy Shared Electric Connected Automated Vehicles (SECAV), by supporting vehicle automation, vehicle connectivity, intelligent sensor-based infrastructure, data analytics, strategic business models and partnering opportunities, smart grid and electric vehicles.

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[67] British Columbia – Washington Memorandum of Understanding https://news.gov.bc.ca/files/BC_WA_Innovation_MOU.pdf, accessed February 2017.

[68] SFMTA, City of San Francisco. Meeting the Smart City Challenge, 2016 https://www.transportation.gov/sites/dot.gov/files/docs/San%20Francisco%20Vision%20Narrative.pdf

Southeast Michigan Asset and Other Maps

This section includes the overall, regional asset map as well as other maps that display relevant, CAV information geographically.

The Regional CAV Assets map in Figure 19 shows that Oakland, Wayne, and Washtenaw counties have, by far, the highest concentration of CAV-related companies and initiatives across the ecosystem. Specifically, the counties' share of CAV assets map represents each county's share of both academic and industrial assets. Ingham and Genesee counties host far fewer CAV assets, and the remaining counties host one or none.

Figure 19. Regional CAV Assets in Southeast Michigan

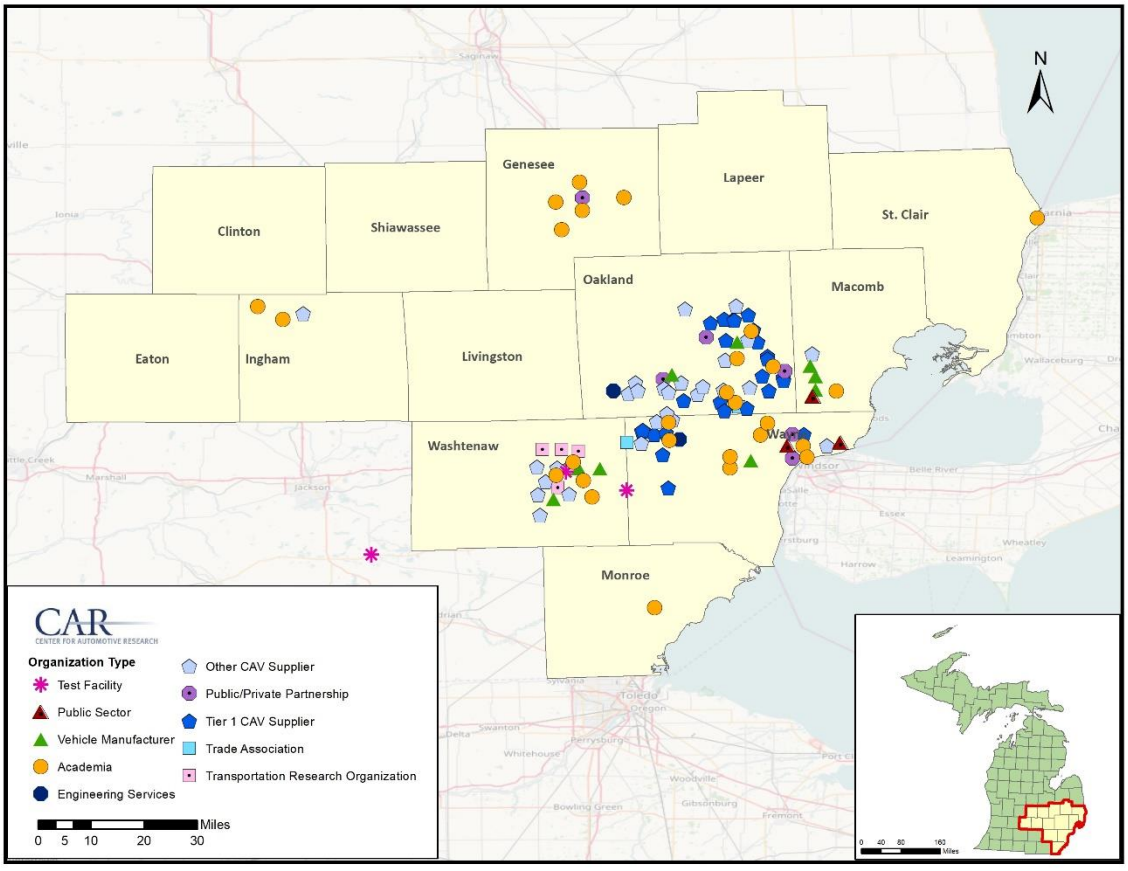
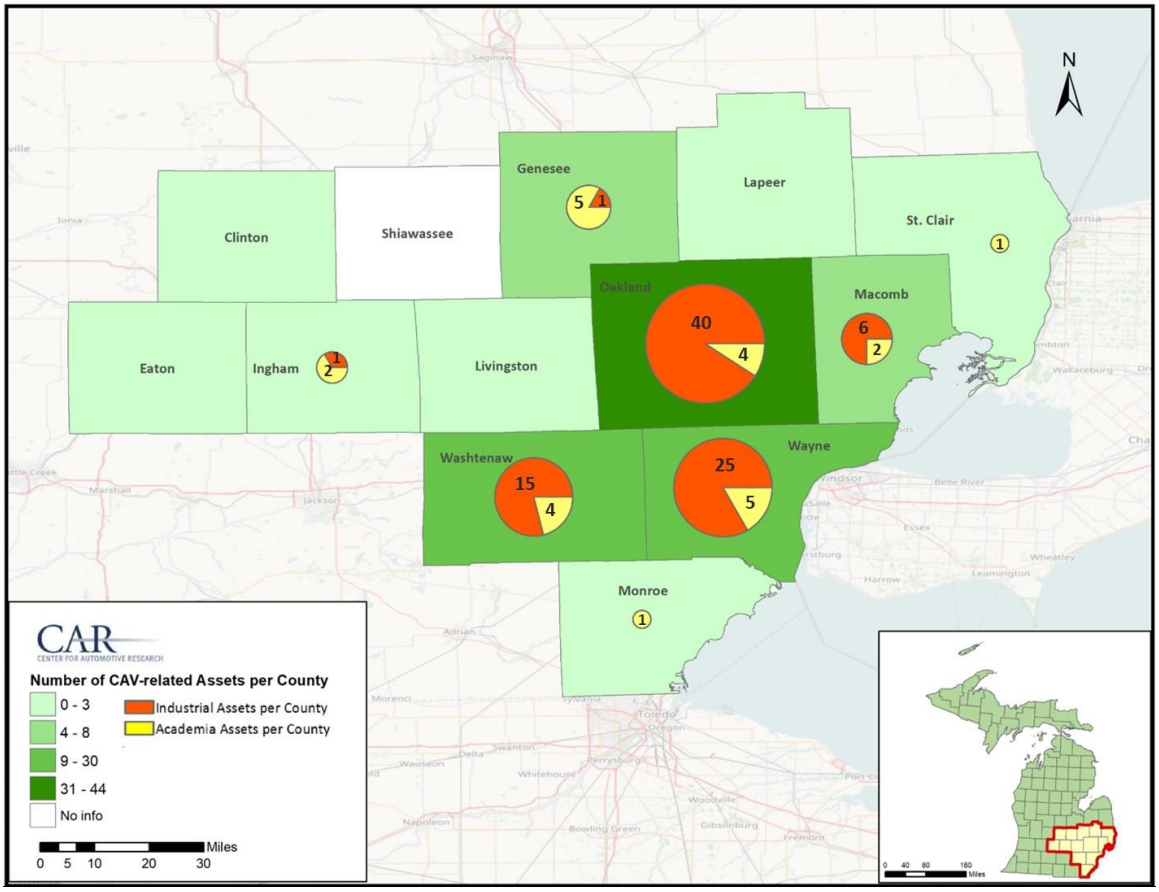
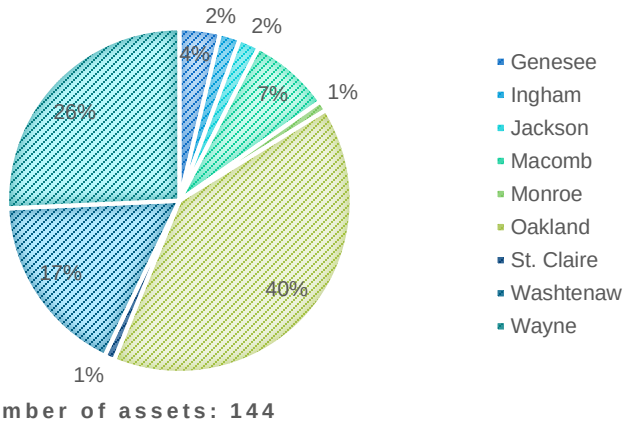


