SMART MOBILITY AND THE FUTURE OF LABOUR IN CANADA

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About the FOCAL Initiative

The Future of Canadian Automotive Labourforce (FOCAL) Initiative, funded by the Government of Canada, is a collaboration of the Canadian Skills Training and Employment Coalition (CSTEC), the Automotive Policy Research Centre (APRC) and Prism Economics and Analysis.

The FOCAL Initiative has produced labour market information and data related to Canada's automotive manufacturing sector, examined key trends affecting the automotive labour market, and produced forecasts of supply and demand for key occupations in the broader automotive sector.

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Introduction

The transportation industry — both personal and commercial — is at an inflection point. The emergent concept of smart mobility is shifting from the traditional transportation system to mobility as a service (MaaS), where increasingly advanced vehicle systems interact and connect with a sophisticated infrastructure. Mobility as a concept; and the vehicles that operate within, will experience dramatic changes in the coming years, with the introduction of high-quality and efficient services for public and commercial stakeholders, and a reduction in the transportation's collective carbon footprint and environmental impacts. As smart mobility changes the way we move people and goods, it alters vehicles and their technologies. As the automotive manufacturing sector responds advancements in smart mobility systems and its move towards MaaS, vehicles systems are expected to increasingly become connected, autonomous, shared, and electric (CASE).

This report will examine how emerging smart mobility systems and vehicle technologies may potentially impact the automotive manufacturing sector and its labour force. The report first establishes what a smart mobility is, outlining the key technologies enabling enhanced connectivity and automation, and advancing shared and electric mobility options. It discusses how far along the automotive industry is in realizing each of these components of smart mobility before exploring the key barriers and obstacles to large-scale development and implementation. The report then examines the trends and projections for labour implications in the smart mobility revolution, and explores the potential impacts of smart mobility on automotive manufacturing jobs. Finally, the report concludes with recommended steps to secure a socially responsible and sustainable future for Canada’s automotive labour force in the shifting transportation system.

Smart(er) vehicles: Connected, autonomous, shared, and electrified

As the automotive industry makes the transition from traditional concepts of mobility (ownership model) to smart mobility and MaaS (access model), the majority of automakers share a human-centred innovative outlook. The approach to putting the customer at the epicentre of smart mobility is captured by four key aspects: Connected products, Autonomous (or automated) vehicles, Shared mobility, and the Electrification of vehicles – otherwise known as CASE. Over the past few decades, CASE technologies have been making vehicle systems more advanced, and in some cases intelligent, with a focus on achieving self-driving vehicles. While the past ten years have seen unprecedented integration and adoption of CASE technologies, with significant resources and capital invested into self-driving vehicles, the automotive industry still hasn’t achieved fully functional smart mobility systems. This section explores where the automotive sector is in developing each of the components of smart mobility and outlines key barriers to large-scale smart mobility development.

Vehicle Connectivity

There is a rising demand for vehicles with greater connectivity – with more functionalities and features than simply getting passengers from point A to point B. Vehicles, in the smart mobility landscape, are a link and a pathway for communication between people, machines and the other technologies. Advanced features allow vehicles and their passengers to engage with other vehicles, traffic infrastructure, cloud systems, and mobile devices via vehicle components, smartphones, and wearable devices. By bringing together driver and vehicle data, automakers can enhance the driver's experience with modern features such as remote vehicle, pedestrian, and traffic management monitoring and safety, and enable emergency alert systems. The modern, software-defined vehicles connect to more than just other automobiles, interacting with other drivers and surrounding infrastructure[1].

There are multiple levels of vehicle connectivity. Privacy4Cars, an automotive technology company, identifies six levels of vehicle connectivity – see table 1 below. Based on the company's definition of driving connectivity[2] – Level 0 vehicles are those with no connectivity (Privacy4Cars Inc., 2022). Vehicles that have the minimum requirements to be categorized as "connected vehicles" under generally accepted laws and frameworks satisfy Level 1[3,4]. Level 1 connected vehicles are vehicles that have been commercially available for two decades and make up the majority of current vehicles on the road in developed countries and resale options (Privacy4Cars Inc., 2022).

The systems and capabilities supporting higher levels of connectivity require greater reliance on software housed in a growing number of electronics in the vehicle. Currently, most vehicles have the capability of connecting whenever they are within proximity of short-range radio frequency channels or within range of a cellular network. Vehicles that have direct access to a mobile telecom network (through a Telematics Control Unit (TCU)), are considered Level 3 connected vehicles. Between Levels 3 and 5 of vehicle connectivity are where almost all of the new vehicles produced today fall. Level 5, the highest level of connectivity, are those vehicles that connect to everything, or V2X, a level of connectivity accessible to consumers today. However, unlike computers and mobile devices, the majority of connected vehicles currently available to consumers do not have over-the-air (OTA) software updates, which are vehicle software downloads that take place with a Wi-Fi connection or over a cellular network.

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[1] Connected and automated vehicles – Transport Canada.
[2] Privacy4Cars' proposed standardizing framework for driving connectivity mirrors that of the Society of Automobile Engineers' (SAE International) on automation.
[3] Laws and frameworks such as the General Data Protection Regulation (GDPR) or the Draft International Standard 21434: Road Vehicles Cybersecurity Engineering.
[4] This draft was co-developed by the International Standards Organization (ISO) and the Society of Automobile Engineers (SAE International). These standards serve as a baseline for vehicle manufacturers and suppliers to ensure that connectivity and the cyber security risks that come with it are managed effectively and efficiently.

