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Chair Green, Vice Chair Greenspan, Ranking Member Sheehy, members of the House Transportation and Public Safety Committee, I am Jason Swanson, Director of Strategic Foresight at KnowledgeWorks, a Cincinnati-based operating foundation, which is focused on offering a portfolio of innovative education approaches and advancing aligned policies, that allow each student to thrive.

I am here today to provide testimony that explores the potential of autonomous and connected vehicles to improve safety and mobility; the expected societal, environmental, infrastructural, and planning impacts of the proliferation of these vehicles; and the ways in which autonomous and connected vehicle technology may reshape various industries and the overall economy. I would like to commend this panel for exploring the possible implications of such technologies.

Since 2006, KnowledgeWorks has been involved in rigorous exploration of the future. My team and I do this work so we can help stakeholders understand what is driving change, and make more informed choices to shape the future. While no one can predict the future, it is important that we think deeply and critically about changes on the horizon and how those changes affect our lives so that we can act to shape the future. Among such changes that we are now facing is the emergence of autonomous (A/V) and connected vehicles (C/V). My testimony today will focus on some of the potential implications that autonomous and connected vehicles may present to the state of Ohio, and it should serve as a starting place rather than an exhaustive list. It should also be noted that my testimony takes the perspective that full automation and connectivity will be achieved, and focuses on the implications of fully autonomous and connected vehicles rather than stages of partial automation or connectivity, so that we can better understand how such vehicles might affect the state and act to shape the future so that it works for all Ohioans.

Fully autonomous and connected vehicles (A/Vs and C/Vs) represent a major shift in transportation. Vehicles with autonomous and connected features have been around for a number of years. Such features can be categorized as “lean forward” technologies, or technologies that augment a human driver’s capabilities. Examples of lean forward technologies in vehicles include lane change assist, a technology that acts to alert drivers against impending collisions when switching lanes; and intelligent parking systems, an autonomous feature where a vehicle parallel parks itself. Vehicles and smart devices also have combined to create a digital technology ecosystem that has supported our personal transportation and activities. The next evolution in transportation is full automation and connecting the vehicle to the world around it, moving autonomous and connected vehicles from lean forward technologies, to “lean back” technologies, or technologies that allow the human to lean back while the machine does all the work. In the case of autonomous and connected vehicles, the machine takes over and replaces the human driver, and vehicles connect and interact not only with personal digital devices but also with the outside world and might include things like traffic lights, other cars, pedestrian walkways, gas stations, and mechanics shops, as well as sensor technology that may come to be

embedded in places not typically thought of as being related to an automobile, such as a smart refrigerator. As vehicles evolve, so too will the industries, organizations, and systems that are involved in some way with transportation.

The most obvious implication for autonomous and connected vehicles is the widely held belief that fully autonomous and connected vehicles will make driving safer. In 2015, there were 35,092 deaths due to auto accidents in the USA, and in Ohio there were 1,110 such fatalities.[i] AVs and CVs will dramatically impact these numbers. Unlike human drivers, they are not prone to distraction, nor can they drive while intoxicated or impaired. Machines are not affected by the Dunning Kruger effect, a bias where people believe their ability in a certain area is greater than it actually is.[ii] Self-driving vehicles will mean safer driving, and safer driving will lead to savings on health-care costs, put less burden on emergency services tasked with responding to auto accidents, and will require the auto insurance industry to dramatically change, just to name a few implications.

Using autonomous and connected vehicles for the transportation of people will have many other implications beyond increased safety. They can provide increased mobility for those who cannot drive due to age or physical limitations. A person's age will be irrelevant with respect to mobility given that autonomous and connected vehicles can be summoned using a smartphone or computer app, and those previously unable to drive due to physical limitations will have new mobility options. With such growth in the use of A/Vs and C/Vs for the transportation of people, Ohio will have to figure out what it means to have a driver's license and what it means to be of driving age in a world where vehicles drive themselves, as well as the effect this will have on revenues from licensing and license renewals, and for those who work at the Ohio BMV.