Figure 20. CAV Assets Share by County



The share of CAV-related assets, as shown in Figure 20 and Figure 21, demonstrates that most of the CAV suppliers (Tier 1 and others) are concentrated in Oakland County, and a few are within Wayne and Washtenaw Counties. A closer look at the map reveals that the CAV industry has spread primarily through the southeastern part of the region. With the current MDOT testing efforts, this area has the potential to act as a development catalyst for the entire study region.

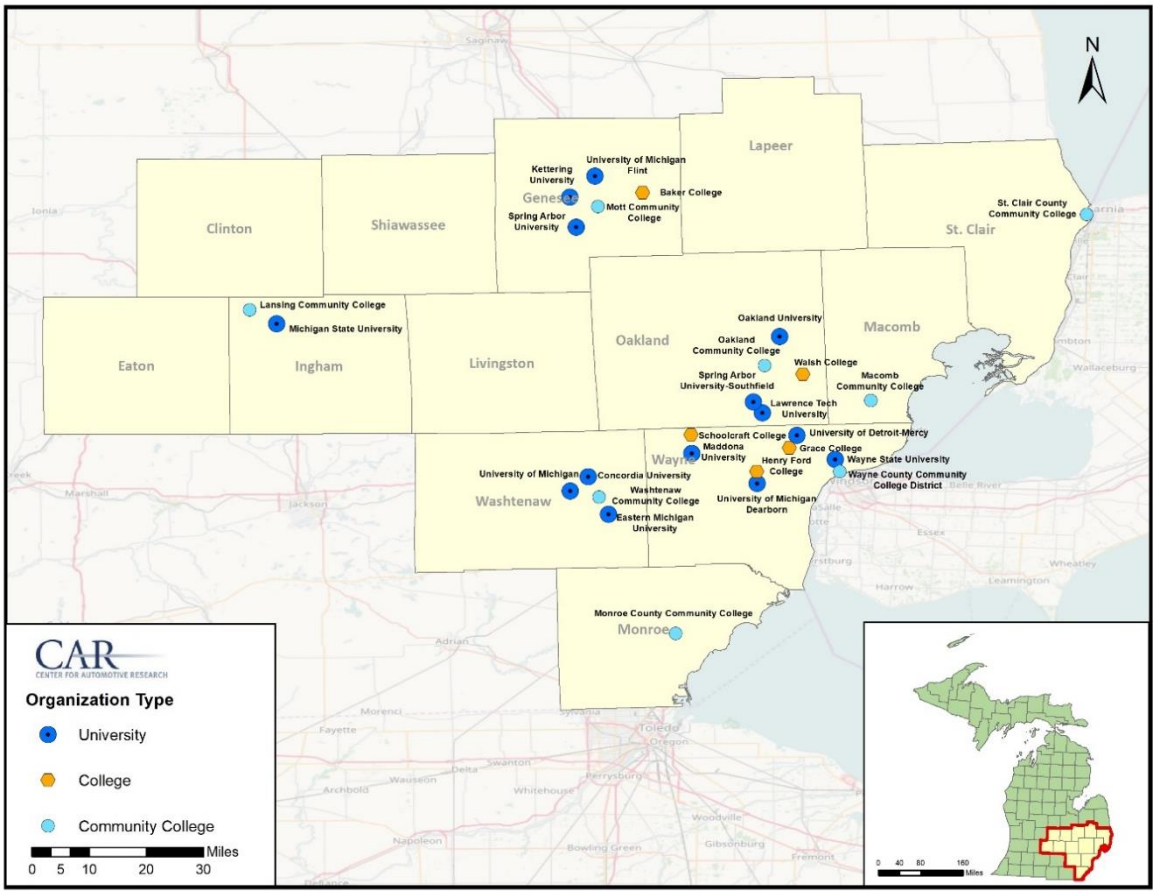
Figure 21. Regional Share of CAV Assets in Southeast Michigan



Total number of assets: 144

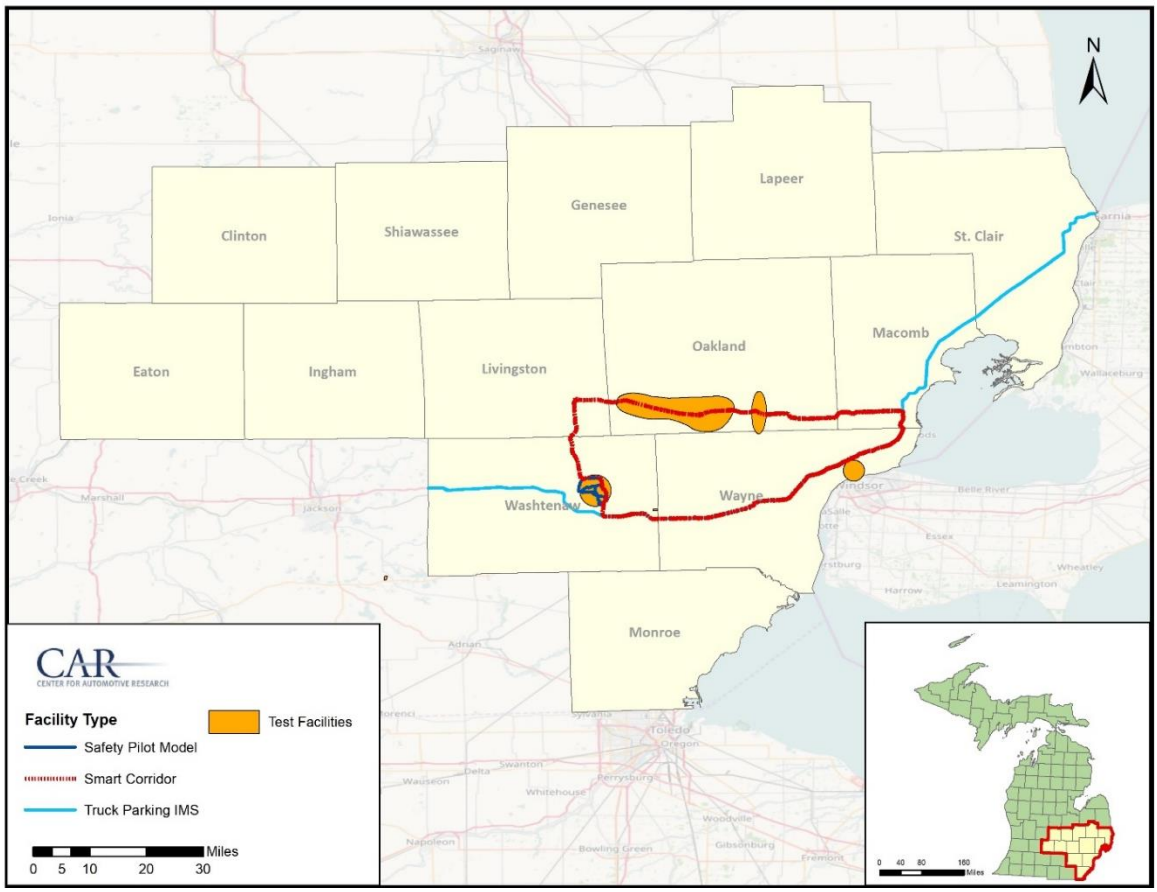
Among Michigan's colleges and universities, the Advance Michigan Region is host to 29 universities and community colleges with commitments to advancing CAV technologies. By offering CAV-related courses and programs, and developing innovative research labs, these colleges and universities have the potential to prepare the southeast Michigan workforce for the emerging needs of the advanced automotive industry. The density of industrial and academic institutions is one of the region's opportunities that can facilitate partnerships between academia and industry. Please see Figure 22 below for specific locations of academic institutions across southeast Michigan.