Figure 1. Levels of driving connectivity

Level 0	Overview: No Connectivity Connectivity:The vehicle lacks internet connectivity and is not equipped with Bluetooth capabilities.
Level 1	Overview: Local connectivity only Connectivity: The vehicle can link to other devices, such as through Bluetooth or USB, but it cannot use these devices' connectivity to provide connected services inside the vehicle.
Level 2	Overview: Indirect connectivity via connected devices Connectivity: The vehicle lacks built-in connectivity; however, it can connect to external devices (such as via Bluetooth or USB) and utilize their connectivity to deliver OEM-designed connected services through the infotainment system.
Level 3	Overview:Direct connectivity, in-vehicle only, OEM only services Connectivity: The service provider (OEM/Tier1) can access extensive information about the vehicle and its occupants at any time, including geolocation, behavior, and recordings. This data is stored both in the vehicle and on OEM/Tier1 servers, where it might be shared with third parties or compromised in a data breach.
Level 4	Overview: Direct connectivity, OEM services inside and outside of vehicle, including with personal devices of users Connectivity: The vehicle is equipped with built-in connectivity (such as a telematic connection through an embedded "SIM") that provides an in-vehicle experience with a wide array of online services. These services can be seamlessly accessed both inside and outside the vehicle by linking personal devices to the vehicle.
Level 5	Overview: Direct connectivity, vehicle is a hub supporting and communicating with several third party services inside and outside the vehicle, including other vehicles and infrastructure (V2X) Connectivity: The vehicle features native connectivity through an embedded "SIM" telematic connection, enabling a broad array of online services accessible both within and outside the vehicle through linked personal devices. Additionally, it can interact with infrastructure and other vehicles equipped similarly.

Source: Privacy4Cars Inc.

Some vehicles, particularly more technologically advanced vehicles, are a precursor of what connected, software-defined vehicles will offer in the future. Connected commercial vehicles will develop into advanced fleet management and enhance telematics with real-time planning, route optimization, driver performance monitoring, predictive maintenance and remote diagnostic capabilities to boost fleet operations and minimize vehicle downtime. Connected vehicle features are becoming more important for consumers and are emerging as a key differentiator amongst automakers.

Autonomous Vehicles Technologies

Currently, most vehicles only have basic advanced driver-assistance system (ADAS) features, such as adaptive cruise or light control, traffic sign recognition, automatic emergency braking, lane departure warning and correction, and pedestrian detection and avoidance. However, while driving automation systems (DAS) that support these functions are already commonplace in vehicles currently being built and sold, they have operational limits. No highly automated or autonomous vehicles (AVs) are commercially available to consumers today. Based on the Society of Automobile Engineers' (SAE) Levels of Driving Automation, vehicle automation available to the consumer is primarily between Level 2 and 3+ capabilities (see Figure 2 for a description of each level). However, autonomous driving capabilities are growing. Vehicles will eventually reach what the SAE defines as Level 4 autonomy, with driverless control under certain conditions. With anticipated advancements in artificial intelligence (AI) and sensor technology (particularly Light Detection and Ranging (LiDAR)), vehicles will be able to better interact with each other and traffic infrastructure and adapt and respond to a wider range of conditions to provide consumers with a safer and more efficient operation. Prototypes of autonomous shuttles, delivery vehicles, and autonomous taxis – also referred to as robo-taxis – are already operating at low speeds across Canada, though operating strictly within specific jurisdictions or routes (CCA, 2021).

Figure 2. Levels of driving automation

	Who is Driving?	Level of Automation	Required Monitoring	Features
Level 0 Driver Assistance	Human is Responsible	**Minimal**: Offers brief assistance	Must be continuously monitored	• automatic emergency braking • blind spot warning • lane departure warning
Level 1 Driver Assistance	Human is Responsible	**Partial**: Offers steering **OR** braking support	Must be continuously monitored	• lane centering **OR** • adaptive cruise control
Level 2 Partial Automation	Human is Responsible	**Partial**: Offers steering **AND** braking support	Must be continuously monitored	• lane centering **AND** • adaptive cruise control
Level 3 Conditional Automation	Automated System is Responsible	**Full**: Operates only under specific conditions	When prompted you must drive	• traffic jam chauffeur
Level 4 High Automation	Automated System is Responsible	**Full**: Operates only under specific conditions	When prompted you must drive	• local driverless taxi • pedals/steering wheel may or not be installed
Level 5 Full Automation	Automated System is Responsible	**Full**: Operates under all conditions	When prompted you must drive	• same as level 4, but feature can drive everywhere in all conditions

Source: SAE International.