Autonomous and connected vehicles likely will allow for more efficient transportation of goods. A fully autonomous and connected vehicle that has the ability to connect with other vehicles and to traffic systems such as stop lights will be able to find the quickest route from point a to point b, and drive in the most efficient manner, within the bounds of the law, to get to its destination. Unlike human drivers, A/Vs and C/Vs won't need to sleep or break to rest, eat, or use the bathroom, but only refill on fuel or recharge its batteries. The faster, more efficient movement of vehicles will mean faster driving times, congestion mitigation, a possible raise in highway speeds (due to the increase in safety of A/Vs and C/Vs), all of which could add up to a 45% decrease in energy demand, as estimated by the Center for Integrated Energy Research.[iii] This will mean that the gas stations and other pieces of energy infrastructure related to automobiles will likely change to account for a drastic reduction in demand. Such an increase in efficiency for transporting goods may have other implications beyond energy savings. For example, any cost savings that A/Vs and C/Vs would have for shipping goods could be passed onto the consumer, which would make internet based commerce more appealing, putting pressure on brick and mortar business, and affecting tax revenues.

Beyond safety and transportation, as more autonomous and connected vehicles enter the roadways, we can expect infrastructure to change. The automobile helped Americans rethink how to use land space with the creation of suburbs. Autonomous and connected vehicles will have the same effect, causing us to once again rethink how we use land space. In looking at the use of land space and infrastructure,

there is potential for reconfiguring state highway systems, with lanes repurposed as autonomous and connected vehicle-only lanes, which could allow for swift transport and minimize accidents between autonomous and connected vehicles and human-driven vehicles. The A/Vs and C/Vs could change how stop signs and traffic lights are designed; traffic lights could be embedded with sensors that talk to vehicles, allowing for better traffic control, which will provide a bird's eye view of traffic patterns in order to spot points of congestion. Parking may also become very different. There is approximately 5.7 billion square feet dedicated to parking in the U.S.[iv] Because autonomous and connected vehicles can park themselves then return to pick up their riders, storefront parking will have less demand, and revenues from metered parking and parking tickets will decline. A/Vs and C/Vs will require less space to park given that they can drive to meet a rider at the point of need, cutting 4 inches off either side of a traditional 21 foot parking spot, which will give city planners more room to work with. With less storefront parking space required coupled with minimized need to park A/Vs and C/Vs in close proximity to riders, parking could be more centralized, with lots and vehicle storage locations moved from city centers to the edge of a city or to an area zoned just for parking. This would create an opportunity for legislators, city planners and citizens to consider policies and ideas for repurposing unneeded parking lots. New city parks, community gardens, bicycle-friendly zones or increased housing units are but a number of possibilities for use of this reclaimed space

Beyond highways and parking, autonomous and connect vehicles will help maintain and map road infrastructure. Sensors in A/Vs and C/Vs can be used to detect road issues such as potholes, sending information back to local governments and transportation planners whenever these vehicles bounce from hitting potholes. Installed cameras, GPS, and other sensors will continuously map the vehicles' surroundings, giving ever-more precise images and data for the areas where the vehicles travel. Such data can help with better planning but also raise privacy questions. Among them: what is a reasonable expectation for privacy if most vehicles on the road are mobile camera and sensor networks?

Just as introduction of the automobile changed how Americans think about land space, it also created new types of jobs and services. Likewise, it can be expected that autonomous and connected vehicles will also have an impact on employment, eliminating some jobs and creating others. The mention of autonomous vehicles typically elicits two types of visions for the future when it comes to their impact on work: one vision usually consisting of commuters zipping around in autonomous vehicles doing work, checking email, and otherwise enjoying the benefits of automation; the other, typically more dystopian in nature, portraying a world where truckers, cabbies, and other transportation occupations are put out of work. In reality, the future will lay somewhere in between these extremes, in what might be best described as a "both-and" future. As such, it is critically important to think through the implications of a future where the two realities coexist.

