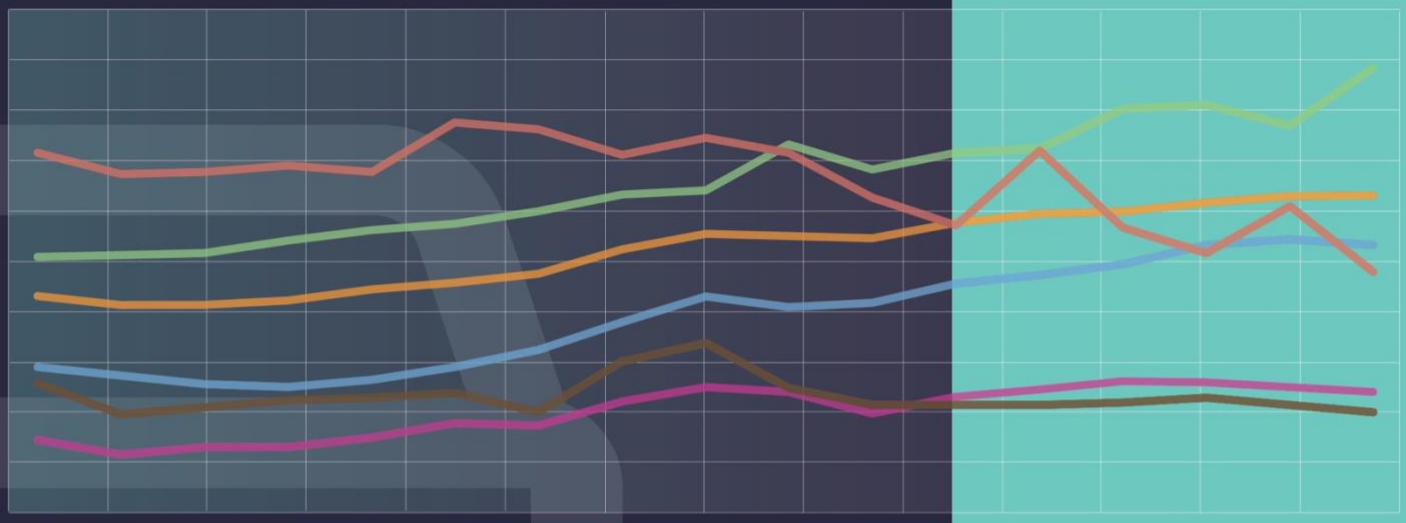
FOCAL Initiative
Future of Canadian Automotive Labourforce
Sur l'avenir de la main-d'œuvre de l'industrie automobile canadienne

TREND REPORT

# AUTOMOTIVE INDUSTRY LABOUR MARKET ANALYSIS

# IMPACT OF INDUSTRY 4.0 TECHNOLOGIES ON KEY OCCUPATIONS IN AUTOMOTIVE MANUFACTURING



**The project is a collaboration of the Canadian Skills Training and Employment Coalition, Prism Economics and Analysis, and the Automotive Policy Research Centre.**

April, 2020

*futureautolabourforce.ca*

**THIS PAPER** was prepared for the Auto Labour Market Information (LMI) Project, now known as the Future of *Canadian Automotive Labourforce (FOCAL) Initiative.*

The goal of the project is to help stakeholders better understand the automotive labour market. The Project will create industry-validated, regional, occupational supply and demand analyses and forecasts and skill profiles for skilled trades and other key skilled occupations in the broader automotive sector including vehicle assemblers, parts manufacturers and technology companies that supply the industry. The project will also examine various labour market trends in the sector and facilitate discussions among stakeholders about how to address any forecasted skills shortages and other labour market challenges. The planned outcome of the project is enhanced regional labour market information that will support colleges, employers, policy makers and other stakeholders in taking practical steps to address skills shortages and other labour market challenges in the automotive sector.

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# EXECUTIVE SUMMARY

"Industry 4.0" is one of the leading trends in manufacturing technologies. For the Canadian automotive manufacturing sector to maintain its competitiveness and share in the North American market, production technology investments and upgrades such as Industry 4.0 systems can be one of the strategies Canadian automotive manufacturing firms can follow to increase their competitive edge in a highly dynamic market. Through its technologies, Industry 4.0 offers several advantages and incentives which can translate to increasing productivity in manufacturing, improving product quality, enabling mass customization in production and optimizing demand prediction and just-in-time delivery.

However, challenges in technology, integration and skills are also expected to arise with the adoption of Industry 4.0 technologies, which require increased industry collaboration to overcome. The cooperation of companies in the sector to drive towards Industry 4.0 adoption can contribute to better positioning Canada's automotive manufacturing sector within the North American and the global markets.

This paper outlines our study of the potential impact of the Industry 4.0 system on the automotive manufacturing workplace and on the tasks that are part of its key occupations. The aim of the study was to analyze potential changes and upgrades in tasks, roles and skills of key automotive occupations that could result from the accelerated adoption of advanced manufacturing technologies and systems such as Industry 4.0. In this task analysis, we consider the ten technologies most commonly associated with the Industry 4.0 system: artificial intelligence; smart sensors; internet of things (IoT); big data and analytics; cyber security; autonomous robotics; cloud computing; simulation; augmented reality and additive manufacturing.

We selected 48 automotive manufacturing-related occupations[1] for this task impact

[1] Previous reports and the supply and demand labour forecast under this project have identified 49 occupations relating to the automotive manufacturing sector however, this study examines 48 automotive manufacturing occupations out of the list, as the tasks performed by Automotive service technicians, truck and bus mechanics and mechanical repairers could not be assessed in a manufacturing or a production line context.

analysis. These 48 automotive manufacturing occupations were selected based on the number of employees in each occupation (a threshold of at least 100 workers in any one of the automotive manufacturing regions in Canada that we studied) by our project, or based on the set of skills and tasks performed by the occupation which are relevant to automotive manufacturing.

We grouped the 48 occupations into three main categories: Professional, Engineering and Technical occupations, Skilled Trades occupations, and Supervisors and Production occupations. We examined more than 1000 work tasks associated with these 48 occupations and assessed them for potential impact by one or more of the ten Industry 4.0 technologies. The tasks were assessed for three main forms of impact:

1. Tasks altered: tasks which would require an upgrade of skills to keep up with new technologies, systems and machinery.
2. Tasks partially eliminated: tasks partially assisted by new technologies, but which would still require a worker's input.
3. Tasks fully eliminated: tasks which would be fully automated and performed by new technologies or machinery.

We validated the results of our assessment by comparing our results to a previous study by Frey and Osborne (Frey & Osborne, 2013), which assessed 701 industrial occupations for potential impact by computerization, and a McKinsey & Company report (McKinsey & Company, 2018), which examined the occupations for their susceptibility to automation.

The results showed that the highly skilled, highly paid occupations are projected to be least impacted by the adoption of Industry 4.0 systems (Figure 1). Less than 30% of the tasks for occupations in the Professional, Engineering and Technical category are forecast to be impacted and only 8% of those tasks are forecast to be fully eliminated (with the exception of "*Shippers and receivers*", and "*Production logistics coordinators*" where the impact was around 90%). In this occupational category, big data and analytics, simulation and cloud computing are forecast to have the most impact on the tasks of occupations in this category. The "*Senior managers*"

occupation is the only occupation that is forecast not to be affected by the changes introduced by Industry 4.0 systems, and "*Engineering managers*" and "*Human resources professionals*" remain at the lower end of the impact. On the other hand, 42.5% of the tasks of technicians and technologist are expected to be affected by the Industry 4.0 technologies, as the tasks in these occupations involve a higher level of manual work.

Almost 50% of the tasks carried out by employees in the Skilled Trades category will potentially be impacted by the new production technologies that are part of Industry 4.0. The forecast results within this category vary: the tasks of "*Electricians*" are expected to be modestly impacted (23.8%), whereas occupations such as "*Tool and die makers*" and "*Machinists"* will be significantly impacted (approximately 82% of tasks will be impacted). In this occupational category, autonomous robotics and smart sensors have as much impact as data analytics, cloud computing and simulation.

Occupations in the Supervisors and Production category are forecast to be the most impacted by the technology upgrades of Industry 4.0. In this category, almost 83% of employees' tasks will be potentially impacted and close to 50% of tasks will be potentially fully eliminated. The "*Motor vehicle assemblers, testers and inspectors*" occupation, which includes the largest number of employees in this category (48,000 employees), is forecast to have 75% of its tasks impacted by the technologies of Industry 4.0. "*Plastic products assemblers, finishers and inspectors*" is the most impacted occupation among the 48 automotive manufacturing occupations - for these jobs, the projected impact rate is close to 96%.

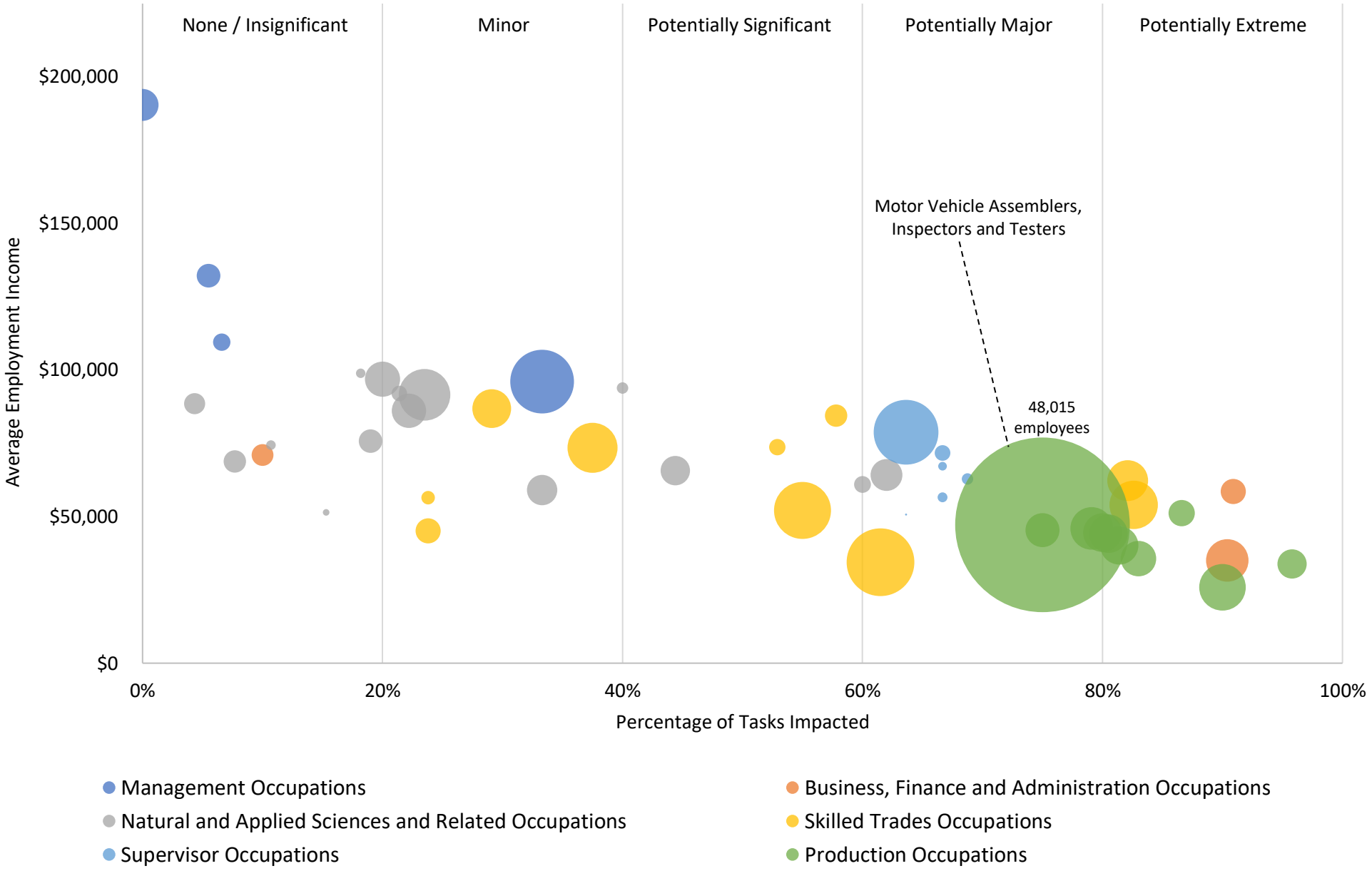
The introduction of new production technologies that are part of Industry 4.0 will also lead to the creation of new job titles within workplaces in Canada. Jobs such as "*3D printing machinists*", "*Cyber security specialists*", "*Mechanical design simulation engineers*" and "*Robotic welding technician*" may become new job titles which fall under one or more of the 48 selected automotive manufacturing occupations. New occupations may also be created for work related to installing, operating and maintaining the technologies and systems of Industry 4.0.