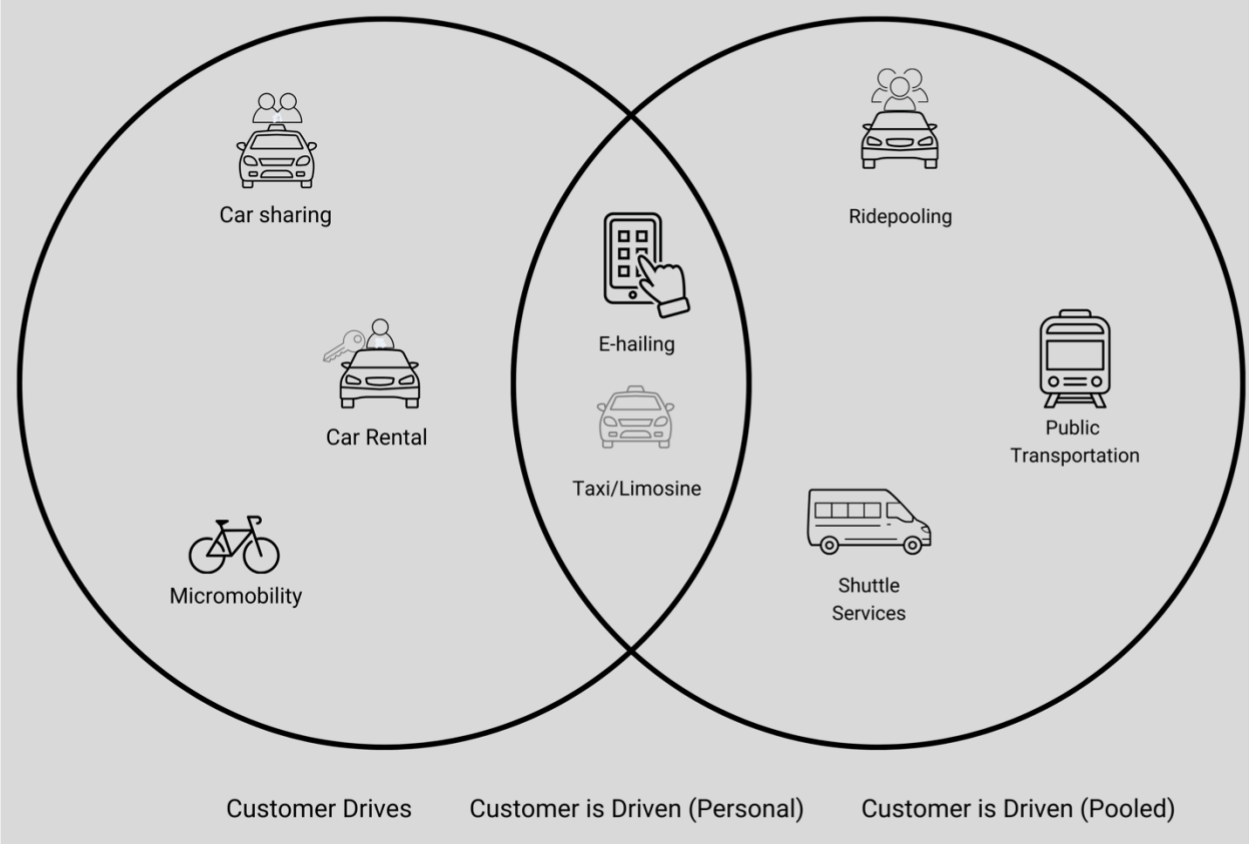
By 2030, it is forecasted that 12% of new passenger vehicles sold will have Level 3+ autonomous technology, increasing to 37% by 2035, assuming original equipment manufacturers (OEMs) accomplished their glidepaths for AV launches, with a certain level of customer adoption (Deichmann et al., 2023).

Shared Mobility

While sharing is not a new concept when it comes to mobility, new services that engage with mobility technologies are updating shared mobility and offering new travel options. No longer is it strictly vehicles being shared, with other types of mobility assets and services being shareable as well. The mobility sector is responding to consumers' increasing demand for more sustainable and convenient shared modes of transportation as an alternative to utilizing private vehicles. The evolution of shared mobility promises to combat traffic congestion, reduce air pollution levels, and reduce parking competition.

The transportation sector has significantly grown since the first major ride-hailing service was offered, with peer-to-peer and ride-sharing options. The sector has also expanded to initiatives such as shared electric scooters. Figure 3 provides a breakdown of modern shared mobility modes.

Figure 3. Segments of shared mobility



Source: (Heineke et al., 2021)

Hailed mobility, car sharing and shared micro-mobility, the three primary forms of shared mobility, are becoming increasingly popular. However, private vehicles remain the dominant method of transportation globally, with car sharing being third to public transportation (Heineke et al., 2021). Shared mobility increasingly complements and competes with these dominant modes of transportation, leveraging emerging technologies, such as autonomous driving, mobile computing, and electric vehicles. Despite the increasing interest in shared mobility systems, innovative methods focusing on optimization are necessary to sway consumer engagement. The next steps in smart mobility will focus on robo-taxis and aerial forms of transportation.

Vehicle Electrification

The final component of vehicles in the smart mobility landscape – electrification – is well underway, proliferating through EV adoption. EVs are an economical and, in most cases, environmentally friendly alternative to ICE vehicles. In a relatively short timeframe, significant movement has transpired in the automotive industry, setting a solid foundation and clear vision for an electric future that winds down the role of ICE vehicles in the modern mobility system. With increasing demand from personal and fleet vehicles, around 500 EV models have been announced by OEMs through 2025. To realize this electric future, auto OEMs have made massive investments and existing and new technology companies are entering the landscape to aid in the transition away from traditional mechanical components to increasingly complex digitized and connected infrastructure, changing the way vehicles are manufactured.

EV sales are on the rise in Canada and globally. In 2021, EVs accounted for 5.3% of total vehicle registrations in Canada (Canada Energy Regulator, 2022). As of 2022, EVs – battery electric vehicles (BEVs), hybrids, plug-in hybrids, and fuel cell vehicles – made up a 14% share of the overall car market (International Energy Agency, 2023). Canada's EV market unit sales are expected to reach over 250k in 2028, with the global EV market share anticipated to increase to account for 35% by the end of 2023 (International Energy Agency, 2023). BEVs are projected to be the most common form of vehicles manufactured and sold as ICEs are phased out, having gained popularity over the last decade. BEVs are steadily gaining popularity over their hybrid counterparts due to their high efficiency, increasing battery range and the availability of reliable charging infrastructure. Decreasing battery costs per kWh has also contributed to making EVs more affordable for the mass market. Ambitious policy programs, such as the European Union's Fit for 55 package and the United States' (US) Inflation Reduction Act, are projected to further bolster market share for EVs.