Transportation workers, including truck drivers, delivery drivers, bus drivers, taxi and ride share drivers (Uber and Lyft) are all likely to be impacted by autonomous and connected vehicles. Transportation occupations account for some 4 million jobs nationwide, and are considered solid, middle class occupations.[v] As fewer human transportation workers are needed, there will be a pressing need to retrain and help support them as they transition into new industries and employment opportunities. Some policy considerations might include:

- **Automatic Unemployment Insurance:** Unemployment insurance and benefits could start automatically for workers in areas of Ohio who are working in industries that will be hardest hit by automation.
- **New Taxation Structures:** Ohio might explore the viability of taxing the technologies displacing workers, including autonomous vehicles, robots, and other forms of automation, as a means to stabilize its tax base and to fund new types of supports for workers who might be displaced due to automation.

- **Education and Retraining:** The vast majority of work in transportation occupations has lower levels of educational attainment.[vi] Helping displaced workers in this field to retrain and seek further education could help them secure new work. Ohio should explore policies that promote training options and affordable post-secondary education. Ohio should also begin thinking through the skills, knowledge, and dispositions future workers will need in order to be ready for employment in the future. The changing nature of work as exemplified by the turbulence likely created by autonomous and connected vehicles will create the need to redefine what it means for a learner to be ready.

- **Crowd Equity:** Ohio could consider the creation of an equity marketplace where those being displaced by autonomous and connected vehicles, as well as other forms of automation, can buy equity stakes in the technologies that are displacing them. Such a marketplace will need careful legislation in order to benefit the at-risk worker, not just the investor, including resources to access and participate in existing markets.

- **Universal Basic Income:** Given the rapid pace of technological advancements, including autonomous and connected vehicles, the rate of advancement may outpace our ability to replace jobs that have been automated with new jobs for those that have been displaced. It would be prudent to create a universal basic income in order to cushion the blow that automation will have on Ohio's labor market.

While certain sectors will experience job loss, autonomous and connected vehicles will also create jobs. One area of job creation will be the need for human workers to load and unload automated vehicles containing goods or people. Such a scenario might include a future in which the connected vehicle communicates with a digital shopping list as well as a refrigerator, the latter of which has the ability to identify the items it contains. When the refrigerator is low on food, the autonomous and connected vehicle drives itself to a supermarket, where human staff assist in retrieving items on the shopping list and loading them into the vehicle. The vehicle then drives itself back to its owner. Another scenario might involve transporting an elderly person to the doctor for a doctor's appointment. In this future, once the appointment is made, an autonomous and connected vehicle is scheduled to take the person to their doctor. Even with the option to be transported to the doctor's office by autonomous vehicle, another individual may need to help the elderly person into and out of the car. As these scenarios illustrate, even though the act of driving is automated, there is still the need for a human at both the start and finish of the journey.

Beyond loading and unloading vehicles, autonomous and connected vehicles may also create data-based jobs in transportation. A/Vs and C/Vs will create vast amounts of data. Research firm McKinsey and Company estimates that data from autonomous and connected vehicles will be worth as much as $750 billion by 2030.[vii] Given the amount of data being collected and its projected worth, storing, sorting, and organizing this data may become an industry of its own in the near future.

Such an expansion of data collection and the reliance of autonomous and connected vehicles on internet-based technologies may also lead to growth in IT-based jobs. Research firm Strategy Analytics forecasts that there will be a need for people to create and tend IT systems that house the cloud services and predicative analytics that will make autonomous and connected vehicles work.[viii]

While there should be excitement at the prospect of new job creation and unlocking new markets, that excitement should be tempered with caution. There is a risk of rising income inequality, as many of the jobs that are forecasted to be created with the introduction of autonomous and connected vehicles tend to be low-skill, low-wage jobs, such as the need for someone to load and unload vehicles. While jobs in data science and IT are also likely, these jobs will likely require far fewer people.