While the impact of technology upgrades in the workplace has historically been limited to the automation and elimination of manual tasks, the potential impact of Industry 4.0 will be broader than just physical and routine tasks. With Industry 4.0's technologies involving analytics and computing capabilities, almost all of the occupations selected for this study will be impacted in one way or another.

In general, the impact of Industry 4.0 technologies is greater for the lower paid occupations, especially production occupations which will have the majority of their tasks potentially impacted and a significant number of them fully eliminated. Meanwhile, employees in other occupations such as engineering, technical and skilled trades occupations will have to upgrade some of their skills and face some task changes in the workplace.

With increased digitization in the workplace, the recent acceleration in the adoption of cloud-based systems for corporate resource management and the constant incorporation of robotics across the production line, it is anticipated that the upcoming years will carry the sector's transition towards the new industrial system of Industry 4.0. This transition will be driven by numerous factors and incentives including the need to maintain the competitiveness, position and share of the Canadian automotive manufacturing sector within the North American market, the need to continue being part of the complex, dynamic and rapidly evolving regional supply chain, and the need to offer higher levels of flexibility in both products and processes. This transition will bring changes to the manufacturing workplace and workforce. Therefore, in order to achieve a successful and smooth transition, anticipating and comprehending the upcoming changes will be important and will aid in maintaining the sector's competitiveness.

***Figure 1. Distribution of the impact of Industry 4.0 technologies on the 48 selected automotive manufacturing occupations***



# INTRODUCTION

Automotive manufacturing in Canada has long maintained its position among the country's most prominent industrial sectors. In 2019, the sector (North American Industry Classification System codes 3361, 3363) accounted for almost 7.7% of Canada's manufacturing GDP and 20.2% of the country's manufacturing trade (Statistics Canada, 2019; Industry Canada, 2019). It is also part of an extensive, complex, competitive and rapidly evolving regional and global supply chain. In an earlier report prepared by this project, we estimated that over 170,000 people are employed in automotive manufacturing and its supply chain (FOCAL, 2019)[2]. The sector's high-quality products and growing productivity are competitive advantages; it is important to sustain both in order to maintain the sector's regional and global positions, as well as its share of North American production (FOCAL, 2019)[3].

In manufacturing, implementing and integrating automation and new production technologies have historically been associated with higher efficiency and greater productivity. The McKinsey Global Institute (MGI) estimates that increased automation could raise global productivity by 0.8 percent annually (McKinsey & Company, 2017). In Canada, improving the automotive manufacturing sector's productivity requires significant capital investments in automation and in new production technologies and systems (CAPC, 2016). An accelerated adoption of manufacturing technologies in the Canadian automotive manufacturing sector yields a more technologically advanced, productive, efficient and competitive industry regionally and globally.

While there are numerous production technologies and systems which companies can consider investing in to upgrade their manufacturing operations, Industry 4.0 stands out as one of the leading trends towards automation and data exchange in

[2] Future of Canadian Automotive Labourforce Initiative: Defining the Broader Automotive Sector, 2019.
[3] Future of Canadian Automotive Labourforce Initiative: Production Mandates and Impact on Labour Market Forecasts, 2019.

manufacturing. Industry 4.0 is an integrated system of simultaneously connected technologies, machinery, components, assembly lines and services which use data and analytics to offer a more efficient, productive and precise manufacturing process (Liu Y, 2016; BCG, 2015). Industry 4.0 also allows for mass customization in production, optimizes demand prediction, enhances just-in-time (JIT) delivery and opens the door to data-driven product design.

While the adoption of the technologies of Industry 4.0 manufacturing systems is predicted to accelerate in the upcoming years, this adoption will be accompanied with challenges in technology, integration and skills. Managing large quantities of generated data, establishing communication and sharing data among the different Industry 4.0 systems across the supply chain, and ensuring the presence of a high-level of talent and skills in the sector are among the anticipated challenges for Industry 4.0 systems, which the sector can overcome through increased cooperation and collaboration between Canadian companies (Deloitte, 2014).

Our study aims to analyze the impact that the adoption of Industry 4.0 systems and technologies might have on the workplace and the automotive manufacturing workforce. The main objective is to forecast potential changes in the tasks and roles of 48 selected automotive manufacturing occupations due to the increased adoption of advanced manufacturing technologies and systems such as Industry 4.0. Our findings will assist automotive manufacturing companies, managers, policy makers, educators and workers in anticipating the resulting broad changes in occupations and the demands at the specific, individual occupational level. Our study also aims to introduce stakeholders to a set of skills which might be required by each occupation to perform manufacturing tasks. Finally, a list of new job titles associated with Industry 4.0 is presented which will be potentially associated with one or more of the 48 automotive manufacturing occupations. Being aware of and understanding the upcoming changes and skill upgrades can assist in developing relevant policies and facilitate a smoother transition towards an upgraded manufacturing system in the sector (Geissbauer, R., 2016).

# INDUSTRY 4.0

Recent developments in manufacturing technologies have seen an increased shift towards digitization supported by the incorporation of computerization and connectivity in the workplace (WEF, 2016). The increased generation and collection of data by sensors, equipment and machinery, and the advances in fields of data analytics and robotics have all contributed towards accelerating the introduction of Industry 4.0 systems. Industry 4.0 is a set of physical and digital manufacturing assets and technologies which use data to enhance the overall manufacturing process and product (Bagheri, 2015). Industry 4.0 also provides enhanced transparency across the supply chain, integrating and connecting suppliers, manufacturers, customers and the product itself over a single network (BCG, 2015).

While different manufacturing technologies could impact production and the tasks of manufacturing occupations, this paper focuses on a specific set of technologies associated with Industry 4.0 and examines their potential impact on the workplace and on 48 automotive manufacturing occupations.

## Technologies of Industry 4.0

Numerous technologies have been associated with the modern manufacturing system of Industry 4.0 over the course of the past decade. However, previous research conducted by the Automotive Policy Research Centre (APRC) has identified the ten technologies and elements that are most commonly linked to this new industrial system (Kazzaz & Mordue, 2019). The technologies and their descriptions are:

1- Artificial Intelligence: Artificial intelligence (AI) allows machines and computers to learn from experience using new input, problem-solving and machine learning algorithms. Based on data and data patterns collected from sensors, machines, computers and human-input, AI can be used to train machines and computers to perform specific tasks and simulate the

intellectual and analytical process of humans in the decision-making (SAS, 2020).

2- Smart Sensors: Smart sensors are electronic components which collect, convert and process physical inputs to digital data. While traditional sensors constitute of analog or digital sensors only which collect and output data points, smart sensors include digital sensors, microprocessors and communication technologies which analyze and communicate useful information with other components. Smart sensors allow data to be processed and analyzed closer to the source, making real-time decisions as data is collected (EY, 2019).

3- Internet of Things (IoT): The Internet of Things is a system of interconnected digital devices which communicate and interact using standard internet-based protocols. The digital devices of IoT include sensors, machines, computers, phones, products and other components. IoT makes use of the embedded computing capabilities of devices to decentralize analytics and make real-time decisions (BCG, 2015).

4- Big Data and Analytics: The digitization associated with Industry 4.0 systems allows the gathering and organizing of big datasets from various sources across the supply chain. “Big Data and Analytics” is the collection, processing and analyzing large datasets using advanced algorithms to detect complex data patterns and correlations. Big data and analytics can assist in detecting errors and failures, enhance production quality and accuracy and increase supply chain efficiency (BCG 2015, Walker, 2016).

5- Cyber Security: The digital transformation in both the production process and final product is associated with digital risk of malicious cyber-threats and attacks. Such risks might cause to damage to the industrial systems and connected components and products. Cyber security in automotive includes in-vehicle security, vehicle-to-everything (V2X) security, and the overall manufacturing supply chain. Cyber security systems protect the product, as

well as the overall manufacturing system from various cyber-attacks and threats (APMA, 2020; Huelsman, 2017).

6- Autonomous Robots: Robots and robotic arms are becoming increasingly functional, accurate, flexible and cooperative. With smart sensors, the constant generation and exchange of data and with the presence of artificial intelligence, autonomous robots are aware of their environment, continuously learning and independently making decisions on the production line and in other divisions. Autonomous robots improve efficiency and accuracy and are capable of cooperating with humans to reduce manual labour input and injury risk (EY, 2019; Deloitte, 2017).

7- Cloud Computing: The cloud is a network of remote servers which operate as a single ecosystem for digital information and services. The cloud stores and manages data, runs software, carries analytical processes and delivers digital services. In manufacturing, the cloud hosts and analyzes the data generated from the various machinery, sensors, computers and human resources. The cloud also establishes and coordinates the digital communication among the various components of the supply chain to offer an integrated end-to-end manufacturing process (Microsoft, 2020).

8- Simulation: Simulation modeling and analysis is the use of software to create numerical models of systems and products. Simulations assist in the design, development, analysis and testing of new systems or concept products prior to implementing them. Carrying out simulations helps in the gathering of information which may be otherwise difficult to obtain or measure, and in the early detection of errors and risks. This technique reduces costs, minimizes failures and optimizes the performance or design of processes and products (Mourtzis, 2014).

9- Virtual Reality / Augmented Reality: The generation of 2D and 3D graphics which can be displayed on tablets and wearable glasses can enhance the efficiency and flow of operations during production. Such equipment can

display instructions and graphics, as well as show real-time indicators to workers while they execute a task or a set of tasks. Augmented reality can also be used in hands-on and safety training without interrupting production flow and wasting additional resources (PwC, 2016).

10- Additive Manufacturing: Additive manufacturing is a computer-aided manufacturing process which creates parts or components through adding layers of material. The most common method of additive manufacturing is 3D printing which has numerous advantages in small batch productions as well as in prototyping and customized complex products. Additive manufacturing is considered to be an efficient and cost-effective method which is already being utilized in several industrial applications (BCG, 2015).

## Advantages of Industry 4.0 Systems

There are numerous incentives and reasons to consider the adoption of an Industry 4.0 framework in a manufacturing setting. These advantages contribute to enhancing a firm's final product and production process and can also leverage a company's competitive edge in the sector. Below are some of these incentives:

i. Individually Customized Products: Through the real-time exchange of data across the manufacturing supply chain, the interconnected Industry 4.0 system allows customers to individually customize their products. When a customer selects a product with certain specifications, information is sent across the supply chain where all parts suppliers and manufacturers can manufacture the customized product with minimal coordination (Geissbauer, R., 2016).

ii. Consumer Driven Design: Designing and optimizing the product can become mainly reliant on consumer preference under Industry 4.0. The digitally collected consumer feedback can assist product designers and manufacturers in offering a competitive product that meets consumer preferences (McKinsey & Company, 2015).

iii. Data-driven Demand Prediction and Real-time Supply Chain Optimization: Based on previous demand data and using analytical algorithms, Industry 4.0 systems can assist manufacturers in predicting consumer demand thus assisting them in efficiently managing their supply, inventories, production and output (McKinsey & Company, 2015).

iv. Maintaining the Industry's Competitiveness: The adoption of the Industry 4.0 framework and technologies allows the suppliers and manufacturers of the sector to operate and communicate over a unified system using big data and the virtual cloud (Bagheri, 2015). Manufacturing stakeholders should maintain the advanced industrial infrastructure to remain competitive within the regional and global supply chain.

v. Productivity: Investments in technological upgrades in manufacturing have continuously resulted in increased industrial productivity (CAPC, 2016). With the greater levels of automation, speed and accuracy offered by robotics, smart sensors and data exchange, it is anticipated that the adoption of new production technologies will lead to higher efficiency and greater employee productivity (Sage, 2020).

vi. Improved Product Quality: While Canadian automotive parts and products are well-known for their high quality, investments in production technologies continue to further improve the overall output's quality. Several features within an Industry 4.0 system contribute to such improvements including greater precision through automation, digital quality control through smart sensors and big data, and digital product and consumer feedback through the Internet of things (IoT) (FOCAL, 2019)[4]. Such features reduce the margin of error and ensure the quality of products.