Figure 22. Distribution of CAV-Related Academic Institutions in Southeast Michigan



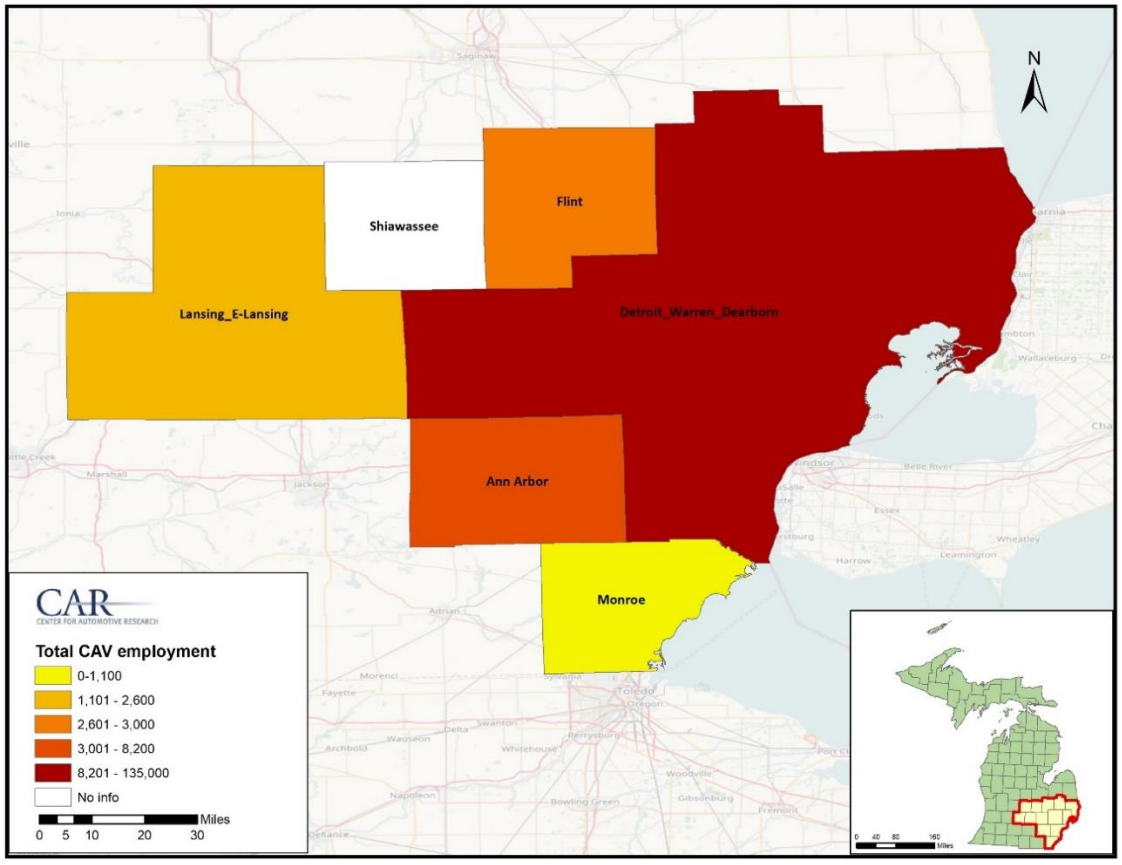
The State of Michigan has strongly supported the CAV industry. MDOT, along with federal, other public, and private agencies like the University of Michigan and American Center for Mobility, have funded the development of two CAV test environments. The Southeast Michigan region also has several advanced intelligent transportation systems (ITS) for CAVs such as Smart Corridor facilities, the Safety Pilot Model, along with Parking Information and Management Systems. These low speed and high speed test environments, coupled with real time ITS systems, can support southeast Michigan's CAV leadership. These test environment locations are displayed below in Figure 23 for further detail.

Figure 23. Distribution of CAV Test Environments in Southeast Michigan



Detailed current employment statistics are published at the MSA level as opposed to the county level. As expected, employment in both auto industry and related information technology services follows the spatial distribution pattern of the auto industry in the Detroit region. While jobs related to the information and technology side of CAVs are mostly concentrated in the Detroit-Warren-Dearborn MSA, non-IT auto industry jobs are more widely distributed across the region as shown below in Figure 24, Figure 25, and Figure 26.

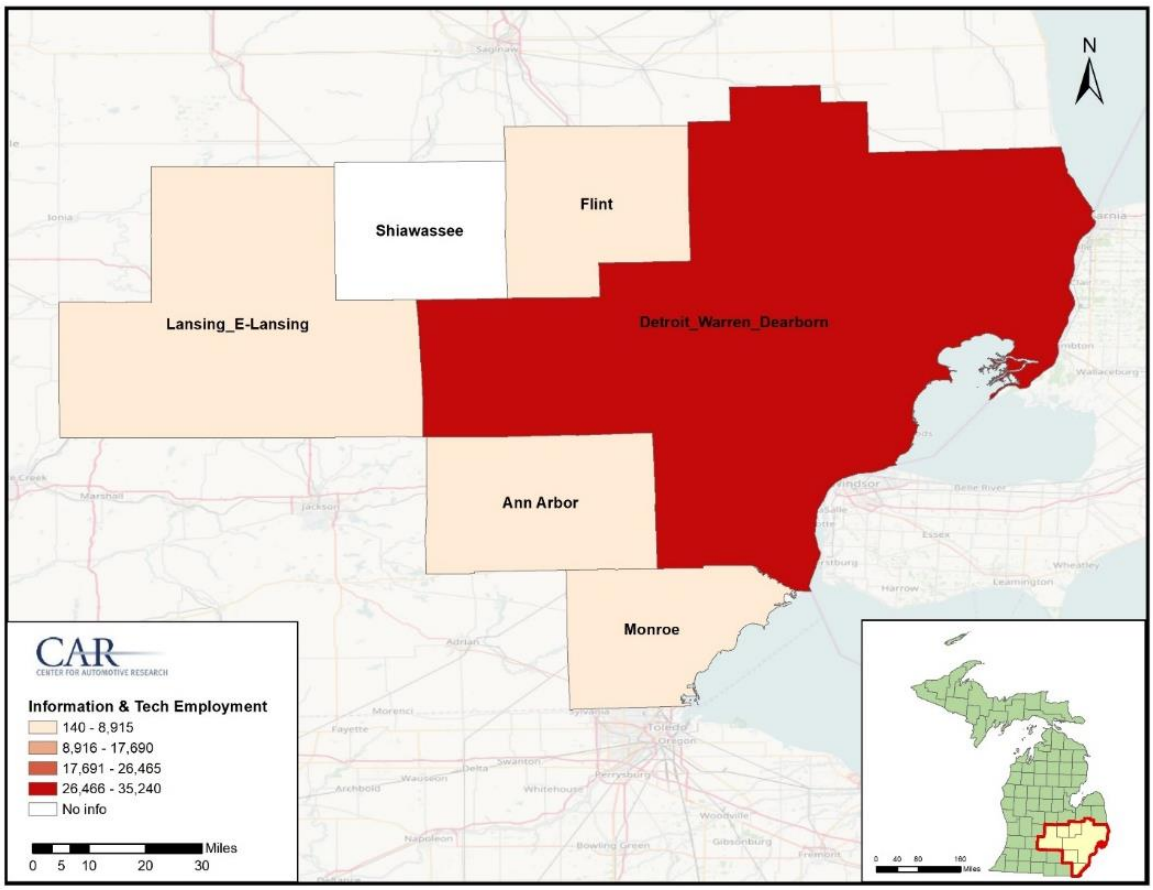
Figure 24. Distribution of CAV Workforce in Southeast Michigan, 2016[69&70]