Based on numerous studies, in comparison to an ICE vehicle, EVs have 70% fewer parts. The transition towards electric motors is supported by their functionality – having shorter response times, less energy consumed while idling, a wider usable rpm range, and offering a much smoother driving experience. The powertrain of BEVs has fewer components and fewer moving and wearing parts relative to ICE vehicles, as traditional fuel-powered ICEs are substituted with electric motors. Electric motors get their power from the energy provided by an onboard battery pack – mostly a lithium-ion battery (LIB).

Access to reliable charging infrastructure has been a major roadblock in the adoption of EVs. A significant portion of early EV adopters today charge at home and have access to a residential charger. However, as EVs become increasingly popular, providing EV drivers with ample charging options at workplaces, shopping centres, and along highway corridors is critical – especially for those who do not have access to an off-street parking spot.

There are a lot of things that go hand-in-hand with smart mobility, from connected products to autonomous driving, shared mobility, and vehicle electrification. As technology drives forward, it impacts how vehicles are designed, produced, sold, repaired, and used, thereby impacting every facet of the industry as it becomes more digital, greener, and more complex.

Obstacles to large-scale smart mobility

Despite the promise of an electric and autonomous mobility future, with enhanced connectivity, and sharing capabilities, backed by at least a decade of technology development, and billion dollars invested for this potential to come to fruition, large-scale development of smart vehicles has not been reached yet. Google's co-founder Sergey Brin, announced to an audience in 2012 that he anticipated driverless cars by 2017. Since 2014, Tesla's CEO Elon Musk has annually promised cross-country driverless trips. Though connectivity is advancing, driverless cars do exist, the sharing economy is progressing, and the transition is well underway to its ambition of being fully electric by 2050, there are critical interlinked obstacles to overcome to see large-scale development of smart mobility and its vehicles.

Technological challenges

Technological considerations are one of the numerous reasons we have yet to see smart vehicles develop to an advanced and large scale. Though they have increasingly connected and autonomous capabilities, smart vehicles cannot replace drivers yet, who rely primarily on vision, with hearing also playing a role. Smart vehicles and their makers use big data and machine learning to drive decisions based on the mapping the vehicle system can create, sending commands to the engine, steering, and brakes to respond. Using a combination of this collected data and simulations, machine-learning algorithms are progressively trained to better direct vehicles under various circumstances. Though these vehicles are great in scenarios they are familiar with from their training set, the technology still struggles to deal with new, out-of-the-ordinary circumstances, also known as edge cases. Edge cases are instances in which the smart vehicle has not yet been trained and is not captured in the data set, thereby preventing the vehicle from responding accordingly. These edge cases have led to accidents and injuries in several cases and need to be tackled with extreme caution.

Smart vehicles increasingly use a multitude of sensors – radar, cameras, sonar and LiDAR, that AI and advanced algorithms then put together to analyze surroundings. Additionally, the costs associated with CASE technologies, automakers in the smart vehicle game (i.e., General Motors (GM), Waymo, Tesla, etc.) have each developed their own combination of sensors, as well as electric platforms, each with varying levels of capabilities and capacities. Tesla vehicles are equipped with a combination of cameras, ultrasonic sensors, and radar. Neural networks are then used for processing the collected data. In comparison, Cruise (GM) and Waymo vehicles are equipped with a suite of sensors, including lidar, radar, and cameras. Lidar is a technology that uses laser light to measure distances and create detailed, high-resolution 3D maps of the environment. In terms of electrification, to achieve widespread adoption, technological advancements must continue to be made to increase their affordability and performance, particularly regarding range and charge times. Future pathways being explored include lithium-metal, solid-state batteries, and silicon.

Regulation and safety challenges

The regulation of vehicles, particularly smart vehicles, faces several regulatory challenges and distinctions in the Canadian context – largely due to the multi-layered governance structure impacting the large-scale development of smart mobility and the vehicles that support the concept. Automakers developing smart technology must follow the watermark set by Canada's Motor Vehicle Safety Act (MVSA), which sets out guidelines for all vehicles regarding what type of vehicle can come into Canada and across its provinces and when. The MVSA and related regulations have been updated to permit the import of more advanced CASE technologies, such as AVs. However, there are severe limits on permitted usage once in Canada. In the case of AVs, they are only allowed for testing purposes. Consumer vehicles that have advanced connectivity and self-driving capabilities must comply with the MVSA, which will likely require amendments to regulate advancing levels of automation in the near future.

Where federal legislation dictates entry requirements for smart vehicles into Canada, provincial regulations determine whether vehicles are safe to drive on public roads within its jurisdiction, regulating the safe operation of vehicles, registration, licensing, insurance, traffic regulation, and maintenance standards. Alberta, Manitoba, Ontario, and Québec are piloting numerous innovative programs to take advantage of AV technology.

In addition to coordinating amongst internal levels of governance, Canada must continue to align with the US Department of Transportation on CASE transportation, given how integrated North America's automotive manufacturing, marketplace, and transportation networks are. Canadian automakers, as they pursue developing smart technologies, will need to improve systems and reduce cyber vulnerabilities to align with best practices adopted by the US and other importers of Canadian vehicles.