[4] Future of Canadian Automotive Labourforce Initiative: Production Mandates and Impact on Labour Market Forecasts, 2019.

# OCCUPATIONAL IMPACT ANALYSIS

To examine the impact of Industry 4.0 on automotive manufacturing occupations, we closely and individually analyzed the work tasks performed by 48 automotive manufacturing occupations and identified the tasks which will be potentially affected by the technologies under consideration.

Appendix A includes a list of the 48 occupations that our analysis identified as related to the automotive manufacturing sector under the National Occupational Classification system (NOC). These selected occupations have been used in our project's trend reports which were produced in the fall of 2019 and which are also utilized in our forecasts of labour supply and demand. While those reports and forecasts dealt with 49 occupations relating to the automotive manufacturing sector, this task impact analysis examines 48 automotive manufacturing occupations, as the tasks performed by automotive service technicians, truck and bus mechanics and mechanical repairers could not be assessed in a manufacturing or a production line context. The 48 automotive manufacturing occupations were selected based on the number of employees in the occupation or the technical skills relating to the occupation. Automotive manufacturing occupations employing at least 100 employees in at least one of the automotive producing regions[5] under examination rendered a total of 40 automotive-related occupations. Another 8 occupations were identified based on their skill set as they are considered to be highly skilled and/or technically oriented therefore important to the sector.

Our analysis provides the proportion of tasks potentially impacted by the technologies of Industry 4.0 and details the number of tasks which will be potentially altered, partially impacted or fully eliminated. The study also provides brief commentary on the technologies potentially impacting the tasks along with the nature of the impact and the skills which might be required to perform the tasks altered by the new manufacturing technologies.

[5] Automotive producing regions considered under this project include: Ontario, Québec, Eastern Ontario, Golden Horseshoe, Kitchener-Waterloo-Barrie, London/Stratford-Bruce Peninsula, Montréal, Vancouver, Windsor-Sarnia and Winnipeg

## Methodology

To evaluate the impact of Industry 4.0 technologies and sub-technologies on each of the selected 48 occupations identified as part of the automotive manufacturing sector in Canada, a list of the detailed tasks and duties of each occupation was retrieved from the National Occupational Classification (NOC) website. Through an extensive literature review of the technologies and sub-technologies of Industry 4.0 and modern production systems, our analysis individually assessed the impact or influence of each of the identified technologies or sub-technologies on a total of 1015 work tasks of the 48 occupations. This methodology of examining tasks individually has been previously utilized by McKinsey & Company (2015) in examining almost 2000 work individual activities and assessing their probability of being automated by future technologies (McKinsey & Company, 2015).

In performing the impact assessment on the tasks of each occupation, a combination of methodologies is utilized to identify the potentially impacted tasks and the form of impact. This includes: (1) an extensive literature review on the predicted impact of the technologies of Industry 4.0 on work tasks of manufacturing occupations; (2) an identification of the physical and cognitive human capabilities which are susceptible to impact by the manufacturing technologies and equipment of industry 4.0; (3) a review of the modern production technologies, machinery, equipment and systems which are currently present or under development to ultimately make their way into automotive manufacturing facilities, and their projected impact on work tasks. Throughout this technical analysis, the occupational "impact" is examined in three main forms:

a. Task altered: A task where additional training or skills are required to perform a job regardless if some steps are eliminated. In this case, tasks which will be potentially altered by the technologies will eventually require workers to manage, install, set up, operate or maintain new machinery, equipment or system. To perform such upgraded tasks, formal training and new skills will be required by workers.

b. Task partially eliminated: Some steps or operations of the task are automated however; no significant training or additional skills are required to perform the task. In this form of impact, new machinery, equipment or systems will assist workers in performing a specific task through reducing the steps or operations required. For partially eliminated tasks, workers can continue performing their job without requiring significant or formal training.

c. Task fully eliminated: The task is fully eliminated and fully performed by a machine or a technology. In this scenario, the task is fully automated, and no input or interaction is required by an employee.

In assessing the tasks impacted by the technologies and sub-technologies of Industry 4.0, we examine these three forms of impact on each task, identify and categorize the tasks potentially impacted, and provide remarks on the nature of the potential impact on each task. The proportion of tasks impacted by Industry 4.0 production technologies does not imply that the tasks will be fully eliminated or automated, but rather that they will be affected in the forms mentioned above. Additionally, throughout the assessment of tasks, we take an 'extreme case' approach. This means that if a task has possibilities of both partial and full elimination, the full elimination scenario is followed. Thus, the terms "potentially significant", "potentially major" and "potentially extreme" are used.

The proportion of the total tasks potentially impacted by the technologies is subsequently computed to evaluate the impact of the new production technologies on each occupation. Based on the proportion of tasks impacted, we categorize the occupations among the following 5-levels of impact:

1. None or Insignificant 0% – 19.99%
2. Minor 20% – 39.99%
3. Potentially Significant 40% – 59.99%
4. Potentially Major 60% – 79.99%
5. Potentially Extreme 80% – 100%

To validate our assessment on the impact of the new production technologies on the occupations, we refer to the widely cited study by Frey and Osborne released in 2013 (Frey & Osborne, 2013). That study examined the probability of the computerization of 702 occupations based on a labour task model which accounted for automation in routine and non-routine tasks. In assessing the probability of computerisation, Frey and Osborne's methodology takes into account the advances in Robotics, Machine Learning (ML), Data Mining, Machine Vision, Computational Statistics and other sub-fields of Artificial Intelligence, which are technologies closely associated with Industry 4.0. Frey and Osborne's study evaluated the probability of computerization of occupations based on the Standard Occupational Classification System (SOC) used in the United States. The analysis is supported by O*Net data (Occupational Information Network)[6] for detailed task description of SOC occupations, as well as O*Net variables for identifying bottlenecks to computerization of certain tasks performed by humans. We also consider a study carried by McKinsey & Company on the automation probability in US occupations (McKinsey & Company, 2017). The study, which was published in 2017, identified 18 main task categories which can be fully automated, and examined almost 2000 work activities to assess their probability of being fully automated by future technologies.

In validating the impact level of Industry 4.0 technologies on occupations, our work sought to establish the closest match between the Standard Occupational Classification System (SOC) occupations used in the United States, and the National Occupational Classification System (NOC) used in Canada. While these two systems outline occupations in a similar manner, slight differences exist between the occupations (title of occupation, task description) defined under the SOC system and the NOC system. Therefore, in most occasions, one SOC occupation matched another NOC occupation from the list of 48 automotive manufacturing occupations. In few cases, two or more SOC occupations matched the description of one of the NOC occupations, therefore the average of the probability of computerization of the matching SOC occupations is obtained to validate the impact level of new production

[6] O*NET (Occupational Information Network) has detailed information on occupational definitions, task descriptions and related job titles. The O*NET system is based on the United States' Standard Occupational Classification (SOC) system.

technologies on the occupation. This matching of the 48 NOC occupations with the SOC occupations is presented in Appendix B.

While the Frey and Osborne and the McKinsey & Company studies addressed automation and computerization in over 700 US occupations, our study examines the impact of Industry 4.0 technologies on 48 automotive-specific occupations. Although numerous similarities exist between the technologies accounted for in the Frey and Osborne study, the McKinsey & Company study and Industry 4.0 technologies, our study specifically caters to the new manufacturing technologies and systems in the automotive manufacturing sector. Therefore, due to the specific nature of our analysis, differences and variations in the assessment of technological impact may arise.

## Potential Impact of Industry 4.0 by Occupation

The 48 automotive manufacturing occupations selected for assessment under our study were categorized within three main categories:
(1) Professionals/Engineers/Technical; (2) Skilled Trades; and (3) Supervisors/Production. The impact of Industry 4.0 technologies and systems varies in nature and impact level among the three occupational categories. The results align with other studies of technology and computer adoption on the impact level and nature of occupational task change. Appendix C includes the detailed results of our study along with the technologies potentially impacting each occupation and a brief commentary on the nature of the impact.

The least impacted occupations were found to be the highly paid managerial and engineering occupations which involve performing non-routine and cognitive tasks (Figure 1). This category is usually not affected by increased automation and machinery in the workplace. However, because Industry 4.0 systems encompass technologies such as data analytics, machine learning and artificial intelligence, an increased number of tasks of in these professional or senior occupations is anticipated to be impacted with either necessary skill upgrades or partial task eliminations.

On the other hand, lower paid occupations such as production occupations were found to be highly impacted by the technologies, systems and machinery of Industry 4.0. This is due to the nature of tasks performed by production occupations being mostly routine and requiring manual input. Technologies such as autonomous robotics and smart sensors are among the most impactful technologies for this occupational category as they introduce increased automation and autonomy to the production line.

While our work examined the impact of Industry 4.0 technologies on individual tasks of occupations, we also note that several occupations within the same category share similar tasks. This implies that multiple occupations are likely to be impacted in a similar manner of task changes, eliminations or skill upgrades. For example, the six occupations identified as supervisors share similar task descriptions which resulted in similar potential impact forms for this category under our assessment.

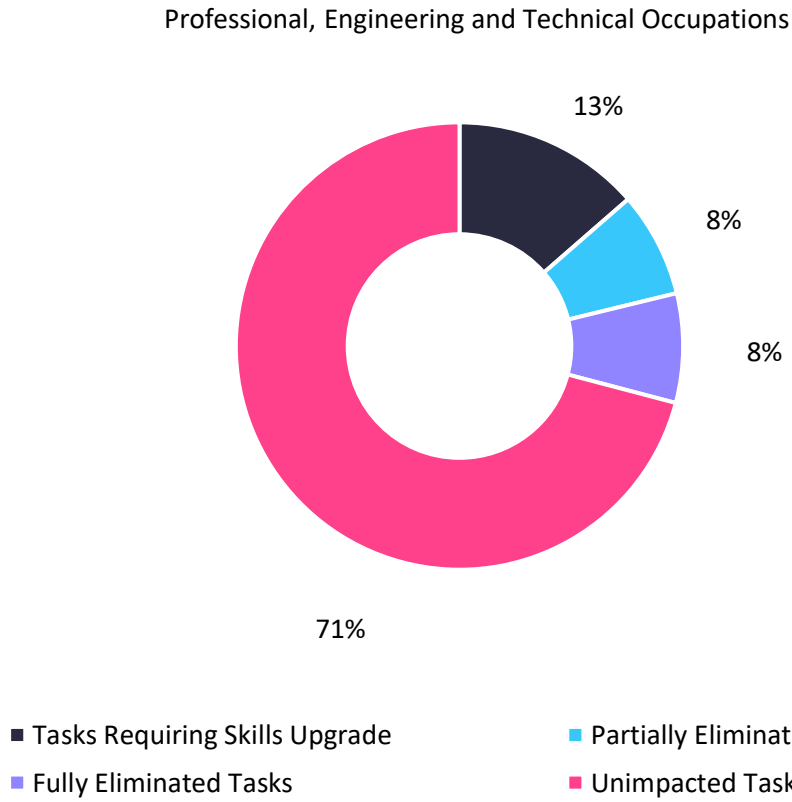
To validate the results of our study, we compared them to the results of Frey and Osborne's study and the McKinsey & Company's study. In respect of the task impact analysis, almost 42% of our study's results fell within +/-5% of the computerization probability (Frey and Osborne) or the automation probability (McKinsey & Company) for the equivalent occupations. Furthermore, close to 71% of our results fell within the range of +/-10% of either the computerization or automation probabilities. Given the differences in job titles, descriptions and tasks between the SOC and the NOC systems, and taking into account the distinct technologies considered in each of the studies, the results of our analysis were considered to fall within the acceptable range, and thus the output of the study is validated.

### 1. Professional, Engineering and Technical Occupations

Overall, the professional, engineering and technical occupational category is the category of occupations least impacted by Industry 4.0 technologies, with the exception of "*Shippers and receivers*" and "*Production logistics coordinators*". The majority of tasks impacted under this category are tasks requiring an upgrade in skills to keep up with administrative, design, production and logistic changes or upgrades.

As presented in Figure 2, on average 29.1% of the tasks for occupations in this category will be impacted by Industry 4.0 technologies, with 13.6% of the total tasks predicted to be altered, 7.6% predicted to be partially eliminated and 7.9% predicted to be fully eliminated. The technology impact results of this category are presented in Table 1 and Figure 3.