[69] Source: Bureau of Labor Statistics <https://data.bls.gov/cgi-bin/dsrv?sm> and

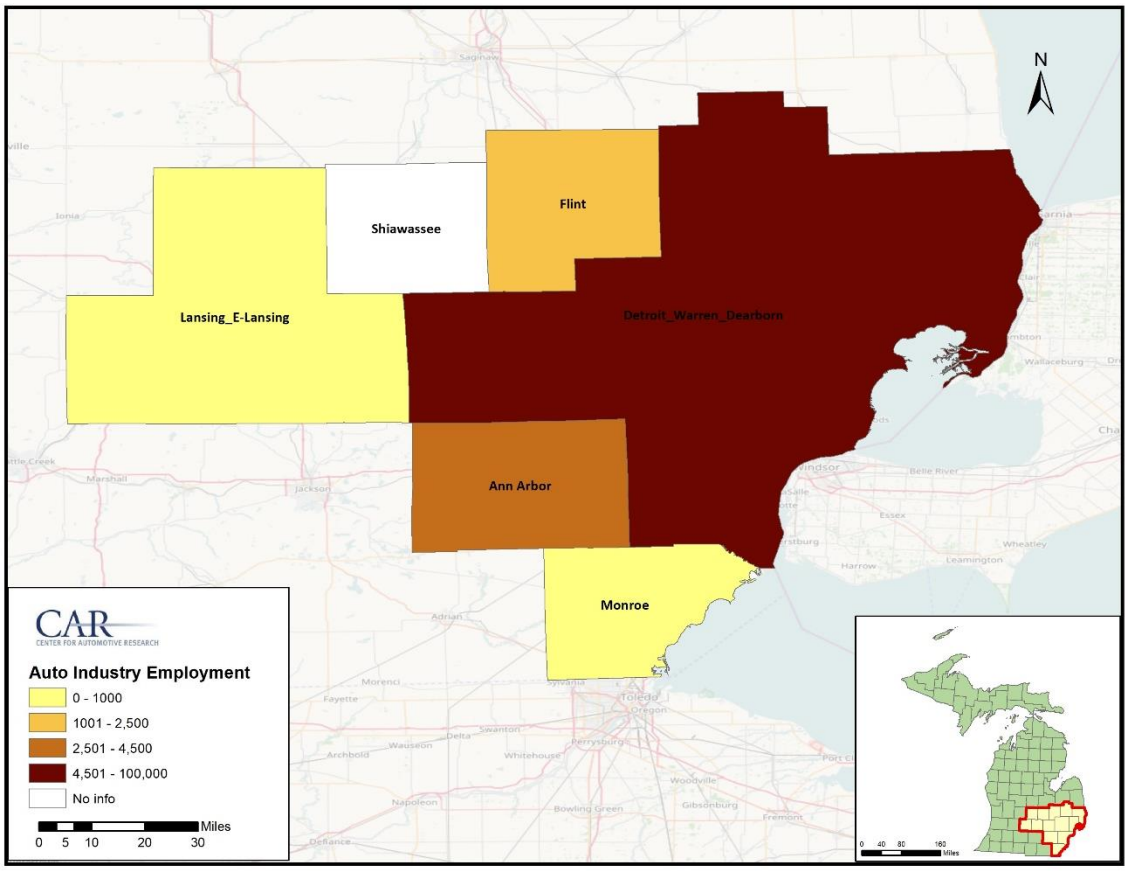
[70] Source: Michigan Bureau of Labor Market Information and Strategic Initiatives <http://milmi.org/datasearch>

Figure 25. Distribution of CAV IT & Technology Workforce in Southeast Michigan, 2016[71]



[71] Source: Michigan Bureau of Labor Market Information and Strategic Initiatives <http://milmi.org/datasearch>

Figure 26. Distribution of CAV industry-related workforce in Southeast Michigan, 2016[72]

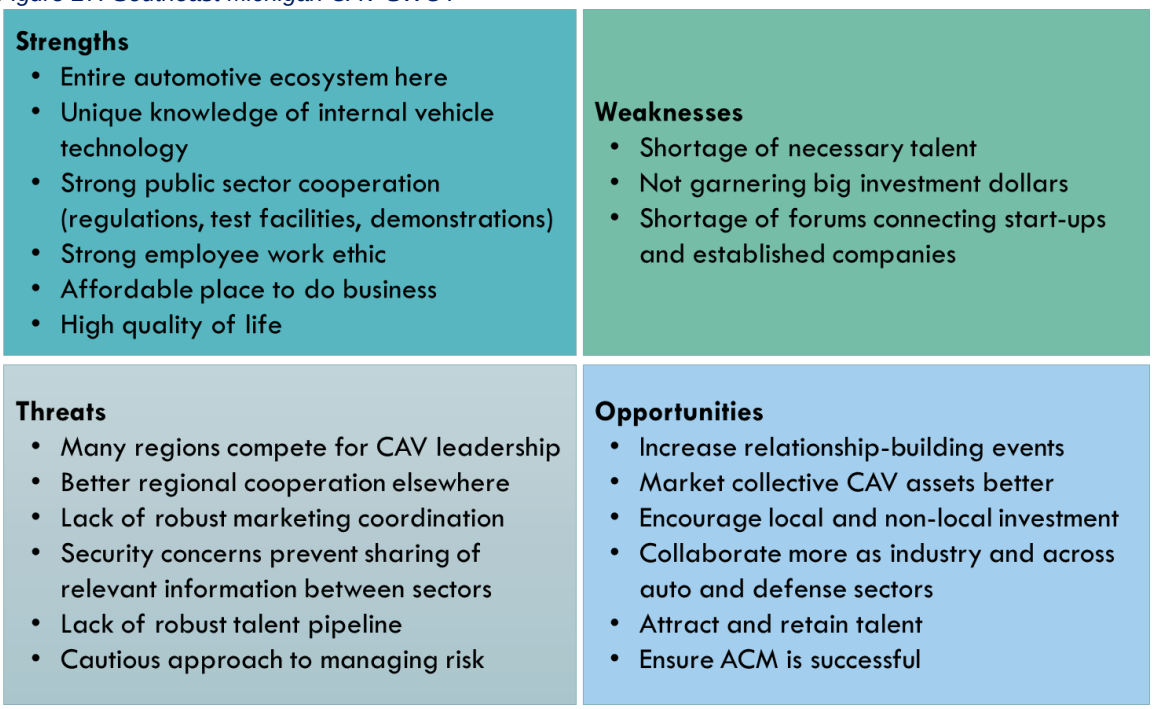


[72]Source: Bureau of Labor Statistics <https://data.bls.gov/cgi-bin/dsrv?sm>

SWOT Analysis Results

Based on initial interviews with the organizations interviewed for this research, Michigan has clear strengths and weaknesses, and the threats and opportunities are evident. Figure 27 summarizes the highlights of the SWOT analysis, and further discussion of each quadrant of the analysis follows. For some quadrants, specific SWOT elements related to defense and CAV collaboration also are detailed.