In addition to the creation and elimination of jobs, many existing industries and systems will also experience changes due to A/Vs and C/Vs. Investment firm Morgan Stanley estimates that A/Vs and C/Vs will boost sales of beer, wine, and spirits by $100 billion dollars.[ix] While alcohol sales are forecasted to rise, DUI and other traffic and parking citations are expected to decline. According to the Bureau of Justice Statistics, 4 out of every 10 police encounters in the U.S. (42%) are traffic related, with traffic stops being the most common way police engage with communities.[x] What might such a change mean for police funding and staffing? How might police work need to be organized differently? How might that change the relationships between police and communities?

Tourism is expected to be affected by autonomous and connected vehicles. A/Vs and C/Vs could cause domestic air-travel to decline since driving long distances would be an automated process. Small towns, rural locations, and previously inaccessible tourist destinations are now within reach. Such areas might find themselves with emerging hospitality industries, and large cities might see a rise in tourism as autonomous and connected vehicles make it easier to get to certain destinations without the worry of having to drive or locate and pay for parking. The opening of such markets might be compared to when train travel was first introduced to the country followed by the automobile, creating medium- and long-range travel options to locations of the country that had once been difficult to access. The introduction of A/Vs and C/Vs has the potential to open up areas for tourism and development in a similar fashion.

The same kind of effect could play out with work commutes. In a future in which autonomous and connected vehicles are the norm work could start when employees enter such vehicles, not necessarily when they enter their physical places of work. It might also mean that a longer work commute might be inconsequential. This could lead to real-estate development in rural areas or locations that would have been less desirable due to their proximities from work centers and employers.

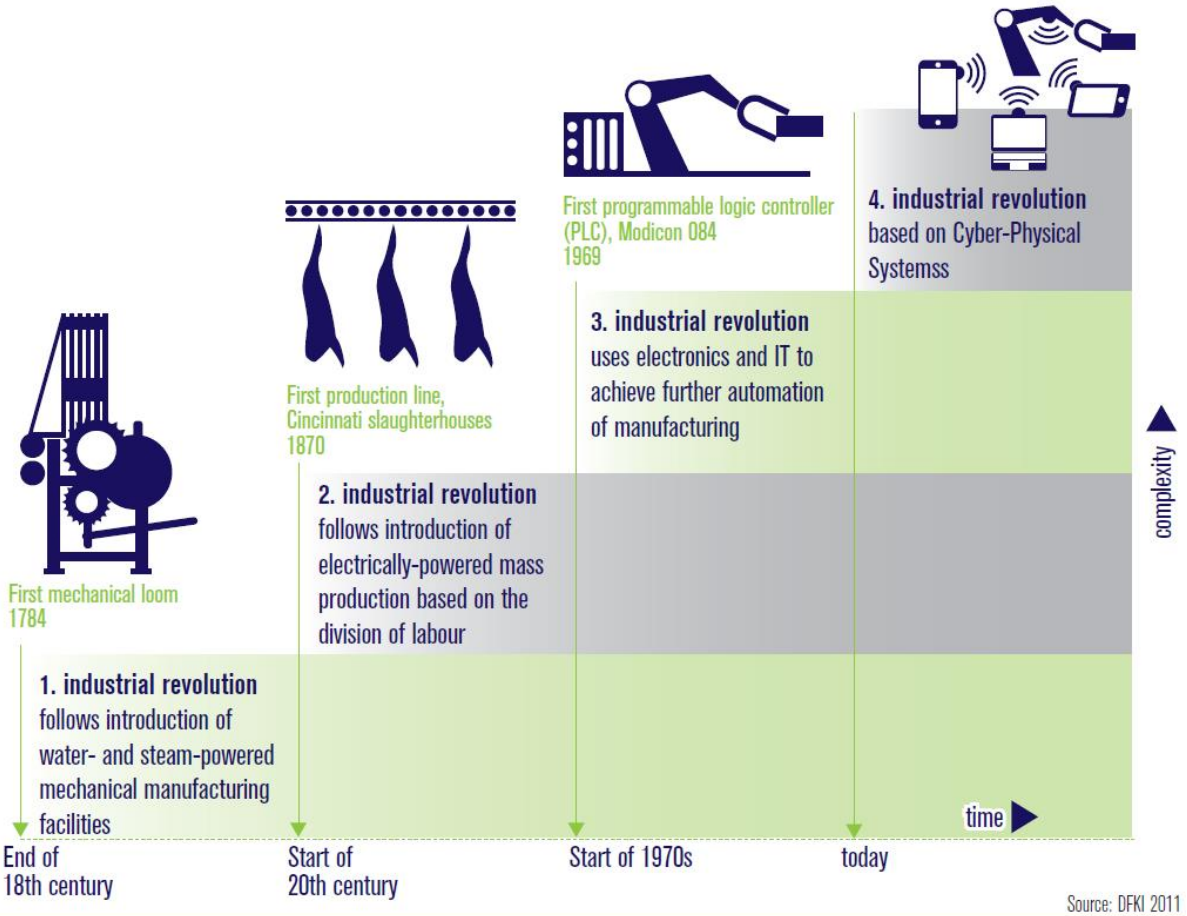
Autonomous and connected vehicles may also reshape K-12 education in Ohio. Having access to A/Vs and C/Vs, either through a fleet, on-demand services, or private ownership, has the potential to