***Figure 2. Average impact of Industry 4.0 technologies on tasks of Professional, Engineering and Technical occupations***




### a. Management Occupations

Management occupations are among the occupations least impacted by Industry 4.0 technologies, as most of their tasks are abstract and non-routine. For "*Engineering managers*" and "*Computer and information system managers*", only one task in each of the occupations will require an upgrade of skills for these employees to continue managing their operations. "*Manufacturing Manager*" is the most impacted management occupations, where 33.3% of this occupation's tasks are forecast to be affected by Industry 4.0 technologies. The impact involves an upgrade of skills to keep up with new maintenance and employee training procedures, partially eliminated

procedures involving big data and analytics assisting in production scheduling, and a fully eliminated task for which digitization, data collection and smart sensors are forecasted to mostly automate production reporting procedures.

### b. Business, Finance and Administration Occupations

In the Business, Finance and Administration occupations, "*Human Resources Professionals*" are forecast to be lightly impacted by Industry 4.0 technology changes with the introduction of digital performance assessment procedures and the full digitization of human resources information and records. On the other hand, almost 90% of the tasks of both "*Shippers and receivers*" and "*Production logistics co-ordinators*" are forecast to be impacted by the new manufacturing technologies of industry 4.0. In this occupational category, big data and analytics is forecast to take a bigger role in assisting or fully performing operations relating to production reporting, smart scheduling, digital coordination and digital inventory management.

### c. Natural and Applied Sciences and Related Occupations

In this occupational group, the impact of Industry 4.0 technologies on tasks of Engineers is forecast to remain below 24%, with the majority of the tasks impacted requiring an upgrade of skills to keep up with the new technologies and operations. The most significant changes include learning to perform computer simulations for research and design purposes, migrating and managing data and operations through the virtual cloud, setting up new predictive maintenance and employee training procedures, and maintaining cyber security systems. Similar technologies are also forecast to affect the tasks of technicians and technologists in this category however, due to the relatively higher portion of their tasks in the workplace being considered "routine", a higher number of these tasks are likely to be impacted. For example, "*Mechanical and industrial technicians and technologists*" will increasingly rely on predictive maintenance systems in machines and equipment which utilize smart sensors and big data and analytics for the early detection and addressing of malfunctions and errors. Another example for "*Computer network technicians*" is the management and maintenance of software, data and networking operations through the virtual cloud instead of following the traditional network frameworks and

systems. Therefore, the average impact of the new manufacturing technologies on technicians and technologists is approximately 42.5%.

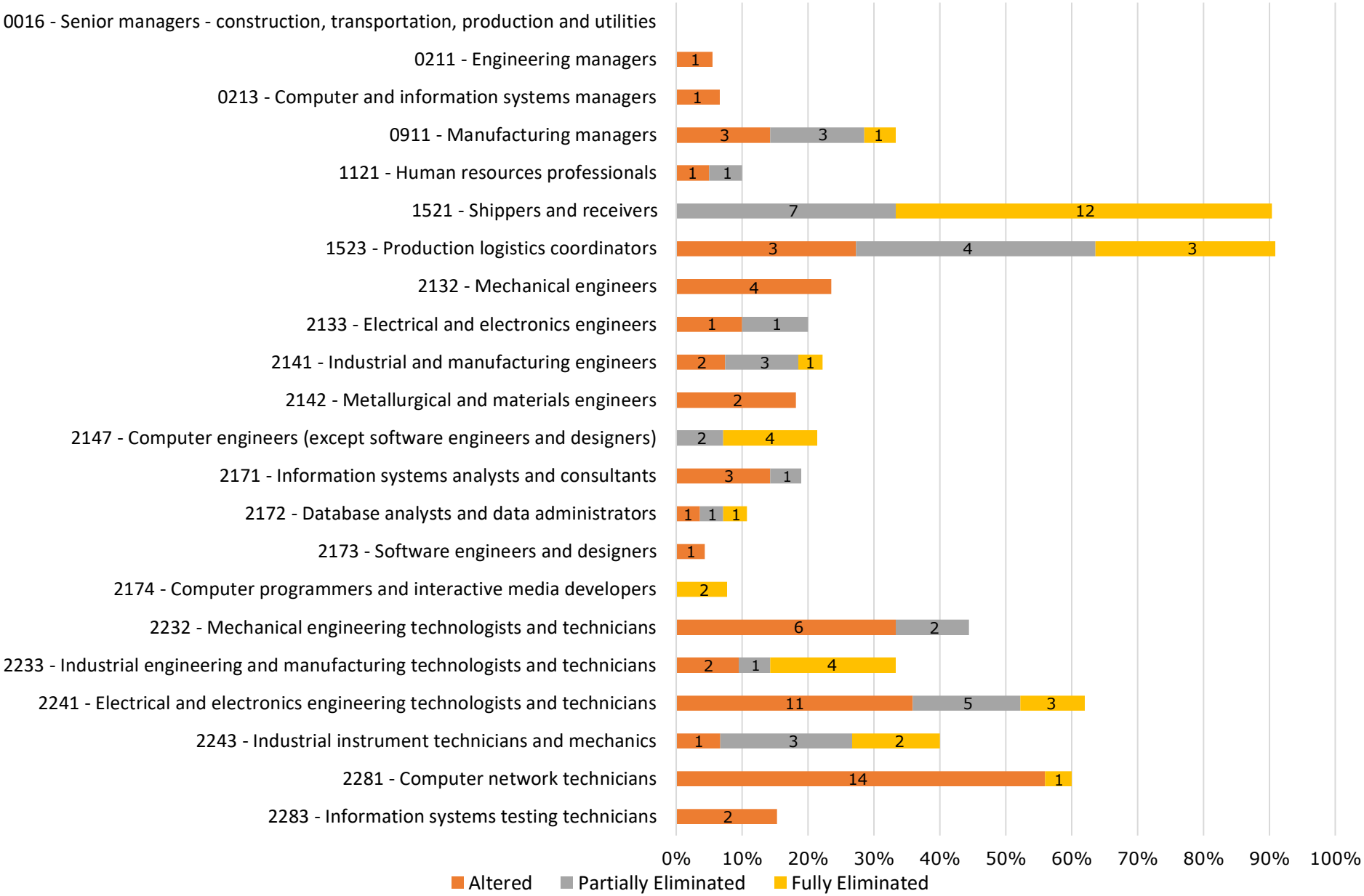
*Table 1. Impact of Industry 4.0 technologies on Professional, Engineering and Technical occupations*

| NOC Code | Occupation | Number of Employees[7] | Percentage of Tasks Impacted (FOCAL Occupational Analysis) | Computerization Probability (Frey & Osborne) | Automation Probability (McKinsey & Company) |
|---|---|---|---|---|---|
| 0016 | Senior managers - construction, transportation, production and utilities | 1,607 | 0% | 1.5% | 25% |
| 0211 | Engineering managers | 880 | 5.5% | 1.7% | 17% |
| 0213 | Computer and information systems managers | 474 | 6.6% | 3.5% | 19% |
| 0911 | Manufacturing managers | 6,385 | 33.3% | 3% | 38% |
| 1121 | Human resources professionals | 746 | 10% | 0.55% | 14% |
| 1521 | Shippers and receivers | 2,841 | 90.4% | 98% | 79% |
| 1523 | Production logistics coordinators | 996 | 90.9% | 88% | 49% |
| 2132 | Mechanical engineers | 4,189 | 23.5% | 1.1% | 17% |
| 2133 | Electrical and electronics engineers | 1,946 | 20% | 6.25% | 21% |
| 2141 | Industrial and manufacturing engineers | 1,855 | 22.2% | 2.85% | 14.5% |
| 2142 | Metallurgical and materials engineers | 141 | 18.18% | 2.1% | 18% |
| 2147 | Computer engineers (except software engineers and designers) | 379 | 21.4% | 22% | 25% |
| 2171 | Information systems analysts and consultants | 870 | 19% | 10.85 % | 47% |
| 2172 | Database analysts and data administrators | 145 | 10.7% | 3% | 37% |
| 2173 | Software engineers and designers | 700 | 4.34% | 1.4% | 17% |
| 2174 | Computer programmers and interactive media developers | 788 | 7.69% | 8.6% | 17% |
| 2232 | Mechanical engineering technologists and technicians | 1,360 | 44.4% | 38% | 23% |
| 2233 | Industrial engineering and manufacturing technologists and technicians | 1,450 | 33.3% | 3% | 7% |
| 2241 | Electrical and electronics engineering technologists and technicians | 1,595 | 62% | 84% | 23% |
| 2243 | Industrial instrument technicians and mechanics | 206 | 40% | 67% | 41% |
| 2281 | Computer network technicians | 443 | 60% | 3% | 62% |
| 2283 | Information systems testing technicians | 69 | 15.3% | 8.6% | 17% |

[7] Annual Survey of Manufacturing and Logging Industries (ASML) Employment Data, 2019

Sources:
FOCAL Occupational Analysis, 2020
Frey & Osborne, 2013
McKinsey & Company, 2018

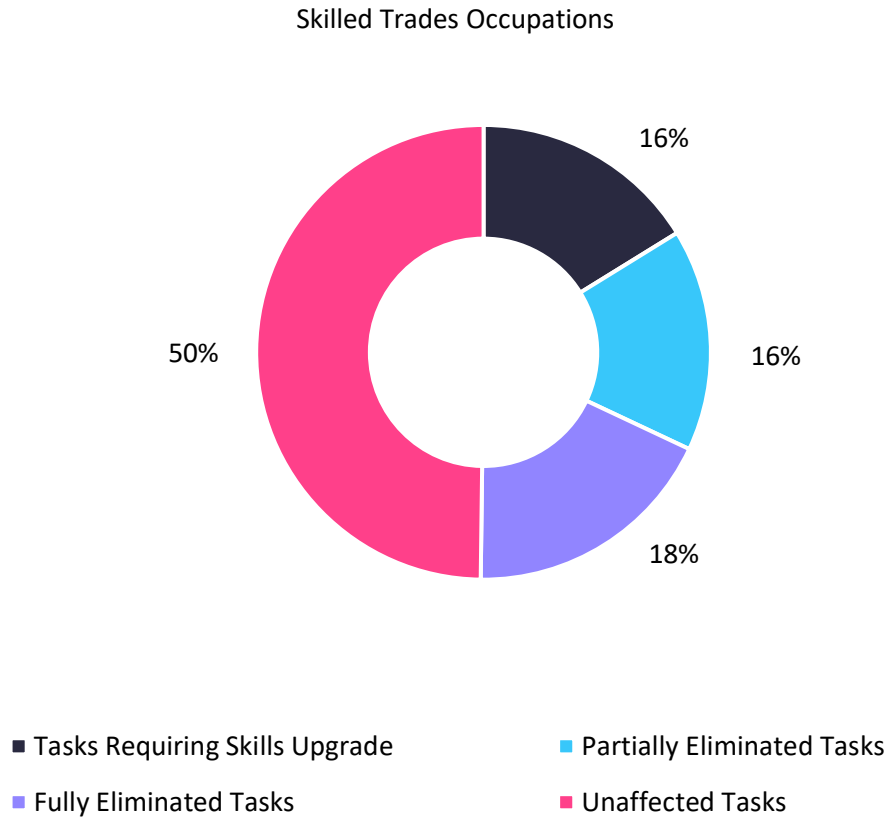
***Figure 3. Impact of Industry 4.0 technologies on tasks of Professional, Engineering and Technical occupations by occupation and impact form***



## 2. Skilled Trades Occupations

The Industry 4.0 impact on skilled trades occupations varies widely and covers a range between 23.8% up to 82.6%. On average, we predict that 50% of the tasks of skilled trades will be impacted by the technologies of Industry 4.0 systems. Among the total tasks examined under skilled trades, almost 16.2% will require training or upgrades in skills, 15.8% will be partially eliminated and partially performed by new technologies and machinery, and 18.2% will be fully eliminated (Figure 4). The technology impact results on skilled trades are presented in Table 2 and Figure 5.

***Figure 4. Average impact of Industry 4.0 technologies on tasks of Skilled Trades occupations***



In the skilled trades category, autonomous machinery and advanced equipment contribute to the elimination of a number of tasks. For example, autonomous robotics will be capable of performing numerous operations including fitting, installing, assembling, material handling and parts transporting. For "*Tool and die makers*", close to 45% of their tasks can be fully eliminated if autonomous robotic machining operations are adopted for cutting, turning, milling, drilling and shaping operations in production. For "*Welders and related machine operators*", 25% of the tasks can be eliminated if robotic arms and smart sensors are used to perform welding and soldering operations in a fully automated production process.