Figure 27. Southeast Michigan CAV SWOT



Strengths

By far, the Detroit region's most commonly mentioned CAV strength was the region's strong automotive ecosystem. In addition to being the place where "decisions are made," the entire manufacturing value chain is also located here, and Detroit has the highest concentration of automotive manufacturing, R&D, and headquarters in the country. The region also boasts top-notch universities, test beds, and venture capital funds, thus creating an even more robust ecosystem. Having all these players in one place allows people to easily meet with others and see things in person, and respondents view this density as very valuable. One interviewee noted that in terms of the ability to connect with the right people, the region is similar to Silicon Valley. Additionally, the region's workforce has the necessary knowledge of the vehicle's internal technological make-up to be able to employ CAV technology solutions adeptly.

On the public side of the equation, Michigan agencies recognize the region's assets, and are working hard to maintain and grow them. MDOT is known for being a very strong player in this space, helping Michigan develop one of the largest portfolios of CAV initiatives, testbeds, and deployments in the country. Southeast Michigan also has a robust educational system to upskill

employees with the CAV-specific skills they need to advance their careers. Respondents also mentioned that the state legislature helps promote the right regulatory environment to enable such testing, specifically the 2016 laws that permit driverless vehicles to operate on Michigan roadways.

In addition to the above strengths, some interviewees cited additional benefits in Michigan such as the generally strong work ethic, and that the state compares favorably to Silicon Valley in terms of cost of living.

Defense-specific Strengths

TARDEC's defense R&D center in the Detroit region is one reason interviewees gave to support the ability to connect the automotive and defense sectors, especially on the topics of cybersecurity and vehicle platooning.

Weaknesses

Respondents reported that talent was by far the biggest weakness for CAV advancement in southeast Michigan, though the region is not unique in this respect—most regions vying for CAV leadership face this same challenge. Figure 28 lists the specific talent needs interviewees identified. Respondents expressed concerns about finding people with both IT and automotive experience, and those that do exist are in such high demand they do not stay in one place for very long, or are recruited away to join firms outside the region. The fight for talent is not unique to the automotive industry, of course, but was mentioned frequently by respondents as a concern. In addition, while there is a proliferation of universities and talented engineering programs, both Silicon Valley and Seattle regions have higher, per capita numbers of residents with CAV-related higher education degrees.

Another weakness mentioned is there are not enough high-quality forums for start-ups to connect with those in the auto industry. Many events could provide such a forum, but attendees may not know which to attend, or how to prioritize among the wide variety of offerings. Without clear standout "must attend" events, the networking opportunities are spotty, and the ability to connect with the right people is more difficult.

Figure 28. CAV Talent Needs in Southeast Michigan

CAV Talent Needs in SE Michigan
- Autonomous Vehicle Experts
- App Developers
- Artificial Intelligence Experts
- Coders
- Cybersecurity
- Embedded Software Engineers
- Mid-Level Engineering Managers
- Robotics Engineers
- Programmers
- Systems Engineers
- User Experience Specialists

Source: CAR Research

Defense-specific Weaknesses

By nature, defense activities must follow stringent security guidelines, but these guidelines also inhibit the opportunity for defense to share relevant, use-case information with automotive companies and vice versa.

In addition, interviewees perceived that defense companies typically prefer to do business with stable, U.S.-based partner companies such as Tier 1s, not start-ups, foreign firms, or younger, smaller organizations. This is partly because the defense procurement processes and product timelines are significantly longer than in the automotive industry, and many smaller companies do not have the financial ability to wait as long as is needed for contract finalization.

Threats to Michigan

Given the potential economic benefits of CAVs and new mobility development, there are many regions in the United States and globally that are competing for technological leadership in this area. The competition for both public and private investment dollars is fierce, and Michigan must maintain its focus on encouraging the technology and industry as a whole, or else other areas could take our place. The Detroit area has a weak history of regional collaboration, and some competitor regions have a longer track record in building and maintaining productive regional efforts. Michigan has top-notch universities and engineering talent, but this may not be enough. Many other regions have similar academic capabilities; thus this may not be a differentiating factor for the state. Economic developers and policymakers must also beware of trying to oversell or misrepresent the region's strengths and opportunities. One respondent recalled an initiative to brand southeast Michigan as a robotics headquarters, which in this person's mind seemed to be a stretch compared to other regions that may have better-developed robotics specialties.

Another threat is the lack of large investment dollars in the region and state, both from a venture capital and institutional perspective. The benchmark research data in this report confirm that the Detroit region is at a disadvantage in terms of both VC and other capital investments. Several interviewees viewed investment capital availability in this region as small compared to the coasts, and stated that they view automakers as part of the problem. Citing GM's recent acquisition of Cruse, one respondent remarked that automakers are so keen to be involved with Silicon Valley that they may miss what is in their own backyards (i.e., in southeast Michigan).

The Detroit region currently lags behind some other regions in the competition for talent, and this could become a threat to the region's CAV leadership if not addressed, as talent will continue to migrate elsewhere.

Additionally, respondents mentioned the Detroit region may be too risk-averse. While the Silicon Valley risk model is viewed by some as "too bold," the auto industry should move to increase its risk tolerance to reach a middle ground between the current state and the level of risk (and reward) that is common in Silicon Valley.

Opportunities for Michigan

Southeast Michigan can capitalize on several opportunities to maintain and grow its CAV leadership role. First, the region could offer more relationship-building and networking opportunities to both connect start-ups with larger companies, and to connect CAV players in the auto and defense industries. Several of the smaller companies interviewed mentioned challenges connecting all big

players is a special challenge with potential defense customers, and auto company respondents mentioned wanting to interact more with entrepreneurs.

Marketing Michigan's positive aspects is seen as an opportunity for the entire state, but especially in terms of promoting the state's CAV assets. Letting others in the region know who is doing what with respect to CAV technology could serve to encourage more local investment and help attract the big investment dollars SE Michigan that are currently not active in the state. Michigan's marketing efforts could improve the state's position as an attractive destination for foreign direct investment, as well.

A third opportunity revolves around working more cohesively as an industry. Regional entities offer the opportunity to work together toward a common goal, such as when MDOT funded CAR to convene quarterly CAV Working Group meetings. Soon thereafter, the CAV working group relationships were leveraged to help Michigan unite to win the U.S. DOT V2V Safety Pilot Deployment competition.

On the talent side, the region can continue to work toward attracting and retaining the necessary talent. Perhaps industry players can offer student loan forgiveness programs for those with CAV skills and knowledge, and step up apprenticeship, coop and internship opportunities for university students to get a better glimpse of today's automotive industry and secure a future workforce pipeline. These latter efforts are already underway.

Cultural attitudes can be hard to change, but Michigan has the opportunity to promote the benefits of risk-taking, and even of failure. If the auto industry is aware of being overly risk-averse, people in leadership positions can attempt to create a culture where failure is seen more as a learning opportunity than a disaster to be avoided at all costs.