Ultimately, when it comes to smart vehicles, the regulation landscape required for safe, comprehensive CASE adoption does not exist. Historically, when vehicles became more commonplace and associated deaths began to rise, the automakers self-regulated by inventing safety features, but it required government policy that standardized and enhanced these features. Smart mobility requires regulations and safety policies to guide automakers and drive safe deployment, particularly when auditing smart systems presents its own challenges. For example, if autonomous vehicles routinely update their software via cloud services, it will likely be difficult to determine whether the introduced change will impede an approved feature, such as a vision system. Despite these challenges, many barriers to adoption can be improved with regulator standards that help establish trust for function and safety, and create a minimum requirement for these emerging technology systems.

Social acceptance of technological development

Though smart mobility, and smart vehicles themselves, have many potential social and economic benefits, from a reduced environmental impact, quicker travel times, and the promise of fewer road accidents, their implementation depends on public acceptance. While a mobility future founded on wholly realized CASE technology may seem ideal, the amplification of smart vehicles will largely be driven by attitudes toward these technologies and risk aversion. There is public distrust and resistance when it comes to certain CASE technologies. For example, the battery function of EVs, or mistrust in autonomous technology achieving better driving performances compared to human operators. Public perception has a powerful influence on political priorities and changing regulatory and policy landscapes that foster their large-scale development. As buyers focus on infrastructure challenges, prioritize purchase costs and other barriers to adoption, there may be a tendency to stick with the products they are familiar with (i.e., ICE vehicles) instead of being front-runner purchasers of smart vehicles.

Security considerations

With increased technology, data collection and sharing, and digitization, smart vehicles may be at greater security risk than traditional vehicle models. The same connectivity capabilities that promote MaaS, such as software updates and data sharing, leave vehicles vulnerable to breaches without adequate cybersecurity management systems. While the ISO/SAE 21434 risk assessment is a solid foundation from which to develop these necessary systems, manufacturers will be required to have enhanced cybersecurity systems in place as smart vehicles continue to advance and new security risks are created.

Infrastructure development

Smart vehicles require smart mobility infrastructure. Achieving large-scale development requires a radical structural overhaul. For example, advanced autonomous vehicles require clear lane striping and massive digital infrastructure to house vehicle and driving data. For shared mobility, urban planning would see a reduction of parking lots, with more pick-up and drop-off locations. EVs require a more robust charging network. These mass-scale changes, to physical infrastructure (roads and buildings), digital (data servers), and all the technologies required, can be costly to develop, deploy, and maintain.

Implications of smart mobility on labour

Both personal and commercial transportation plays a critical role in defining the future of smart mobility. This section examines the impact of smart mobility adoption on labour, particularly exploring the implications of smart mobility development across Canada on the automotive manufacturing labour market.

Smart mobility has the potential to make transportation cleaner, safer, cheaper, faster, and more accessible. As the mobility sector faces significant transformation spurred by ongoing technological disruptions, the overall impact of the smart mobility revolution is anticipated to be positive. From training initiatives, skill development, and job creation to cybersecurity, infrastructure development and legislative adaption, smart mobility is reshaping and responding to societal needs. However, the impact on jobs remains uncertain. As Canada works towards a net-zero economy, especially in the mobility sector, jobs are impacted by shifts towards sustainable consumer preferences, technologies, supply chain structures, and modes of production and processes. This suggests that incoming generations of workers in the mobility sector, and related areas, may require different skills than what is required today.

Canada has yet to achieve the same level of smart mobility as other major auto manufacturers like US, Japan, and Germany. As its CASE technologies improve, proliferate, and become more widely accepted, Canada's labour market will experience more disruptions, changes, challenges and opportunities. Similar to previous periods of technological advancement, the rise of CASE technology in the smart mobility transition will likely result in changes to Canada's labour market needs; required job skills and roles will shift with the adoption of new technology in production.

Connected and autonomous vehicles – Implications on jobs

The role of connected and autonomous vehicles (CAVs) in the smart mobility transition may have mixed impacts on jobs, depending on the uptake of technologies and regulatory frameworks. The impact of CAVs on jobs will also vary depending on the region and industry. Though some jobs will likely be displaced, it is anticipated that the advent of CAV vehicles will result in new jobs, particularly in engineering, vehicle monitoring, cybersecurity, and data analysis.

The adoption of CAVs may lead to human-operated driving jobs being phased out in specific sectors within the transportation system, specifically in the trucking and passenger transportation sectors (namely taxis and chauffeurs) (Cutean, 2017). While increasing connectivity and automation are anticipated to displace jobs in certain branches of the transportation sector, job reductions will likely occur gradually over the next decades as graduated levels of each technology are adopted. In a study regarding freight automation, partial automation is unlikely to have significant adverse effects on the workforce, and Level 4 and 5 automation technology may take up to 25 years to be widely adopted (Fitzpatrick et al., 2017; Simpson et al., 2019).

The scope and permanency of potential job losses is unclear. Gradual job losses may be eased by an aging and retiring workforce and an already existing shortage of qualified drivers at existing pay rates, such as in the trucking industry. Though some workers may encounter unemployment and lower wages in the early stages of adoption of Level 4 and 5 automation technologies (Mudge et al., 2018), CAVs will likely not lead to long-term job losses. It is anticipated that such technologies may attract new drivers to the sector by establishing an improved quality of the available jobs and reduced stress as driver roles and responsibilities shift with connectivity and automation (Short & Murray, 2016; Stantec & ARA, 2020).