On the other hand, "*Machinists and machining tool operators*" will increasingly utilize additive manufacturing methods such as 3-D printers for small production runs and prototyping, which require training and new computer skills to design parts and operate the printers. "*Machinists and machining tool operators*" and "*Tool and die makers*" will also start operating CNC machines using mechanical simulation software which can virtually duplicate the machining steps and enhance the machining methods and the final outcome of parts and products.

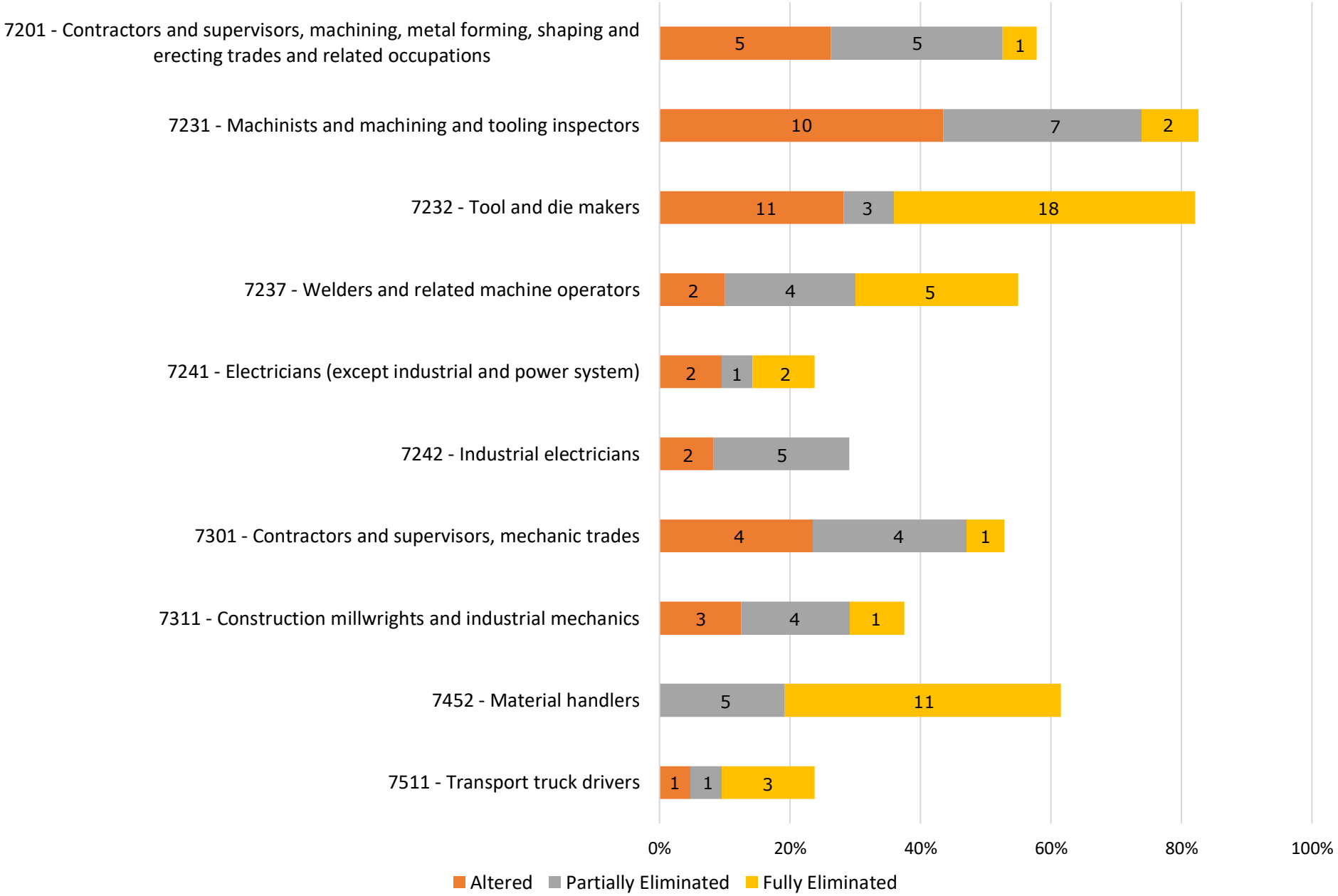
Other partially eliminated tasks include performing maintenance procedures less frequently by "*Electricians*" and "*Industrial electricians*" as predictive maintenance systems replace preventative maintenance standards. Moreover, data generation and exchange among manufacturing divisions and departments will lead to a reduction in production coordination activities which are carried by skilled trades contractors and supervisors.

| *Table 2. Impact of Industry 4.0 technologies on Skilled Trades occupations* | | | | | |
|---|---|---|---|---|---|
| **NOC Code** | **Occupation** | **Number of Employees[8]** | **Percentage of Tasks Impacted (FOCAL Occupational Analysis)** | **Computerization Probability (Frey & Osborne)** | **Automation Probability (McKinsey & Company)** |
| **7201** | Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations | 786 | 57.8% | 1.6% | 33% |
| **7231** | Machinists and machining and tooling inspectors | 3,685 | 82.6% | 65% | 80% |
| **7232** | Tool and die makers | 2,624 | 82.1% | 84% | 87% |
| **7237** | Welders and related machine operators | 5,111 | 55% | 61% | 87.5% |
| **7241** | Electricians (except industrial and power system) | 286 | 23.8% | 15% | 42% |
| **7242** | Industrial electricians | 2,364 | 29.1% | 15% | 42% |
| **7301** | Contractors and supervisors, mechanic trades | 421 | 52.9% | 53.5% | 34% |
| **7311** | Construction millwrights and industrial mechanics | 3,939 | 37.5% | 59% | 77% |
| **7452** | Material handlers | 7,216 | 61.5% | 85% | 7% |
| **7511** | Transport truck drivers | 992 | 23.8% | 79% | 81% |

Sources:
FOCAL Occupational Analysis, 2020
Frey & Osborne, 2013
McKinsey & Company, 2018

[8] Annual Survey of Manufacturing and Logging Industries (ASML) Employment Data, 2019

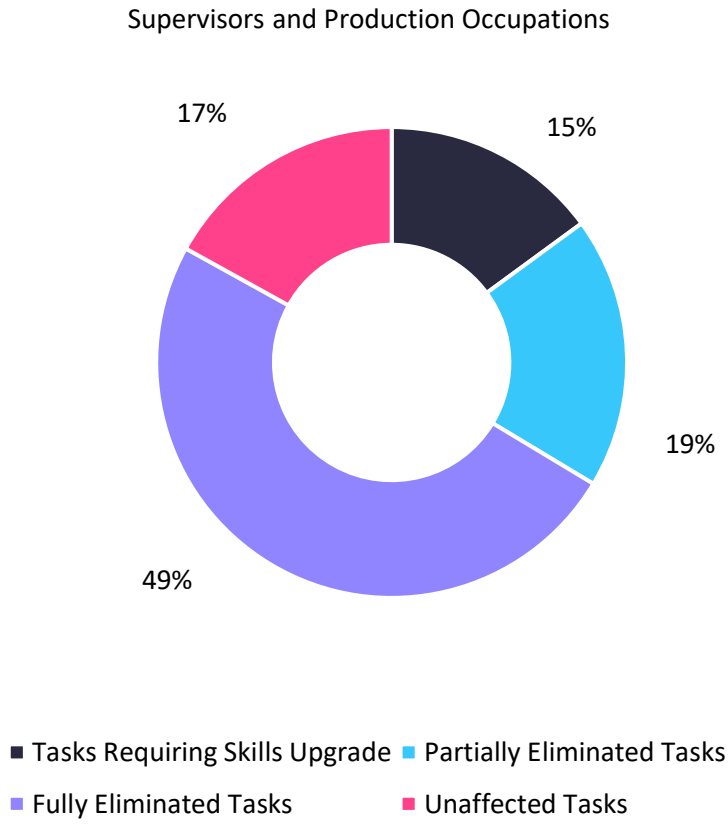
***Figure 5. Impact of Industry 4.0 technologies on tasks of Skilled Trades occupations by occupation and impact form***



### 3. Supervisors and Production Occupations

In the supervisors and production occupational category, two impact forms can be identified among the occupations examined: the technology's impact on supervisors which is mostly affected by the role of big data and analytics; and the impact of autonomous robotics and smart sensors on the tasks of production occupations. The six occupations identified as supervisors are impacted in a very similar manner as they share very similar task sets. On the other hand, production workers are forecast to experience a broader range of impact levels by new manufacturing technologies, ranging between 75% to almost 96%. The technology impact results on supervisors and production occupations are presented in Table 3 and Figure 7.

***Figure 6. Average impact of Industry 4.0 technologies on tasks of Supervisors and Production occupations***



### a. Supervisors

For supervisors, the average proportion of tasks impacted is around 66% out of an average of 12 tasks identified for each occupation. Among the total number of tasks examined for supervisors, 23% are altered tasks requiring training or new skills, 35% are partially eliminated and 8% are fully eliminated. The new role of big data and analytics across manufacturing facilities will potentially have a significant impact on the tasks of production supervisors. For example, tasks which include production reporting can be mostly digitized, whereas production coordination among the manufacturing departments and divisions will be less required as production and logistics data will be increasingly generated and exchanged. New data-driven production scheduling systems, which are also known as smart scheduling systems, might require some training in order to be used by supervisors.

### b. Production

For production occupations, an average of 82.5% of tasks are forecast to be impacted by the manufacturing technologies of Industry 4.0. Among the total number of tasks analyzed for production occupations, 12.8% will require additional training or new skills, 14.2% are forecast to be partially eliminated and 55.1% of are forecast to be fully eliminated if the new manufacturing technologies are fully adopted.

Autonomous robotics will be the most impactful technology on the role of production workers in automotive manufacturing. With the advancement in autonomous systems, robotics and smart sensors, manual tasks which include assembling, installing, aligning, positioning, fastening, bolting, screwing, clipping, welding and soldering parts and components can be accurately and efficiently performed by autonomous robotics guided by vision and proximity sensors across the production line. In some situations, assistive or collaborative robotics (Cobots) might be used along the production line, guided by production workers to perform these labour-intensive manual operations. In some situations, this technology advancement is not capable of addressing certain tasks, such as wiring and connecting cables or performing fitting and installation tasks in tight locations.