Finally, the region could collaborate to ensure that the American Center for Mobility (ACM) becomes financially and otherwise viable, as some interviewees see ACM as the critical "development" part of R&D, while MCity supports the "research" portion.

Defense-specific Opportunities for Michigan

The primary ways in which most interviewees see hope for defense and automotive collaboration is in cybersecurity and platooning. Defense representatives can take a larger role in defining standards for the technology, such as via SAE International's Vehicle Electrical System Security Committee. In such a forum, defense and automotive engineers can work together on developing mutually beneficial technological standards that will then guide future product development.

To allay security concerns, a special committee could be established that would grant special clearance to key automotive sector representatives so that auto and defense industries can collaborate on issues each party is having, and work collaboratively toward solutions drawing on each industry's unique expertise and experiences.

Finally, the defense R&D sector can take advantage of CAV testbeds in the region, such as using MCity or, more likely, the developing ACM to test their own products.

Appendix A: Combined Statistical Areas

A Combined Statistical Area (CSA) consists of adjacent metropolitan (one urban area that has a population of at least 50,000) and micropolitan (one urban area that has a population of at least 10,000 but less than 50,000) statistical areas. According to the U.S. Census, "both metropolitan and micropolitan areas are comprised of the central county or counties or equivalent entities containing the core, plus adjacent outlying counties that have a high degree of social and economic integration with the central county or counties as measured through commuting."[73] Table 1 depicts the CSAs used to define each region as well as what areas are included in this boundary.

Table 1. Combined Statistical Area Definitions, July 2015

Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (μSA)	Counties
Detroit (SE MI)	Detroit – Warren – Ann Arbor	Ann Arbor		Washtenaw
		Flint		Genesee
		Monroe		Monroe
		Detroit – Warren – Dearborn		Lapeer, Livingston, Macomb, Oakland, St. Clair, & Wayne
			Adrian	Lenawee
Seattle	Seattle – Tacoma	Bremerton – Silverdale		Kitsap
		Mount Vernon – Anacortes		Skagit
		Olympia – Tumwater		Thurston
		Seattle – Tacoma – Bellevue		King, Pierce, & Snohomish
			Centralia	Lewis
			Oak Harbor	Island
			Shelton	Mason
Silicon Valley	San Jose – San Francisco - Oakland	Napa		Napa
		San Francisco – Oakland – Hayward		Alameda, Contra Costa, Marin, San Francisco, & San Mateo
		San José – Sunnyvale – Santa Clara		San Benito & Santa Clara
		Santa Cruz – Watsonville		Santa Cruz
		Santa Rosa		Sonoma
		Stockton – Lodi		San Joaquin
		Vallejo - Fairfield		Solano
Pittsburgh	Pittsburgh – New Castle – Weirton	Pittsburgh		Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, & Westmoreland
		Weirton – Steubenville		Brooke, Hancock, & Jefferson
			New Castle	Lawrence
			Indiana	Indiana
Boston	Boston-Worcester-Providence	Boston-Cambridge-Newton		Norfolk, Plymouth, Suffolk, Essex, Middlesex, Rockingham, & Strafford
		Providence-Warwick		Bristol, Bristol (RI), Kent, Newport, Providence, & Washington
		Worcester		Windham & Worcester
		Manchester-Nashua		Hillsborough
		Barnstable Town		Barnstable
			Concord	Merrimack
			Laconia	Belknap

[73] https://www.census.gov/geo/reference/gtc/gtc_cbsa.html

Appendix B: Overall Demographics

Table 2. Total Population by Combined Statistical Area, 2016

Regional Descriptions					Total Population
Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Population
Detroit	Detroit-Warren-Ann Arbor	Ann Arbor		Washtenaw	364,709
		Flint		Genesee	408,615
		Monroe		Monroe	149,208
		Detroit-Warren-Dearborn		Lapeer, Livingston, Macomb, Oakland, St. Clair, Wayne	4,297,617
			Adrian	Lenawee	98,504
					5,318,653
Seattle	Seattle-Tacoma	Bremerton-Silverdale		Kitsap	264,811
		Mount Vernon-Anacortes		Skagit	123,681
		Olympia-Tumwater		Thurston	275,222
		Seattle-Tacoma-Bellevue		King, Snohomish, Pierce	3,798,902
			Centralia	Lewis	77,066
			Oak Harbor	Island	82,636
			Shelton	Mason	N/D
					4,622,318
Pittsburgh	Pittsburgh-New Castle-Weirton	Pittsburgh		Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland	2,342,299
		Weirton-Steubenville		Brooke, Hancock, Jefferson	66,704
			New Castle	Lawrence	87,294
			Indiana	Indiana	86,364
					2,582,661
Silicon Valley	San Jose-San Francisco-Oakland	Napa		Napa	142,166
		San Francisco-Oakland-Hayward		Alameda, Contra Costa, San Francisco, San Mateo, Marin	4,679,166
		San Jose-Sunnyvale-Santa Clara		San Benito, Santa Clara	1,919,402
		Santa Cruz-Watsonville		Santa Cruz	274,673
		Santa Rosa		Sonoma	503,070
		Stockton-Lodi		San Joaquin	733,709
		Vallejo-Fairfield		Solano	440,207
					8,692,393

Table 2 Continued. Total Population by Combined Statistical Area, 2016

Regional Descriptions					Total Population
Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Population
Boston	Boston-Worcester-Providence	Boston-Cambridge-Newton		Norfolk, Plymouth, Suffolk, Essex, Middlesex, Rockingham, & Strafford	4,794,447
		Providence-Warwick		Bristol, Bristol (RI), Kent, Newport, Providence, & Washington	1,565,683
		Worcester		Windham & Worcester	819,589
		Manchester-Nashua		Hillsborough	407,761
		Barnstable Town		Barnstable	214,276
			Concord	Merrimack	148,582
			Laconia	Belknap	N/D
					7,950,338

Table 3.Total Population Broken Out by Gender, 2016

Regional Descriptions					Gender			
Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Female	% of Population	Male	% of Population
Detroit	Detroit-Warren-Ann Arbor	Ann Arbor		Washtenaw	184,626	50.6%	180,083	49.4%
		Flint		Genesee	211,896	51.9%	196,719	48.1%
		Monroe		Monroe	75,534	50.6%	73,674	49.4%
		Detroit-Warren-Dearborn		Lapeer, Livingston, Macomb, Oakland, St. Clair, Wayne	2,206,761	51.3%	2,090,856	48.7%
			Adrian	Lenawee	48,283	49.0%	50,221	51.0%
					2,727,100	51.3%	2,591,553	48.7%
Seattle	Seattle-Tacoma	Bremerton-Silverdale		Kitsap	130,574	49.3%	134,237	50.7%
		Mount Vernon-Anacortes		Skagit	62,112	50.2%	61,569	49.8%
		Olympia-Tumwater		Thurston	140,159	50.9%	135,063	49.1%
		Seattle-Tacoma-Bellevue		King, Snohomish, Pierce	1,901,460	50.1%	1,897,442	49.9%
			Centralia	Lewis	38,075	49.4%	38,991	50.6%
			Oak Harbor	Island	40,039	48.5%	42,597	51.5%
			Shelton	Mason	N/D	N/D	N/D	N/D
					2,312,419	50.0%	2,309,899	50.0%
Pittsburgh	Pittsburgh-New Castle-Weirton	Pittsburgh		Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland	1,201,716	51.3%	1,140,583	48.7%
		Weirton-Steubenville		Brooke, Hancock, Jefferson	34,333	51.5%	32,371	48.5%
			New Castle	Lawrence	44,552	51.0%	42,742	49.0%
			Indiana	Indiana	42,743	49.5%	43,621	50.5%
					1,323,344	51.2%	1,259,317	48.8%
Silicon Valley	San Jose-San Francisco-Oakland	Napa		Napa	71,616	50.4%	70,550	49.6%
		San Francisco-Oakland-Hayward		Alameda, Contra Costa, San Francisco, Marin, San Mateo	2,367,473	50.6%	2,311,693	49.4%
		San José-Sunnyvale-Santa Clara		San Benito, Santa Clara	950,578	49.5%	968,824	50.5%
		Santa Cruz-Watsonville		Santa Cruz	138,555	50.4%	136,118	49.6%
		Santa Rosa		Sonoma	257,423	51.2%	245,647	48.8%
		Stockton-Lodi		San Joaquin	368,104	50.2%	365,605	49.8%
		Vallejo-Fairfield		Solano	220,986	50.2%	219,221	49.8%
					4,374,735	50.3%	4,317,658	49.7%