transform how learning is organized. A/Vs and C/Vs could be used to take students from school to other place-based learning centers. For example, a student studying history could take their history class at the museum, or a student working in a project based learning environment could gain valuable experience working at different companies and organizations. A/Vs and C/Vs have the power to create a true learner-centered ecosystem where students can access local places and resources as part of a cohesive educational experience, potentially making learning more relevant and engaging. Careful attention should be paid to the issue of equity in this scenario as only those with the resources may have access to such transportation options.

The examples in my testimony only begin to scratch the surface of the changes that autonomous and connected vehicles will bring. While we cannot know the full scope of impact these vehicles will create, policy makers should be thinking as broadly as they can, envisioning all the change that might occur. Civic legislation will need to be passed to help with the transition to autonomous and connected vehicles, and to foster the new industries and start-ups that will follow.

Zooming out a bit, it must be noted that autonomous and connected vehicles are at the forefront of a new economy being ushered in by entirely new production paradigms. The World Economic Forum calls this transition the Fourth Industrial Revolution, and its defining features are production paradigms that include automation, artificial intelligence, synthetic biology, and additive manufacturing.[xi]

There are two main reasons for this shift. The first is that paradigm-busting innovations such as steam, electricity, and information systems, have helped us move past our limits to growth. Humanity has enjoyed near exponential growth in our quality of life and such advances allow us to continue this trend. The other is that the means of production I have outlined above are largely digital technologies, meaning they are advancing at an accelerating rate. Given population growth, resource constraints, and the accelerating rate of advancement of digital technologies, it is expected that the time between industrial revolutions will continue to compress, as evidenced by the chart below:



Taking a more granular view of this shift from the 3rd Industrial Revolution to the 4th Industrial Revolution, our perspective is that two drivers of change are at play, and that they will radically reshape work for many in Ohio and elsewhere.

The first of these drivers is one we call the rise of smart machines. Much like the autonomous and connected vehicle is poised to do, Artificial Intelligence (AI), machine learning, robotics, and other forms of automation are quickly entering our work places and our daily lives. Historically, technology has made work less repetitive and safer. This is due to the fact that machines have excelled at performing cognitive, routine-based tasks, or tasks that are process- and rules-driven. Now, we have innovations that are increasingly capable of doing cognitive, non-routine tasks or jobs that require abstract thought and creativity, qualities once thought safe from automation. Driving is an example of such a task, which is based on rules but requires complex thought and improvisation when faced with circumstances that break the rules, such as dealing with a jaywalker or the sudden lane change of a human driver.