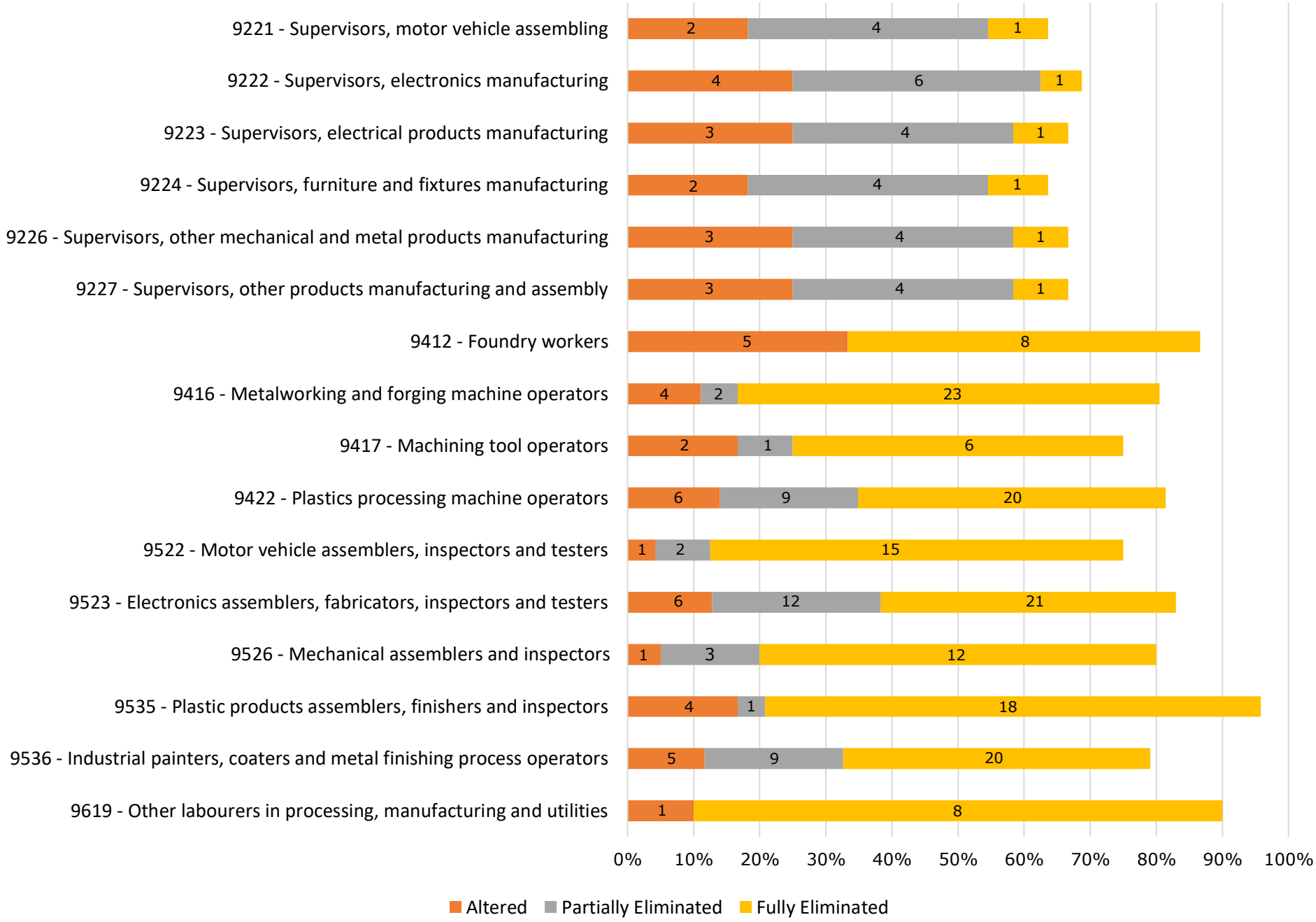
In automotive manufacturing sector, "*Motor vehicle assemblers, inspectors and testers*" constitute close to 26% of the work force. For these occupations, we predict that 75% of work tasks will be impacted by Industry 4.0 technologies, with almost 62.5% of tasks to be fully eliminated by autonomous robotics and smart sensors. The job description of this occupation identifies two groups of workers: "*Motor vehicle assemblers*"; and "*Motor vehicle inspectors and testers*". Since this occupation has almost 48,000 workers in the sector, we examine the tasks of each sub-group separately. "*Motor vehicle assemblers*" are predicted to have almost 92.5% of their tasks impacted by the new industrial system and its technologies, with 78.5% of their total work tasks forecast to be fully eliminated. This is mostly due to the increased automation and incorporation of autonomous robotics and smart sensors across the production line. But only 50% of the tasks of "*Motor vehicle inspectors and testers*" are impacted by smart sensors. Smart sensors can assist in detecting, locating and keeping track of defects and dents across a vehicle's body.

| *Table 3. Impact of Industry 4.0 technologies on Supervisors and Production occupations* | | | | | |
|---|---|---|---|---|---|
| **NOC Code** | **Occupation** | **Number of Employees[9]** | **Percentage of Tasks Impacted (FOCAL Occupational Analysis)** | **Computerization Probability (Frey & Osborne)** | **Automation Probability (McKinsey & Company)** |
| 9221 | Supervisors, motor vehicle assembling | 7,216 | 63.63% | 1.6% | 33% |
| 9222 | Supervisors, electronics manufacturing | 992 | 68.75% | 1.6% | 33% |
| 9223 | Supervisors, electrical products manufacturing | 6,596 | 66.67% | 1.6% | 33% |
| 9224 | Supervisors, furniture and fixtures manufacturing | 205 | 63.63% | 1.6% | 33% |
| 9226 | Supervisors, other mechanical and metal products manufacturing | 118 | 66.67% | 1.6% | 33% |
| 9227 | Supervisors, other products manufacturing and assembly | 6 | 66.67% | 1.6% | 33% |
| 9412 | Foundry workers | 384 | 86.6% | 67% | 100% |
| 9416 | Metalworking and forging machine operators | 153 | 80.5% | 93% | 90.5% |
| 9417 | Machining tool operators | 1,088 | 75% | 85% | 95% |
| 9422 | Plastics processing machine operators | 2,330 | 81.4% | 85.6% | 91% |
| 9522 | Motor vehicle assemblers, inspectors and testers | 1,819 | 75% | 95% | 81% |
| 9523 | Electronics assemblers, fabricators, inspectors and testers | 2,296 | 83% | 93% | 59% |
| 9526 | Mechanical assemblers and inspectors | 48,015 | 80% | 82% | 70% |
| 9535 | Plastic products assemblers, finishers and inspectors | 1,976 | 95.8% | 95% | 89% |
| 9536 | Industrial painters, coaters and metal finishing process operators | 2,352 | 79.1% | 91.5% | 71.5% |
| 9619 | Other labourers in processing, manufacturing and utilities | 1,347 | 90% | 66% | 97% |

Sources:
FOCAL Occupational Analysis, 2020
Frey & Osborne 2013,
McKinsey & Company 2018

[9] Annual Survey of Manufacturing and Logging Industries (ASML) Employment Data, 2019

*Figure 7. Impact of Industry 4.0 technologies on tasks of Supervisors and Production occupations by occupation and impact form*



# NEW OCCUPATIONS GENERATED BY INDUSTRY 4.0

While this study has examined the impact of the new manufacturing technologies on the tasks of 48 important automotive manufacturing occupations, we also predict that Industry 4.0 systems will generate new job opportunities and new roles in the sector. Although new job titles will become relevant to the automotive manufacturing sector under Industry 4.0, it is expected that the majority of the workforce will remain under the traditional identified automotive manufacturing occupations. In Appendix D, we identify a list of 45 new job titles which are forecast to become relevant to the sector with the adoption of Industry 4.0, and we associate these job titles with one or more of the 48 NOC occupations considered for this study. This list of new job titles is based on our literature review of the impact of Industry 4.0 on the manufacturing work force and occupations, as well as job postings with requirements relevant to the ten technologies of Industry 4.0.

Among the newly identified job titles, we identify jobs relating to additive manufacturing operations. The use of additive manufacturing in some production operations will generate new jobs in operating such technologies, as well as implementing and maintaining additive manufacturing-related machinery and equipment. In operating additive manufacturing machines and equipment, jobs with titles such as "*3D printing machinist*" and "*Additive manufacturing technician*" may be associated with occupations of "*Machinists and machining and tooling inspectors*" or "*Industrial Engineering Technologists and Technicians*". "*Additive manufacturing engineers*" may be responsible for developing, customizing, implementing and integrating additive manufacturing operations in the workplace. "*3D scanning engineers*" and "*3D scanning technicians*" may also become relevant to the field of additive manufacturing as they reduce the time and effort required to measure and layout specific parts and components.

With increased use of cloud-based network systems for operations management, data storage and computing power, job titles in the field of cloud technologies and cyber security will also become relevant to the automotive manufacturing sector. "*Cloud computing engineers*" and "*Cloud infrastructure architects*" may become relevant jobs to manage and maintain corporate information resources systems. Such jobs relating to cloud operation might become part of the "*Software engineers and designers*" occupation. As for cloud security and cyber security jobs, "*Cloud security engineers*" and "*Cyber security specialist*" may become new job titles under the "*Information systems analysts and consultants*" occupation.

# CONCLUDING REMARKS ON THE IMPACT OF INDUSTRY 4.0

Our occupational technology impact analysis has shown that almost all occupations will be affected in one way or another by the Industry 4.0 system and its new technologies. While there are numerous tasks which we forecast to be partially or fully eliminated (especially in the skilled trades and production occupations), needs for training and acquiring new skills to perform new or altered tasks are also expected across these categories. For example, in some mechanical and industrial engineering, technical and skilled trade occupations, performing computer simulations for research, design, failure prediction and operating machines might be one of the new occupational requirements. "*Computer engineers and technicians*" might have to build skills in operating and maintaining cloud computing and management systems, cyber security systems and data collection and analytics software and algorithms. Supervisors may have to learn how to make use of the collected and analyzed data across the manufacturing facility to coordinate operations, schedule productions and oversee the performance of workers. Production occupations will likely follow new predictive maintenance systems instead of preventative maintenance standards and rely on smart sensors and collected data to for a more accurate quality control process.

The changes in the flow of work tasks under Industry 4.0 indicate that although some tasks are forecast to be partially or fully eliminated, we also forecast a shift towards a larger proportion of highly skilled occupations and a highly skilled labour force. With increased manufacturing technology adoption, production tasks are forecast to be less labour intensive, while supervisory and inspection work of automated machinery and systems are forecast to remain essential to the flow of production. Concepts such as "*lights-out manufacturing shifts*" (a fully automated production shift carried out by machines and robotics only with no production workers or manual work required) can also become possible with minimal presence of supervisory personnel on the fully automated production line (Lee, 2018).

While all of the elements and technologies of Industry 4.0 might not be fully adopted in the foreseeable future, it is important that manufacturers are aware of the impact that these new manufacturing systems and technologies can have on their businesses. It is also important for policy makers and educators to stay up-to-date with the changes in the nature of work carried out in manufacturing firms and with the future demands for specific new skills. University and college graduates and apprentices should possess skills to administer and operate new technologies (e.g. performing mechanical simulations, using 3-D printers, setting up smart sensors) or at least have some level of exposure to these new systems. Training the upcoming generation of the automotive manufacturing work force will help to ensure that the sector can both maintain these advancements in manufacturing technologies and increase the competitiveness of the sector.

Industry 4.0 and its associated manufacturing technologies represent an opportunity for the Canadian automotive manufacturing sector to remain competitive and among Canada's leading industries both nationally and globally. As discussed in this paper, there are several incentives behind shifting towards this new industrial framework including enhanced productivity and product quality, customized mass-production, data-driven supply / demand prediction and consumer-driven product design.

While the new industrial system is forecasted to present suppliers and manufacturers with numerous market opportunities, Industry 4.0 is also expected to bring a variety of new skills to the automotive-related occupations and expand the spectrum of job occupations and titles in the sector. Therefore, a structured framework for the adoption of new manufacturing technologies and systems across the Canadian supply chain supported by governments and leading industry organizations is one of the routes toward maintaining the sector's productivity, competitiveness and attractive image.

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# APPENDIX A: LIST OF THE SELECTED 48 OCCUPATIONS[10] IDENTIFIED TO BE RELATING TO THE AUTOMOTIVE MANUFACTURING SECTOR UNDER THE NATIONAL OCCUPATIONAL CLASSIFICATION SYSTEM (NOC)

## Professional, Engineering and Technical Occupations

| NOC Code | Occupation |
|---|---|
| 0016 | Senior managers - construction, transportation, production and utilities |
| 0211 | Engineering managers |
| 0213 | Computer and information systems managers |
| 0911 | Manufacturing managers |
| 1121 | Human resources professionals |
| 1521 | Shippers and receivers |
| 1523 | Production logistics coordinators |
| 2132 | Mechanical engineers |
| 2133 | Electrical and electronics engineers |
| 2141 | Industrial and manufacturing engineers |
| 2142 | Metallurgical and materials engineers |
| 2147 | Computer engineers (except software engineers and designers) |
| 2171 | Information systems analysts and consultants |
| 2172 | Database analysts and data administrators |
| 2173 | Software engineers and designers |
| 2174 | Computer programmers and interactive media developers |
| 2232 | Mechanical engineering technologists and technicians |
| 2233 | Industrial engineering and manufacturing technologists and technicians |
| 2241 | Electrical and electronics engineering technologists and technicians |
| 2243 | Industrial instrument technicians and mechanics |
| 2281 | Computer network technicians |
| 2283 | Information systems testing technicians |

[10] Previous reports and the supply and demand labour forecast under this project have identified 49 occupations relating to the automotive manufacturing sector however, this study examines 48 automotive manufacturing occupations out of the list, as the tasks performed by Automotive service technicians, truck and bus mechanics and mechanical repairers could not be assessed in a manufacturing or a production line context.