Table 3 Continued. Total Population Broken Out by Gender, 2016

Regional Descriptions					Gender			
Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Female	% of Population	Male	% of Population
Boston	Boston-Worcester-Providence	Boston-Cambridge-Newton		Norfolk, Plymouth, Suffolk, Essex, Middlesex, Rockingham, & Strafford	2,464,637	51.4%	2,329,810	48.6%
		Providence-Warwick		Bristol, Bristol (RI), Kent, Newport, Providence, & Washington	806,544	51.5%	759,139	48.5%
		Worcester		Windham & Worcester	414,898	50.6%	404,691	49.4%
		Manchester-Nashua		Hillsborough	204,056	50.0%	203,705	50.0%
		Barnstable Town		Barnstable	112,005	52.3%	102,271	47.7%
			Concord	Merrimack	74,762	50.3%	73,820	49.7%
			Laconia	Belknap	N/D	N/D	N/D	N/D
					4,076,902	51.3%	3,873,436	48.7%

Table 4. Total Population Broken Out by Age, 2016

Regional Descriptions					Age Distribution				
Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	19 and Under	20 to 24	25 to 44	45 to 64	65 and Over
Detroit	Detroit-Warren-Ann Arbor	Ann Arbor		Washtenaw	90,907	46,951	93,133	86,725	46,993
		Flint		Genesee	103,883	25,995	97,330	114,099	67,308
		Monroe		Monroe	36,111	8,849	34,368	44,678	25,202
		Detroit-Warren-Dearborn		Lapeer, Livingston, Macomb, Oakland, St. Clair, Wayne	1,064,527	271,603	1,076,620	1,220,815	664,052
			Adrian	Lenawee	23,734	6,530	23,085	27,901	17,254
					1,319,162	359,928	1,324,536	1,494,218	820,809
Seattle	Seattle-Tacoma	Bremerton-Silverdale		Kitsap	60,340	20,942	68,197	70,784	44,548
		Mount Vernon-Anacortes		Skagit	30,439	7,332	28,687	33,138	24,085
		Olympia-Tumwater		Thurston	65,276	15,520	75,358	73,845	45,223
		Seattle-Tacoma-Bellevue		King, Snohomish, Pierce	911,570	241,601	1,157,485	998,916	489,330
			Centralia	Lewis	18,162	4,586	16,941	20,850	16,527
			Oak Harbor	Island	16,619	5,560	18,972	21,897	19,588
			Shelton	Mason	N/D	N/D	N/D	N/D	N/D
					1,102,406	295,541	1,365,640	1,219,430	639,301

Table 4 Continued. Total Population Broken Out by Age, 2016

Regional Descriptions					Age Distribution				
Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	19 and Under	20 to 24	25 to 44	45 to 64	65 and Over
Pittsburgh	Pittsburgh-New Castle-Weirton	Pittsburgh		Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland	505,955	139,501	577,660	672,308	446,875
		Weirton-Steubenville		Brooke, Hancock, Jefferson	15,150	4,418	14,179	19,661	13,296
			New Castle	Lawrence	19,422	5,302	18,966	25,567	18,037
			Indiana	Indiana	20,348	9,522	17,449	23,188	15,857
					560,875	158,743	628,254	740,724	494,065
Silicon Valley	San Jose-San Francisco-Oakland	Napa		Napa	33,222	9,792	34,894	38,471	25,787
		San Francisco-Oakland-Hayward		Alameda, Contra Costa, San Francisco, Marin, San Mateo	1,038,659	274,918	1,429,383	1,251,529	684,677
		San José-Sunnyvale-Santa Clara		San Benito, Santa Clara	476,869	121,514	581,675	493,801	245,543
		Santa Cruz-Watsonville		Santa Cruz	68,209	27,423	63,957	74,238	40,846
		Santa Rosa		Sonoma	112,627	29,991	127,450	140,907	92,095
		Stockton-Lodi		San Joaquin	221,908	51,240	195,589	174,119	90,853
		Vallejo-Fairfield		Solano	108,900	30,414	118,033	118,264	64,596
					2,060,394	545,292	2,550,981	2,291,329	1,244,397
Boston	Boston-Worcester-Providence	Boston-Cambridge-Newton		Norfolk, Plymouth, Suffolk, Essex, Middlesex, Rockingham, & Strafford	1,113,635	347,661	1,302,311	1,312,273	718,567
		Providence-Warwick		Bristol, Bristol (RI), Kent, Newport, Providence, & Washington	363,240	113,083	394,775	438,612	255,973
		Worcester		Windham & Worcester	201,210	57,115	202,153	237,295	121,816
		Manchester-Nashua		Hillsborough	95,881	25,516	103,471	122,039	60,854
		Barnstable Town		Barnstable	37,969	10,633	36,789	65,575	63,310
			Concord	Merrimack	32,870	10,134	35,084	44,438	26,056
			Laconia	Belknap	N/D	N/D	N/D	N/D	N/D
					1,844,805	564,142	2,074,583	2,220,232	1,246,576

Table 5. Population 25 years or Older with Science, Engineering, or Technology Bachelor's Degree or Higher, 2016

Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Computers, Mathematics and Statistics	Engineering	Science and Engineering Related Fields
Detroit	Detroit-Warren-Ann Arbor	Ann Arbor		Washtenaw	7,174	16,399	14,932
		Flint		Genesee	1,410	3,716	7,929
		Monroe		Monroe	398	1,855	2,757
		Detroit-Warren-Dearborn		Lapeer, Livingston, Macomb, Oakland, St. Clair, Wayne	41,609	122,812	101,999
			Adrian	Lenawee	658	1,259	2,407
					51,249	146,041	130,024
Seattle	Seattle-Tacoma	Bremerton-Silverdale		Kitsap	2,185	6,401	5,858
		Mount Vernon-Anacortes		Skagit	777	1,752	1,783
		Olympia-Tumwater		Thurston	3,079	3,561	6,764
		Seattle-Tacoma-Bellevue		King, Snohomish, Pierce	90,342	132,694	101,123
			Centralia	Lewis	277	479	842
			Oak Harbor	Island	199	1,317	1,701
			Shelton	Mason	N/D	N/D	N/D
					96,859	146,204	118,071
Pittsburgh	Pittsburgh-New Castle-Weirton	Pittsburgh		Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland	30,291	49,730	70,612
		Weirton-Steubenville		Brooke, Hancock, Jefferson	486	1,973	2,823
			New Castle	Lawrence	569	731	1,538
			Indiana	Indiana	377	561	1,913
					31,723	52,995	76,886

Table 5 Continued. Population 25 years or Older with Science, Engineering, or Technology Bachelor's Degree or Higher, 2016

Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Computers, Mathematics and Statistics	Engineering	Science and Engineering Related Fields
Silicon Valley	San Jose-San Francisco-Oakland	Napa		Napa	916	1,895	3,785
		San Francisco-Oakland-Hayward		Alameda, Contra Costa, San Francisco, Marin, San Mateo	131,827	186,487	126,924
		San José-Sunnyvale-Santa Clara		San Benito, Santa Clara	91,343	158,564	48,442
		Santa Cruz-Watsonville		Santa Cruz	3,429	6,032	4,843
		Santa Rosa		Sonoma	4,041	8,768	11,748
		Stockton-Lodi		San Joaquin	3,938	5,728	9,443
		Vallejo-Fairfield		Solano	3,250	5,789	10,622
					238,744	373,263	215,807
Boston	Boston-Worcester-Providence	Boston-Cambridge-Newton		Norfolk, Plymouth, Suffolk, Essex, Middlesex, Rockingham, & Strafford	89,627	154,352	132,218
		Providence-Warwick		Bristol, Bristol (RI), Kent, Newport, Providence, & Washington	17,097	24,051	38,427
		Worcester		Windham & Worcester	14,742	20,988	20,595
		Manchester-Nashua		Hillsborough	6,151	9,840	11,245
		Barnstable Town		Barnstable	1,957	4,534	6,137
			Concord	Merrimack	1,784	2,524	4,176
			Laconia	Belknap	N/D	N/D	N/D
					131,358	216,289	212,798

Appendix C: Educational Offerings

Table 6. CAV-Related Programs at Universities, Community Colleges (CC), and Trade/Technical Schools (T&TS) by Region, 2017

Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Universities	University Programs	CC	CC Programs	T&TS	T&TS Programs
Detroit	Detroit-Warren-Ann Arbor	Ann Arbor		Washtenaw	3	24	1	6	2	2
		Flint		Genesee	4	26	1	5		
		Monroe		Monroe			1	7		
		Detroit-Warren-Dearborn		Lapeer, Livingston, Macomb, Oakland, St. Clair, Wayne	10	81	6	50	5	15
			Adrian	Lenawee	2	7	1	7		
					19	138	10	75	7	17
Seattle	Seattle-Tacoma	Bremerton-Silverdale		Kitsap	2	18	1	15	1	2
		Mount Vernon-Anacortes		Skagit			1	4		
		Olympia-Tumwater		Thurston	1	2	1	10	4	12
		Seattle-Tacoma-Bellevue		King, Snohomish, Pierce	11	62	11	73	5	30
			Centralia	Lewis			1	5		
			Oak Harbor	Island	1	3				
			Shelton	Mason						
					15	85	15	107	10	44
Pittsburgh	Pittsburgh-New Castle-Weirton	Pittsburgh		Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland	10	89	4	42	9	27
		Weirton-Steubenville		Brooke, Hancock, Jefferson	4	12	3	20	0	
			New Castle	Lawrence	1	9	0		1	3
			Indiana	Indiana	1	15	0		1	2
					16	125	7	62	11	32

Table 67 Continued. CAV-Related Programs at Universities, Community Colleges, and Skilled Trade/Technical Schools by Region, 2017

Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Universities	University Programs	CC	CC Programs	T&TS	T&TS Programs
Silicon Valley	San Jose-San Francisco-Oakland	Napa		Napa	1	3	1	2	0	0
		San Francisco-Oakland-Hayward		Alameda, Contra Costa, San Francisco, Marin, San Mateo	12	44	20	138	3	4
		San José-Sunnyvale-Santa Clara		San Benito, Santa Clara	5	45	8	53	2	4
		Santa Cruz-Watsonville		Santa Cruz	1	7	1	7	0	0
		Santa Rosa		Sonoma	1	5	2	10	0	0
		Stockton-Lodi		San Joaquin	1	9	2	10	1	17
		Vallejo-Fairfield		Solano			1	5	0	
					21	113	35	225	6	25
Boston	Boston-Worcester-Providence	Boston-Cambridge-Newton		Norfolk, Plymouth, Suffolk, Essex, Middlesex, Rockingham, & Strafford	33	127	9	49	3	8
		Providence-Warwick		Bristol, Bristol (RI), Kent, Newport, Providence, & Washington	10	58	2	6	2	15
		Worcester		Windham & Worcester	3	6	3	30	N/D	N/D
		Manchester-Nashua		Hillsborough	4	12	4	28	N/D	N/D
		Barnstable Town		Barnstable	N/D	N/D	N/D	N/D	N/D	N/D
			Concord	Merrimack	1	2	2	17	N/D	N/D
			Laconia	Belknap	N/D	N/D	N/D	N/D	N/D	N/D
					51	205	20	130	5	23

Appendix D: Employment

Table 7. CAV-Related Transportation Employment by Region, 2016

Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Transportation Equipment Manufacturing	Computer Systems Design and Related Services Employment
Detroit	Detroit-Warren-Ann Arbor	Ann Arbor		Washtenaw	4,146	2,899
		Flint		Genesee	5,627	238
		Monroe		Monroe	981	31
		Detroit-Warren-Dearborn		Lapeer, Livingston, Macomb, Oakland, St. Clair, Wayne	102,343	34,199
			Adrian	Lenawee	1,861	22
					114,958	37,389
Seattle	Seattle-Tacoma	Bremerton-Silverdale		Kitsap	45,204	38,418
		Mount Vernon-Anacortes		Skagit	677	197
		Olympia-Tumwater		Thurston	197	866
		Seattle-Tacoma-Bellevue		King, Snohomish, Pierce	92,416	42,338
			Centralia	Lewis	412	29
			Oak Harbor	Island	ND	80
			Shelton	Mason	9	44
					138,915	81,972
Pittsburgh	Pittsburgh-New Castle-Weirton	Pittsburgh		Allegheny, Armstrong, Beaver, Butler, Fayette, Washington, Westmoreland	1,959	14,428
		Weirton-Steubenville		Brooke, Hancock, Jefferson	ND	33
			New Castle	Lawrence	ND	10
			Indiana	Indiana	ND	46
					1,959	14,517

Source: BLS

Table 7 Continued. CAV-Related Transportation Employment by Region, 2016

Region	Combined Statistical Area (CSA)	Metropolitan Statistical Area (MSA)	Micropolitan Statistical Area (µSA)	Counties	Transportation Equipment Manufacturing	Computer Systems Design and Related Services Employment
Silicon Valley	San Jose-San Francisco-Oakland	Napa		Napa	ND	326
		San Francisco-Oakland-Hayward		Alameda, Contra Costa, San Francisco, Marin, San Mateo	9,707	96,324
		San José-Sunnyvale-Santa Clara		San Benito, Santa Clara	ND	72,623
		Santa Cruz-Watsonville		Santa Cruz	429	706
		Santa Rosa		Sonoma	127	1,123
		Stockton-Lodi		San Joaquin	825	266
		Vallejo-Fairfield		Solano	266	236
					11,354	171,604
Boston	Boston-Worcester-Providence	Boston-Cambridge-Newton		Norfolk, Plymouth, Suffolk, Essex, Middlesex, Rockingham, & Strafford	11,461	70,037
		Providence-Warwick		Bristol, Bristol (RI), Kent, Newport, Providence, & Washington	1,271	6,243
		Worcester		Windham & Worcester	92	4,514
		Manchester-Nashua		Hillsborough	100	3,628
		Barnstable Town		Barnstable	34	487
			Concord	Merrimack	-	319
			Laconia	Belknap	85	88
					13,043	85,316

Source: BLS