Despite anticipated job losses early in the adoption process, the overall job creation potential associated with CAV adoption may be significant and net large-scale job losses across the economy are unlikely (Cutean, 2017). Connected and autonomous advancements will require workers that are equipped with new skills. For example, increasingly connected and autonomous freight may reduce the need for specific jobs, mainly existing truck driving positions, taxis and chauffeuring. Level 4 autonomous vehicles could increase shipping productivity and free up capacity for system monitors to focus on alternative tasks, such as logistics, while the vehicle drives autonomously. Canada is seeing the emergence of several critical occupations within the technology space, such as automotive engineers focused on automated vehicle research, advanced driver systems and AV trainers. Additional areas that will see new jobs created include vehicle monitoring, data analytics, and cybersecurity.

The rising demand for jobs that entail more expertise in advanced technology has yet to result in displacing traditional occupations (e.g., transit dispatchers). However, the skill requirements for these roles may change over time as workers will need to be familiar with the operation and servicing of increasingly connected and autonomous vehicles. Though connected and autonomous-related jobs will bolster demand for digital literacy and alter existing transportation-related occupations, other industries, such as construction, city and public planning, and policy, are also anticipated to experience changes to required job skills and training. CAVs require rethinking and redesigning cities and infrastructure for smart mobility systems to function optimally, necessitating non-CAV jobs such as urban planners and policy makers. Training opportunities in fields relevant to a connected and autonomous economy, such as AI and robotics, are essential for job creation.

Job opportunities in shared mobility

The proliferation of shared mobility has seen a shift in the employment landscape for drivers by expanding opportunities for self-employed drivers. Transportation network companies (TNCs) such as Lyft and Uber have created a market for ride-hailing and sharing services governed by supply and demand, creating millions of jobs (Khamis & Malek, 2023). An MIT Technology Review studied the impacts a growing "shared economy" has on jobs by examining the instructive example of Uber across key US cities, finding that TNCs offering car hire services have resulted in a dramatic rise of almost 50% of self-employed drivers (Berger et al., 2018). Additionally, the study observed a 10% increase in the labour supply of traditional wage-employed (taxi) drivers. While the analysis shows that self-employed drivers have experienced a 10% wage increase, the average hourly earnings of wage-employed drivers have decreased at a consistent rate in those areas where Uber operates. As well as providing additional self-directed sources of income for people, a number of these on-demand, crowd-sourcing point-to-point transportation services have expanded to other sources of employment, such as delivery services.

In addition to evidence that suggests shared mobility offers possibilities for employment opportunities, there are also indirect and social impacts where shared mobility is present and growing. A direct benefit of shared mobility includes improved temporal accessibility provided by subsidized ride-hailing and -sharing services (Marsden, 2022). Specifically, people in areas with limited access to public transportation are to participate in jobs where shared mobility options were available, particularly during non-standard business hours (Marsden, 2022).

Electrification-related job changes

The transition to vehicle electrification has been touted as a source of job creation. The Biden administration stated that evolving US EV policies will create one million new jobs in its domestic automotive industry (The White House, 2021). Canada's Natural Resources Minister Jonathan Wilkinson also predicts the transition toward vehicle electrification will create good, well-paying jobs, spreading economic prosperity throughout the country, with the risk of labour supply not meeting demand (Thurton, 2023). In addition to impacts on automotive manufacturing jobs, electrification will also impact labour in the fossil fuel and biofuel industries, as well as mining. However, level of impact directly attributed to the transition to EVs is directly linked to the rate of the shift in production to vehicle electrification, which is determined by the rate of adoption of these vehicles. FOCAL forecasts that the transitioin to vehicle electrification could create up to 100,000 jobs over the upcoming 15 years if the sector is sucessful in fully shifting to BEV production (FOCAL Initiative, 2024).

Automotive electrification will impact other jobs as well, with a growing demand for higher-skilled jobs also projected due to the changing nature of the work that is needed to repair and maintain electric vehicles and their infrastructure. Jobs such as automotive mechanics may expand to include skills for EV maintenance, and certification programs aimed at regulating these skills may expand the scope of training required in in traditional auto repair occupations.

There is strong belief that though workers will be impacted by the EV transition, there will be the possibility of up-skilling or transitioning to equivalent jobs. However, the scale and speed at which these jobs are affected will depend on how quickly EVs replace ICE vehicles. Increased vehicle electrification is spurring job disruptions across sectors, pointing to the urgent need for workers with new skills to fill a growing gap – from workers to management across industries, such as technology, automotive, mining, and energy. A shortage of advanced digital skills and engineering has already been exposed in the current ratcheting of electrification.

Though opportunity and disruption will spread unevenly across sectors, Canada's automotive manufacturing sector is expected to encounter widespread and substantial transformation and opportunity.

Impacts of smart mobility on automotive manufacturing jobs

The future of the automotive manufacturing workforce is anticipated to be challenging one despite a more than two-century history of undergoing mass disruptions with adopting new technology (ILO, 2021). Much like the impact of smart mobility on the broader labour force, the effects on Canadian automotive manufacturing jobs remains uncertain and contingent on several factors, including the speed and scale of the transition away from ICE vehicle manufacturing, technological developments related to increasing connectivity and automation, adoption of robots and automation within manufacturing settings, AI, alongside a number of economic factors. Though the the nature and scope of the impact on job within the automotive sector is unknown, the smart mobility transition will spur critical changes in production and aftermarket.