## Skilled Trades Occupations

| NOC Code | Occupation |
|---|---|
| 7201 | Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations |
| 7231 | Machinists and machining and tooling inspectors |
| 7232 | Tool and die makers |
| 7237 | Welders and related machine operators |
| 7241 | Electricians (except industrial and power system) |
| 7242 | Industrial electricians |
| 7301 | Contractors and supervisors, mechanic trades |
| 7311 | Construction millwrights and industrial mechanics |
| 7452 | Material handlers |
| 7511 | Transport truck drivers |

## Supervisors and Production Occupations

| NOC Code | Occupation |
|---|---|
| 9221 | Supervisors, motor vehicle assembling |
| 9222 | Supervisors, electronics manufacturing |
| 9223 | Supervisors, electrical products manufacturing |
| 9224 | Supervisors, furniture and fixtures manufacturing |
| 9226 | Supervisors, other mechanical and metal products manufacturing |
| 9227 | Supervisors, other products manufacturing and assembly |
| 9412 | Foundry workers |
| 9416 | Metalworking and forging machine operators |
| 9417 | Machining tool operators |
| 9422 | Plastics processing machine operators |
| 9522 | Motor vehicle assemblers, inspectors and testers |
| 9523 | Electronics assemblers, fabricators, inspectors and testers |
| 9526 | Mechanical assemblers and inspectors |
| 9535 | Plastic products assemblers, finishers and inspectors |
| 9536 | Industrial painters, coaters and metal finishing process operators |
| 9619 | Other labourers in processing, manufacturing and utilities |

# APPENDIX B: CANADIAN NOC OCCUPATIONS AND THEIR EQUIVALENT SOC OCCUPATION

## Professional, Engineering and Technical Occupations

| Occupation (NOC code and Title) | Equivalent SOC Occupation (SOC code and Title) |
|---|---|
| 0016 - Senior managers - construction, transportation, production and utilities | 11-1011 - Chief Executive |
| 0211 - Engineering managers | 11-9041 - Engineering Managers |
| 0213 - Computer and information systems managers | 11-3021 - Computer and Information Systems Managers |
| 0911 - Manufacturing managers | 11-3051 - Industrial Production Manager |
| 1121 - Human resources professionals | 11-3121 - Human Resource Managers |
| 1521 - Shippers and receivers | 43-5071 - Shipping, Receiving, and Traffic Clerks |
| 1523 - Production logistics coordinators | 43-5061 - Production, Planning, and Expediting Clerks |
| 2132 - Mechanical engineers | 17-2141 - Mechanical Engineers |
| 2133 - Electrical and electronics engineers | 17-2072 - Electronics Engineers, Except Computer<br>17-2071 - Electrical Engineers |
| 2141 - Industrial and manufacturing engineers | 17-2111 - Health and Safety Engineers, Except Mining Safety Engineers and Inspectors<br>17-2112 - Industrial Engineers |
| 2142 - Metallurgical and materials engineers | 17-2131 - Materials Engineer |
| 2147 - Computer engineers (except software engineers and designers) | 17-2061 - Computer Hardware Engineers |
| 2171 - Information systems analysts and consultants | 15-1121 - Computer System Analyst<br>15-1179 - Information Security Analysts, Web Developers, and Computer Net- work Architects |
| 2172 - Database analysts and data administrators | 15-1141 - Database Administrator |
| 2173 - Software engineers and designers | 17-2199 - Engineers, All Other |
| 2174 - Computer programmers and interactive media developers | 15-1132 - Software Developer, Application<br>15-1133 - Software Developer, Systems Software |
| 2232 - Mechanical engineering technologists and technicians | 17-3027 - Mechanical Engineering Technician |
| 2233 - Industrial engineering and manufacturing technologists and technicians | 17-3026 - Industrial Engineering Technician |
| 2241 - Electrical and electronics engineering technologists and technicians | 17-3023 - Electrical and Electronics Engineering Technician |
| 2243 - Industrial instrument technicians and mechanics | 49-9041 - Industrial Machinery Mechanics |
| 2281 - Computer network technicians | 15-1142 - Computer System Administrator |
| 2283 - Information systems testing technicians | 15-1132 - Software Developers, Applications<br>15-1133 - Software Developers, Systems Software |

## Skilled Trades Occupations

| Occupation (NOC code and Title) | Equivalent SOC Occupation (SOC code and Title) |
|---|---|
| 7201 - Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations | 51-1011 - First-Line Supervisors of Production and Operating Workers |
| 7231 - Machinists and machining and tooling inspectors | 51-4041 - Machinist |
| 7232 - Tool and die makers | 51-4111 - Tool and Die Maker |
| 7237 - Welders and related machine operators | 51-4122 - Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders |
| 7241 - Electricians (except industrial and power system) | 47-2111 - Electricians |
| 7242 - Industrial electricians | 47-2111 - Electricians |
| 7301 - Contractors and supervisors, mechanic trades | 49-3042 - Mobile Heavy Equipment Mechanic<br>49-9041 - Industrial Machinery Mechanics |
| 7311 - Construction millwrights and industrial mechanics | 49-9044 - Millwright |
| 7321 - Automotive service technicians, truck and bus mechanics and mechanical repairers | 49-3023 - Automotive Service Technicians and Mechanics |
| 7452 - Material handlers | 53-7062 - Labourers and Freight, Stock, and Material Movers, Hand |
| 7511 - Transport truck drivers | 53-3032 - Heavy Truck Driver |

## Supervisors and Production Occupations

| Occupation (NOC code and Title) | Equivalent SOC Occupation (SOC code and Title) |
|---|---|
| 9221- Supervisors, motor vehicle assembling | 51-1011 - First-Line Supervisors of Production and Operating Workers |
| 9222 - Supervisors, electronics manufacturing | 51-1011 - First-Line Supervisors of Production and Operating Workers |
| 9223 - Supervisors, electrical products manufacturing | 51-1011 - First-Line Supervisors of Production and Operating Workers |
| 9224 - Supervisors, furniture and fixtures manufacturing | 51-1011 - First-Line Supervisors of Production and Operating Workers |
| 9226 - Supervisors, other mechanical and metal products manufacturing | 51-1011 - First-Line Supervisors of Production and Operating Workers |
| 9227 - Supervisors, other products manufacturing and assembly | 51-1011 - First-Line Supervisors of Production and Operating Workers |
| 9412 - Foundry workers | 51-4071 - Foundry Mold and Coremakers |
| 9416 - Metalworking and forging machine operators | 51-4022 - Forging machine setters, operators, and tenders, Metal and Plastic<br>51-4011 - Computer Controlled Machine Tool Operators, Metal and Plastic |
| 9417 - Machining tool operators | 51-4034 - Lathe and Turning Machine Tool Setters, Operators, and Tenders, Metal and Plastic<br>51-4011 - Computer Controlled Machine Tool Operators, Metal and Plastic |
| 9422 - Plastics processing machine operators | 51-4023 - Rolling Machine Setters, Operators, and Tenders, Metal and Plastic<br>51-9023 - Mixing and Blending Machine Setters, Operators, and Tenders<br>51-4021 - Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic |
| 9522 - Motor vehicle assemblers, inspectors and testers | 51-9399 - Production Workers, All Other |
| 9523 - Electronics assemblers, fabricators, inspectors and testers | 49-2093 - Electrical and Electronics Installers and Repairers, Transportation Equipment |
| 9526 - Mechanical assemblers and inspectors | 51-2031 - Engine and Other Machine Assemblers |
| 9535 - Plastic products assemblers, finishers and inspectors | 51-2091 - Fiberglass Laminators and Fabricators |
| 9536 - Industrial painters, coaters and metal finishing process operators | 51-9121 - Coating, Painting and Spraying Machine Setters and Operators and Tenders<br>51-9123- Painting, Coating, and Decorating Workers |
| 9619 - Other labourers in processing, manufacturing and utilities | 51-9198 - Helpers - Production Workers |

# APPENDIX C: DETAILED RESULTS AND REMARKS FOR OCCUPATIONAL IMPACT TASK ANALYSIS

## Professional, Engineering and Technical Occupations

| Occupation | Potential Impact Details |
|---|---|
| 0016 - Senior managers - construction, transportation, production and utilities | **Number of Tasks:** 15<br>**Tasks Altered:** 0<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 0<br>**Percentage of Tasks Potentially Impacted:** 0%<br>**Impact Level:** None<br>**Technologies Impacting:** N/A<br>**Remarks on Impact:** N/A |
| 0211 - Engineering managers | **Number of Tasks:** 18<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 1<br>**Percentage of Tasks Potentially Impacted:** 5.5%<br>**Impact Level:** Insignificant<br>**Technologies Impacting:** Simulation<br>**Remarks on Impact:**<br>Simulation modeling and design will assist in the research, design and development in technical projects |

| Occupation | Potential Impact Details |
|---|---|
| 0213 - Computer and information systems managers | **Number of Tasks:** 15<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 1<br>**Percentage of Tasks Potentially Impacted:** 6.6%<br>**Impact Level:** Insignificant<br>**Technologies Impacting:** Cloud Computing<br>**Remarks on Impact:**<br>Procedures for electronic data processing and computer systems development and operations will be migrated and managed through the cloud |
| 0911 - Manufacturing managers | **Number of Tasks:** 21<br>**Tasks Altered:** 3<br>**Tasks Partially Eliminated:** 3<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 7<br>**Percentage of Tasks Potentially Impacted:** 33.3%<br>**Impact Level:** Insignificant<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Augmented reality technologies will alter employee training programs with the increased use of wearable gear and tablets to reduce manufacturing line interruptions and downtime<br>- Production reporting procedures will be digitized and automated with the increased data collection from machinery and sensors<br>- Predictive maintenance will alter routine maintenance schedules and programs<br>- Smart scheduling will assist in setting production schedules based on previous production data and data analytics |

| Occupation | Potential Impact Details |
|---|---|
| 1121 - Human resources professionals | **Number of Tasks:** 20<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 2<br>**Percentage of Tasks Potentially Impacted:** 10%<br>**Impact Level:** Insignificant<br>**Technologies Impacting:** Big Data and Analytics<br>**Remarks on Impact:**<br>Employee performance appraisal programs and human resources information and records will be increasingly digitized and will rely on digital performance assessment |
| 1521 - Shippers and receivers | **Number of Tasks:** 21<br>**Tasks Altered:** 0<br>**Tasks Partially Eliminated:** 7<br>**Tasks Fully Eliminated:** 12<br>**Total Tasks Potentially Impacted:** 19<br>**Percentage of Tasks Potentially Impacted:** 90.4%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Autonomous Robotics, Big Data and Analytics, Smart Sensors<br>**Remarks on Impact:**<br>- Autonomous robots and automated conveyor systems are capable of autonomously transporting material, parts and goods within facilities<br>- Data collection and exchange among the manufacturing elements allow automatic verification and routing of parts and good while recording shortages and keeping track of inventories<br>- Vision and proximity sensors can assist in parts' inspection for damage |

| Occupation | Potential Impact Details |
|---|---|
| 1523 - Production logistics coordinators | **Number of Tasks:** 11<br>**Tasks Altered:** 3<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 3<br>**Total Tasks Potentially Impacted:** 10<br>**Percentage of Tasks Potentially Impacted:** 90.9%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Artificial Intelligence, Big Data and Analytics, Simulation<br>**Remarks on Impact:**<br>- Preparing worksheets and compiling progress reports will be fully automated with the collection of data from machinery and sensors<br>- Smart scheduling will assist in setting production schedules and coordinating production runs<br>- Digital planning and data exchange will assist in coordinating operations among departments |
| 2132 - Mechanical engineers | **Number of Tasks:** 17<br>**Tasks Altered:** 4<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 4<br>**Percentage of Tasks Potentially Impacted:** 23.5%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Big Data and Analytics, Simulation, Smart Sensors<br>**Remarks on Impact:**<br>- Research and design of machinery, component and systems will increasingly rely on computer simulations for analyzing mechanical variables<br>- Predictive maintenance (AI and Smart Sensors) will alter traditional routine maintenance standards and schedules |

| Occupation | Potential Impact Details |
|---|---|
| 2133 - Electrical and electronics engineers | **Number of Tasks:** 10<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 2<br>**Percentage of Tasks Potentially Impacted:** 20%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Simulation<br>**Remarks on Impact:**<br>- Electrical research and design of electrical and electronic components will increasingly rely on computer simulations<br>- Predictive maintenance (AI and Smart Sensors) will alter traditional maintenance standards and schedules |
| 2141 - Industrial and manufacturing engineers | **Number of Tasks:** 27<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 3<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 6<br>**Percentage of Tasks Potentially Impacted:** 22.2%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Smart Sensors<br>**Remarks on Impact:**<br>- Real-time process and product optimization will assist in the optimum utilization of machinery, materials and resources<br>- Employee evaluation systems will partially rely on digital performance assessment of workers<br>- Industrial and manufacturing training programs will incorporate the use of augmented reality equipment to reduce manufacturing downtime |