Even today, people in a wide range of jobs use or work alongside smart machine partners. For example, robots such as one called Baxter now work alongside people on production lines and factory floors, learning and re-learning tasks with relative ease and affordability. Baxter learns programs when its hands are moved through the motions required to perform its assigned tasks.[xii] Some doctors are using

machine learning to help diagnose illness.[xiii] Chess players are partnering with smart machines to compete in advanced chess leagues.[xiv] Indeed, technologies that augment human intelligence are present in nearly every adult's life. Among them, smartphones and smart home assistants such as Amazon's Alexa[xv] and Google Home[xvi] enable people to extend their short-term memories by looking things up and getting reminders. GPS-enabled devices not only help people find their way, but can also recommend shorter routes as traffic conditions change. In addition, programs such as Skype's real-time language translator[xvii] allow people to bridge language barriers instantly. These examples illustrate the potential for smart machines to augment human intelligence.

At the same time, we are also seeing signals of change that point toward technological displacement. For example, lights-out manufacturing, in which factories are fully automated and only a few people are employed to tend to the machines, is on the rise. As we have noted today, transportation is on the verge of being automated: the ride sharing company Uber is trialing self-driving cars;[xviii] and Ott, Uber's self-driving truck, has already made a delivery in Ohio. [xix] Artificial intelligence is replacing some insurance industry employees, including thirty-four people who were laid off from Japan's Fukoku Mutual Life Insurance,[xx] and is writing some news stories.[xxi] Smart machines are also competing with people's ability to perform complex cognitive tasks in medicine and the arts: robotic surgeons such as the Smart Tissue Autonomous Robot have been shown to outperform human surgeons,[xxii] and an artificial intelligence recently completed a painting considered to be the equivalent of an original Rembrandt.[xxiii]

With signals of change supporting both the potential for smart machines to create or reconfigure jobs and to cause widespread technological displacement, experts are making divergent projections. Supporting the possibility that new and reconfigured jobs will employ people faster than smart machines can displace us, economist James Bessen of Boston University points out that automation has historically created or redefined jobs instead of destroying them. He argues that technology is not eliminating jobs but is instead creating the demand for new skills. Bessen forecasts an increase in jobs, specifically those associated with computer use, due to technological change.[xxiv] Similarly, the World Economic Forum projects modest job growth through 2020, with requisite skills changing rapidly.[xxv] A recent Pew survey of some 1,896 experts examining the potential effects of robotic advances on the economy in the year 2025 found that 52% of respondents thought that technology would create more jobs than it would displace.[xxvi]

Supporting the potential for widespread technological displacement, a 2013 study by Carl Frey and Michael Osborne of the University of Oxford suggests that 47% of current US middle-class jobs are at risk due to automation over a twenty-year period.[xxvii] A 2015 McKinsey Global Institute study brings the threat of technological displacement much nearer term, stating that 45% of the activities that workers do today could already be automated.[xxviii] The OECD estimates that technology already accounts for a nearly 80% drop in labor share among its member countries indicating that, even in those countries experiencing GDP growth, much of that growth can be attributed to increased technological efficiency rather than human output. This drop provides strong evidence that displacement is already underway.[xxix]

While the full impact of smart machines in the workplace is not yet clear, we can anticipate that their rise will force us to reevaluate the role of people in the workplace, either almost entirely or in regard to the kinds of skills we need to thrive and the frequency at which we need to acquire new ones.

The second driver of change is one we call the decline of full-time employment. Details show technology is also changing the structure of work, due in large part to the lower coordination costs afforded by the Internet and the access to an expanded labor pool resulting from globalization. The Internet is making it increasingly cost effective for firms to access people with specialized skills on the open market instead of employing people full-time. Globalization has opened up an international talent pipeline and continues to give firms access to cheaper labor markets and specialized talent. Such shifts are contributing to shortening employment tenure, the spread of contingent and project-based work, and the rise of taskification.

In the coming decades, we will likely see a significant decline in full-time employment, with more people piecing together career mosaics comprised of a variety of jobs and work experiences. Career mosaics could include radically different types of work, sometimes with different jobs and tasks spread over a period of time and sometimes with them taking place concurrently. For people employed full time by one organization, jobs and job descriptions are likely to become more and more fluid, flexible, and project based. Employees are likely to move through their workplaces horizontally rather than vertically, taking on a wide variety of tasks and projects as needs change.