Evaluating the labour demand for manufacturing smart vehicles

Canadian automakers, like those around the globe, are working on robotic technology that can enhance adaptability and enable their manufacturing processes to respond quickly to market demand. Canada has a strong history of investing in and utilizing automation and robotics in automotive manufacturing. In 2019, Canada ranked fifth globally in robot density in automotive sectors, placing well above the global average of 113 robot density[5] at 165 in 2021 (NGen, 2021, pp. 3-4). This has resulted in a strong foundation for supporting the sector through the smart mobility transition, both domestically and abroad. With world-class capabilities in automotive solutions and proficiency in flexible assembly, Canada is well-positioned to engage its experience to weather some of the disturbances of the transition.

Applying enhanced robotics, automation, and digitization to the development of smart mobility enables companies to become more productive, optimize new and existing processes, and create higher-quality products while offering more product options and services. For example, robots and digitization are taking on assembly processes such as welding and mounting, painting parts and inspecting their own quality. Generative AI is being applied to create new content and ideas, such as new design options, based on input from developers, driving a transformation of how vehicles are designed and built. Generative AI has the potential to aid automakers in efficiently identifying the best options for increasingly complex systems, such as vehicle features, lightweight structures, and powertrains and propulsion systems (Shapiro, 2023). These conditions allow automotive manufacturers to be more competitive in the global market and grow their businesses further. As success builds, so too can jobs.

In the last 20 years, employment in vehicle assembly and parts manufacturing has steadily declined in Canada (Future of Canadian Automotive Labourforce, 2022). As smart vehicles supplant the manufacturing of ICE vehicles and traditional automotive mechanical work, there is already evidence of some North American reducing production (Ford, 2023). However, the evolving smart mobility market can create numerous new opportunities and jobs, generating valuable revenue for Canada and its automotive sector. For example, the expansion of EV production in facilities such as the CAMI Assembly Plant in Ingersoll which aims to create approximately 300 new jobs and includes a new onsite battery plant (Town of Ingersoll, 2023). The market uptake of EV vehicles has proven to be slower than anticipated, meaning that some of the new facilities like Ford's Oakville Electric Vehicle Complex, are delaying production. This implies that some employment opportunities are deferred and remain tentative (The Canadian Press, 2024). Aftermarket servicing of the smart mobility market will likely require new training for traditional jobs

[5] Robot density is a measure of the number of robots installed per 10,000 manufacturing jobs.

related automotive service and may require create new positions that deal exclusively with the advanced technologies associated with these vehicles.

In the US, there is a growing geographic mismatch, with manufacturing facilities closing (particularly in the Midwest) and with others being opened in the South – where there is typically less of a union presence (Coykendall, Hardin, & Morehouse, 2023). This means that jobs are not necessarily available or accessible to the same people. Unlike the US, federal and provincial investment is spurring new smart mobility production development in Canada, where there is already a strong automotive presence, with announced plans for a new Ford EV plant in Bécancour, Québec (creating 345 new jobs), Stellantis developing a new large-scale battery manufacturing plant in Windsor (creating 2,500 new jobs) and a Volkswagen battery plant in St. Thomas (creating roughly 3,000 direct jobs, and 30,000 indirect positions). In the case of all of these manufacturing developments, Unifor has already been engaged to unionize these facilities. A 2022 study found that due to the labour required to produce the powertrain for smart vehicles, specifically BEVs (the production of EVs requiring more hours to manufacture than ICE vehicles) (Cotterman et al., 2022), there will be a continued demand for jobs. The effect on net jobs is flattened given that the elimination of ICEs means those related auto-parts manufacturing jobs in the supply chain will disappear, and EVs are said to require 30-40% less labour to produce compared to ICE vehicles, and more automation adoption, meaning many assembly jobs may shrink.

Smart manufacturing adoption and labour shortages

The Canadian automotive manufacturing sector is already experiencing a significant mismatch between available workers and the skills required for open positions throughout the production process – something smart manufacturing is seeking to level. Current technology is evolving to be capable of matching the quality and throughput that humans accomplish. Manufacturing is employing AI and other technologies to collect and analyze data to replicate and improve results. However, new technology necessitates trained and specialized workers who are in high demand. For example, experts in digital and data literacy are hard to recruit and retain due to increased competition from other sectors seeking the same skillsets. Automakers are also experiencing tough competition to meet engineering needs and supply shortages of service and repair technicians. Therefore, smart manufacturing will require a labour force that is capable of using smart technology on the shop floor and beyond.

A forecast analysis conducted by Future of Canadian Automotive Labourforce (FOCAL) identified that between 2021 and 2030, there will be approximately 22,100 projected job openings across Canada's automotive sector, with around 16,050 of these positions being needed to fill the recruitment gap in the sector (Future of Canadian Automotive Labourforce, 2023). Table 1 outlines the various occupational deficiencies in Canada's automotive manufacturing landscape as it responds to the evolution of smart mobility.

Table 1. Potential career paths and future in Canada's evolving automotive sector

Occupation	Occupational Employment Across Canada's Sectors & Industries (as of 2021)	Projected Job Openings in Canada's Automotive Sector (2021-2030)	Automotive Recruitment Needs (2021-2030)
Motor Vehicle Assemblers, Inspectors & Testers	>55,000	>10,500	>6,600
Machinists & Machining & Tooling Inspectors	>35,200	>1,100	>930
Welders & Related Machine Operators	>83,000	>1,350	>970
Mechanical Engineers	>53,000	>830	>550
Engineering Managers	>30,000	>210	>50
Supervisors, Mechanical & Metal Products Manufacturing	>2,600	>100	≈90
Construction Millwrights & Industrial Mechanics	>61,000	>1,450	>1,300
Shippers & Receivers	>110,000	>710	>600
Industrial & Manufacturing Engineers	>15,600	>350	>270
Automotive Service Technicians, Truck & Bus Mechanics & Mechanical Repairers	>146,500	>640	>500
Tool & Die Makers	>9,000	≈940	>850
Industrial Painters, Coaters & Metal Finishing Process Operators	>13,500	>680	>500
Database Analysts & Data Administrators	>25,000	>50	>50
Industrial Engineering & Manufacturing Technologists & Technicians	>16,150	>300	>200
Manufacturing Managers	>70,000	>1,500	>1,400
Metallurgical & Materials Engineers	2,700	40	40
Supervisors, Electronics & Electrical Products Manufacturing	>2,100	≈50	50
Supervisors, Motor Vehicle Assembling	>7,385	≈1,300	>1,100