Already, average job tenure is falling. Today, the average adult holds 11.7 jobs in his or her lifetime.[xxx] To put that statistic in perspective, if the average adult works for fifty years, that person will have a new job roughly every four years. The structure of work will change further in the coming decades as project-based, short-term workers, and independent contractors take on more contingent, project-based work. McKinsey Global Institute estimates that 54 to 68 million people in the United States already work in the project-based economy.[xxxi] Intuit forecasts rapid growth in this arena, with the independent workforce exceeding over 40% of the US workforce by 2020.[xxxii]

Taskification is also on the rise. This term refers to the breaking down of formal jobs into discrete tasks, often at lower wages and with informal job structures. Current examples of taskification include Amazon Mechanical Turk,[xxxiii] an online, crowd-sourced marketplace where individuals and businesses coordinate on “human intelligence tasks,” or tasks that computers are currently unable to complete. Task Rabbit[xxxiv] is an online platform that matches freelance labor with people who need tasks, such as house cleaning, home repair, or running errands, completed. The ride sharing services Uber[xxxv] and Lyft,[xxxvi] which have disrupted the taxi industry, use algorithms to match drivers with riders. These algorithms tell drivers where to go and then collect payment, while the drivers’ task is simply to drive.

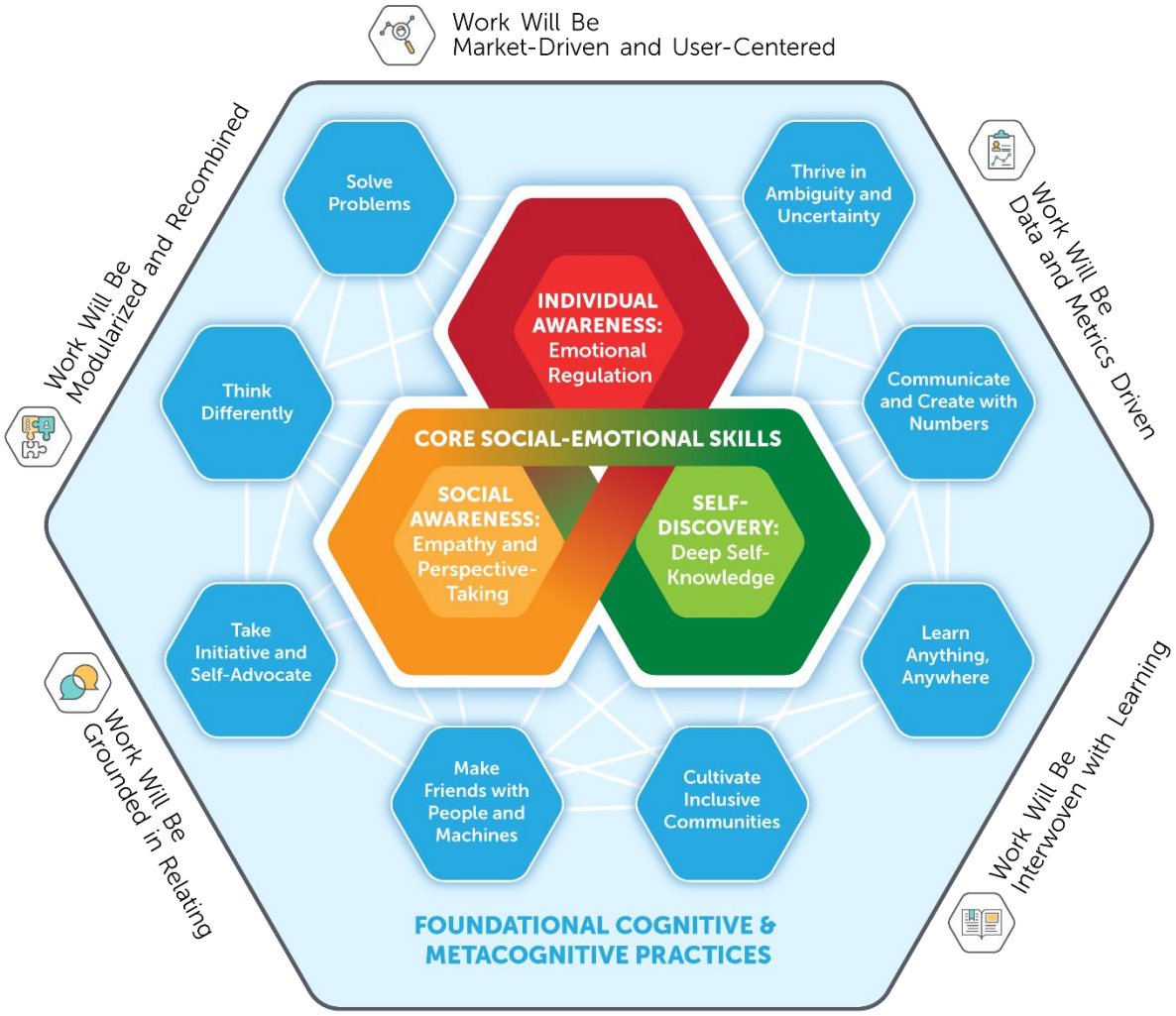
Generational attitudes may also affect the structure of work. Compared to older generations, the Millennial generation, born between 1982 and 1995,[xxxvii] has already shown less loyalty to traditional institutions, including employers. Its expectations for engagement have helped shift some workplace structures to be less hierarchical, and its “always on” habits have blurred the boundaries between work