Source: (Future of Canadian Automotive Labourforce, 2021)

Shifting job opportunities – away from traditional manufacturing jobs

Canada's automotive manufacturing sector is expected to experience substantial structural transformations, with benefits such as higher productivity and the expansion of products and services. Its labour force, similarly will experience some transitions, with traditional jobs and skills at risk of disruption and restructuring. However, the smart mobility transition will create opportunities for new skill development within the existing labour force and may include the addition of new occupations within automotive manufacturing sector. As Table 1 above highlights, there is a growing need for workers at the factory to transition to more skilled work, such as analyzing data collected by robots or maintaining and updating equipment. With smart manufacturing enhancing metrics such as productivity, quality, safety, and capable of performing increasingly complex tasks., technology will systematically replace more manual and repetitive tasks that traditional production jobs entail. This creates an opening for workers to engage in uniquely human skills, such as "soft skills", critical thinking, leadership and creativity. Companies increasingly need workers who can apply these skills and integrate advanced technologies and automation, as manufacturing will continue to rely on technological and digital tools to enhance the production process.

A 2022 study estimates that as Canada continues to strategize and implement policies toward a net-zero economy, relative to 2015, all decarbonization pathways lead to higher numbers of jobs in manufacturing (Atiq et al., 2022). Specifically, 20,000-26,000 more jobs will be created in transportation equipment manufacturing, predominantly those classified as high-skill-level occupations, such as battery technicians in the EV industry (Atiq et al., 2022, p. 57). Professionals who are proficient at applying advanced technologies in a manufacturing setting are critical to the successful implementation of smart factories. Vehicles that feature smart mobility CASE technologies are more complex to build and may require higher levels of automation and advanced robotics in their manufacturing. For example, robotics is increasingly employed throughout the production stages of AVs for welding, painting, and assembly processes.

The transition may also be a platform to improve the quality of work, wages and benefits of those already working in the sector and those looking to enter it. Manufacturing jobs in Canada's automotive industry have been in steady decline since peaking in 2000 with 153,000 jobs (Holmes, 2022). The sector experienced a loss of 56,000 jobs in 2010 before a slight recovery. While facing declining automotive jobs, continued union concessions responding to pressures from automakers to remain competitive in the face of growing foreign-owned non-unionized competition resulted in diminished job quality, along with tightening wages and benefits compensation.

The latest round of collective bargaining in the fall of 2023 in both Canada and the US highlights the priorities and efforts to protect auto workers during the transition to EVs, which require less assembly due to having fewer parts. This can and should be expanded to address other developments in smart mobility technology which are likely to impact automotive manufacturing workers. Most of the protections negotiated into the 2023 contracts Unifor signed with Canada's major auto players focus on improving income supplements for workers throughout the transition, particularly the re-tooling of existing facilities. Recent negotiations will result in a compounded rise of 20% for production workers and 25% for skilled trades over a 36-month period, with cost-of-living adjustment folded in. This results in a respective 6.7% and 8.3% increase annually until the fall of 2026, with existing and new hire employees receiving a pay increase. Additionally, negotiations focused on guarantees that assembly plant workers no longer required to work on EVs' mechanically simpler powertrains will have the opportunity to relocate to other manufacturing positions, particularly battery assembly plants. Shifting those at risk in the smart mobility transition to facilities that are foundational in its success could help avoid layoffs and present new opportunities for training and re-skilling an existing labour force. This employment strategy has been utilized in the EV transition underway in China and South Korea and could help Canada's autoworkers weather the adverse disruptions of the transition.

Conclusion

Although policies are driving increasing adoption of CASE technologies in vehicles to support the adoption of smart mobility technologies, such policies alone will not be able to facilitate a smooth transition for those working within Canada's automotive landscape. Historically, market-led transitions have been tough for workers and those within dependent communities. It is essential for governments and automakers to establish a policy framework, with the necessary long-term planning and support, to help weather the rapidly changing automotive manufacturing landscape. A proactive approach to managing this evolving landscape and shifting employment opportunities around a deliberate wind-down of ICE vehicle manufacturing can have numerous advantages. Deliberately setting a global pace for smart vehicle manufacturing can provide important signals and clear trajectory for stakeholders and other countries, helping to spur planning and allocate resources to ensure that funds and support are available to workers impacted in the transition. Given the Canadian automotive sector is already facing a labour shortage, the shift towards EV's is likely to exacerbate the skills shortage unless supports are put into place to provide training and career paths to current and future workers. Employment opportunities in this changing landscape require time for the necessary labour market, infrastructure, and capital adjustments; early signals that this transition is underway will permit adequate preparations for impacted stakeholders.

Canada has the opportunity to be a global leader by being an early mover in supporting its labour force and spurring other countries to overcome the possible disruptions of a changing automotive landscape driven by increasing pledges to electrify transportation across the globe.

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