and home life. As generation Z, born from 1995 to 2010,[xxxviii] enters the workplace, they will view short-tenure employment, project-based work, and taskification not as emerging phenomena but the new normal for structuring work. This perspective will influence their ideas of what work should be and what it should look like and could further exacerbate the decline of the full-time employee.

As digital technologies continue to advance and people's expectations about what work looks like continue to change, it will become increasingly easy to break down many existing jobs into tasks and to manage them algorithmically. The risk of technological displacement due to automation could also increase. While we do not know what balance of full-time employment, short-term contracts, project-based work, and taskification will emerge in the future, we can anticipate that the structure of work will become increasingly granular, with fewer full-time employees than exist today. Depending on what societal structures and supports exist around work, the employment landscape could also become more competitive.

It is because of these large changes, changes that are being ushered in by autonomous and connected vehicles, committees such as this should address not only the implications for autonomous and connected vehicles, but of automation more broadly. Given the potentially profound effects that these technologies will have on our lives there are two main lines of questioning that should be considered:

1. **What policies might be enacted to support all Ohioans as work continues to change?** Some of these policies might include many of the recommendations made previously in this testimony, but expand to include professions beyond driving occupations.
2. **What types of learning experiences will be needed in order to get citizens "ready" for work as we approach a changing definition of readiness?** As work changes, a new definition for readiness will be needed, and new learning structures will have to be put in place to help cultivate the knowledge, skills, and dispositions captured under this new definition. Given the turbulence forecasted for the future of work due to the rise, rapid advancement, and proliferation of smart machines, and with the atomization of work this new definition for readiness should be built from a foundation that leverages the human emotion system. By leaning into the traits that are not easily automatable while at the same time providing people with the cognitive and metacognitive foundation to easily adapt, thriving in ambiguity, and developing deep self-knowledge will likely be key readiness skills in the future. Such a foundation for readiness may look like:



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The Ohio Department of Education has already begun the deep work of thinking through how readiness might come to be redefined in the future as work changes. I would like to call attention to their work in this area, and suggest that as this committee thinks through the implications of autonomous and connected vehicles, a dialogue is started with the ODE and Superintendent Paolo DeMaria and key education leaders in the General Assembly as to how to better prepare our learners for the coming autonomous future.

This is a critical moment for the state of Ohio. We, as a state, have the potential to craft policies that can help Ohioans transition into the next economy and help the state flourish as autonomous and connected vehicles specifically, and automation in general, reshape how tasks are completed; ways jobs, industries and services are created or eliminated; and how readiness is for work is defined and measured.

KnowledgeWorks stands ready to help with this effort in any appropriate ways possible.

Finally, I want to thank you and applaud your leadership on this important, high impact issue.

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