| Occupation | Potential Impact Details |
|---|---|
| 2142 - Metallurgical and materials engineers | **Number of Tasks:** 11<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 2<br>**Percentage of Tasks Potentially Impacted:** 18.18%<br>**Impact Level:** Insignificant<br>**Technologies Impacting:** Simulation<br>**Remarks on Impact:**<br>Mechanical and materials simulation will be increasingly utilized to study and analyze the properties and characteristics of materials |
| 2147 - Computer engineers (except software engineers and designers) | **Number of Tasks:** 28<br>**Tasks Altered:** 0<br>**Tasks Partially Eliminated:** 2<br>**Tasks Fully Eliminated:** 4<br>**Total Tasks Potentially Impacted:** 6<br>**Percentage of Tasks Potentially Impacted:** 21.4%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Cloud Computing<br>**Remarks on Impact:**<br>Communication and network systems will be migrated and managed over the cloud which are likely to be outsourced for manufacturing companies |
| 2171 - Information systems analysts and consultants | **Number of Tasks:** 21<br>**Tasks Altered:** 3<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 4<br>**Percentage of Tasks Potentially Impacted:** 19%<br>**Impact Level:** Insignificant<br>**Technologies Impacting:** Cyber Security<br>**Remarks on Impact:**<br>Cyber security systems will assist in technical security and risk analyses to data, software and hardware |

| Occupation | Potential Impact Details |
|---|---|
| 2172 - Database analysts and data administrators | **Number of Tasks:** 28<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 3<br>**Percentage of Tasks Potentially Impacted:** 10.7%<br>**Impact Level: I**nsignificant<br>**Technologies Impacting:** Big Data and Analytics<br>**Remarks on Impact:**<br>Advanced algorithms of data manipulation and analysis will alter and automate some database operations |
| 2173 - Software engineers and designers | **Number of Tasks:** 23<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 1<br>**Percentage of Tasks Potentially Impacted:** 4.34%<br>**Impact Level:** Insignificant<br>**Technologies Impacting:** Cloud Computing<br>**Remarks on Impact:**<br>Data storage, network processes and models will be migrated to the cloud |
| 2174 - Computer programmers and interactive media developers | **Number of Tasks:** 26<br>**Tasks Altered:** 0<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 2<br>**Total Tasks Potentially Impacted:** 2<br>**Percentage of Tasks Potentially Impacted:** 7.69%<br>**Impact Level: I**nsignificant<br>**Technologies Impacting:** Big Data and Analytics<br>**Remarks on Impact:**<br>The collection and documentation of user requirements will be increasingly reliant on the digital input and automated feedback gathered from users |

| Occupation | Potential Impact Details |
|---|---|
| 2232 - Mechanical engineering technologists and technicians | **Number of Tasks:** 18<br>**Tasks Altered:** 6<br>**Tasks Partially Eliminated:** 2<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 8<br>**Percentage of Tasks Potentially Impacted:** 44.4%<br>**Impact Level:** Potentially Significant<br>**Technologies Impacting:** Artificial Intelligence, Big Data and Analytics, Simulation, Smart Sensors<br>**Remarks on Impact:**<br>- Mechanical simulations will be utilized in the analyses of machinery performance and dynamics<br>- Simulations, smart sensors and data collected from machinery and equipment will reduce the required mechanical tests and analyses to determine performance, strength, response to stress and other characteristics<br>- Predictive maintenance (AI and Smart Sensors) will alter traditional maintenance standards and schedules |
| 2233 - Industrial engineering and manufacturing technologists and technicians | **Number of Tasks:** 21<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 4<br>**Total Tasks Potentially Impacted:** 7<br>**Percentage of Tasks Potentially Impacted:** 33.3%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Big Data and Analytics, Smart Sensors<br>**Remarks on Impact:**<br>- The collection, compilation and analysis of data will be increasingly digitized and dependant on big data systems and algorithms for analytics<br>- Digital inventory management systems will automate manufacturing inventory programs<br>- Advanced sensor technologies will alter quality assurance strategies and programs with the increased reliance on smart sensors |

| Occupation | Potential Impact Details |
|---|---|
| 2241 - Electrical and electronics engineering technologists and technicians | **Number of Tasks:** 29<br>**Tasks Altered:** 11<br>**Tasks Partially Eliminated:** 5<br>**Tasks Fully Eliminated:** 3<br>**Total Tasks Potentially Impacted:** 18<br>**Percentage of Tasks Potentially Impacted:** 62%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Big Data and Analytics, Simulation, Smart Sensors<br>**Remarks on Impact:**<br>- The design, performance assessment, testing and life-testing of electrical and electronic systems will be performed through simulation and modeling<br>- Operational data will be automatically collected and analyzed with the presence of big data and analytics<br>- Real-time data will allow touchless calibration procedures for electrical and electronic systems by component manufacturers |
| 2243 - Industrial instrument technicians and mechanics | **Number of Tasks:** 15<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 3<br>**Tasks Fully Eliminated:** 2<br>**Total Tasks Potentially Impacted:** 6<br>**Percentage of Tasks Potentially Impacted:** 40%<br>**Impact Level:** Potentially Significant<br>**Technologies Impacting:** Big Data and Analytics, Smart Sensors<br>**Remarks on Impact:**<br>- Smart sensors and big data gathered from machinery and instruments will accelerate the process of diagnosis of faults reducing downtime<br>- Routine and scheduled maintenance procedures will be altered by predictive maintenance systems<br>- Touchless calibration will be used to calibrate machinery based on synchronized real-time data exchanged with instrument manufacturers |

| Occupation | Potential Impact Details |
|---|---|
| 2281 - Computer network technicians | **Number of Tasks:** 25<br>**Tasks Altered:** 14<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 15<br>**Percentage of Tasks Potentially Impacted:** 60%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Big Data and Analytics, Cloud Computing<br>**Remarks on Impact:**<br>- Software, data and network operations will be altered with the shift from the traditional network frameworks to cloud storage and computing<br>- Cyber-security systems will alter traditional security software and procedures to detect risks and eliminate cyber threats |
| 2283 - Information systems testing technicians | **Number of Tasks:** 13<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 6<br>**Percentage of Tasks Potentially Impacted:** 15.3%<br>**Impact Level:** Insignificant<br>**Technologies Impacting:** Cloud Computing<br>**Remarks on Impact:**<br>Software installation and configuration will be carried remotely and over the cloud |

## Skilled Trades Occupations

| Occupation | Potential Impact Details |
|---|---|
| 7201 - Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations | **Number of Tasks:** 19<br>**Tasks Altered:** 5<br>**Tasks Partially Eliminated:** 5<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 11<br>**Percentage of Tasks Potentially Impacted:** 57.8%<br>**Impact Level:** Potentially Significant<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Smart scheduling will assist in establishing schedules of workers and helpers<br>- Production reports will be automated through the data collected from various machinery and components<br>- Augmented reality will be used to train workers<br>- Data collected and shared across the manufacturing divisions will assist in coordinating production activities between divisions |

| Occupation | Potential Impact Details |
|---|---|
| 7231 - Machinists and machining and tooling inspectors | **Number of Tasks:** 23<br>**Tasks Altered:** 10<br>**Tasks Partially Eliminated:** 7<br>**Tasks Fully Eliminated:** 2<br>**Total Tasks Potentially Impacted:** 19<br>**Percentage of Tasks Potentially Impacted:** 82.6%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Additive Manufacturing, Augmented Reality, Autonomous Robotics, Big Data and Analytics, Simulation, Smart Sensors<br>**Remarks on Impact:**<br>- Smart sensors will be utilized for measurements and dimension verification<br>- Robotics and smart sensors can be utilized for 3-D scanning and mapping of parts and products<br>- Additive manufacturing might be a viable option instead of subtractive manufacturing (machining) in prototyping or small productions<br>- Simulation will assist in determining machining methods and the best sequence of operations, and can translate machining steps into G-code for computer numerically controlled (CNC) machines |

| Occupation | Potential Impact Details |
|---|---|
| 7232 - Tool and die makers | **Number of Tasks:** 39<br>**Tasks Altered:** 11<br>**Tasks Partially Eliminated:** 3<br>**Tasks Fully Eliminated:** 18<br>**Total Tasks Potentially Impacted:** 32<br>**Percentage of Tasks Potentially Impacted:** 82.1%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Additive Manufacturing, Autonomous Robotics, Simulation, Smart Sensors<br>**Remarks on Impact:**<br>- Programming of computer numerically controlled (CNC) machines and equipment can be carried through mechanical simulation where machining steps and operations can be translated to G-code<br>- For mass production of parts, robotic arms are capable of autonomously performing a variety of operations including cutting, turning, milling, planing, drilling, boring, grinding and shaping<br>- Smart sensors including vision and proximity sensors are capable of inspecting and measuring parts, and detecting faults and errors in produced parts<br>- Fitting and assembling processes can also be automated using robotic operations |

| Occupation | Potential Impact Details |
|---|---|
| 7237 - Welders and related machine operators | **Number of Tasks:** 20<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 5<br>**Total Tasks Potentially Impacted:** 11<br>**Percentage of Tasks Potentially Impacted:** 55%<br>**Impact Level:** Potentially Significant<br>**Technologies Impacting:** Augmented Reality, Autonomous Robotics, Smart Sensors<br>**Remarks on Impact:**<br>- Autonomous Robotics along with smart sensors will be capable of welding, flame-cutting, brazing and soldering components and parts<br>- Predictive maintenance will alter maintenance schedules and procedures of machinery<br>- Virtual reality gear will display instructions and indicators for welders while performing a task |
| 7241 - Electricians (except industrial and power system) | **Number of Tasks:** 21<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 2<br>**Total Tasks Potentially Impacted:** 5<br>**Percentage of Tasks Potentially Impacted:** 23.8%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Autonomous Robotics, Smart Sensors<br>**Remarks on Impact:**<br>- Autonomous robotics will be capable of installing some of the electrical and lighting fixtures in production<br>- Predictive maintenance will replace preventive maintenance programs and schedules<br>- Augmented reality gear will reduce downtime and assist electricians in viewing instructions and schematics |

| Occupation | Potential Impact Details |
|---|---|
| 7242 - Industrial electricians | **Number of Tasks:** 24<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 5<br>**Tasks Fully Eliminated:** 0<br>**Total Tasks Potentially Impacted:** 7<br>**Percentage of Tasks Potentially Impacted:** 29.1%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Wireless calibration will be used to calibrate some equipment and machinery<br>-Augmented reality gear will reduce downtime and assist electricians in viewing instructions and schematics<br>- Predictive maintenance will replace preventive maintenance programs and schedules |
| 7301 - Contractors and supervisors, mechanic trades | **Number of Tasks:** 17<br>**Tasks Altered:** 4<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 9<br>**Percentage of Tasks Potentially Impacted:** 52.9%<br>**Impact Level:** Potentially Significant<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Smart scheduling will assist in scheduling the activities of labourers and helpers<br>- Augmented reality gear will assist in the training of workers<br>- Production data and reports will be automated with the increased generation and flow of data |

| Occupation | Potential Impact Details |
|---|---|
| 7311 - Construction millwrights and industrial mechanics | **Number of Tasks:** 24<br>**Tasks Altered:** 3<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 2<br>**Total Tasks Potentially Impacted:** 9<br>**Percentage of Tasks Potentially Impacted:** 37.5%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Autonomous Robotics, Smart Sensors<br>**Remarks on Impact:**<br>- Routine maintenance and inspection of machinery and equipment will be altered with the emergence of predictive maintenance<br>- Augmented reality gear will view instructions and diagrams while performing a task<br>- Robotics will assist in the assembly of machinery parts and equipment |
| 7452 - Material handlers | **Number of Tasks:** 26<br>**Tasks Altered:** 0<br>**Tasks Partially Eliminated:** 5<br>**Tasks Fully Eliminated:** 11<br>**Total Tasks Potentially Impacted:** 16<br>**Percentage of Tasks Potentially Impacted:** 61.5%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Autonomous Robotics, Smart Sensors<br>**Remarks on Impact:**<br>- Several transportation and material handling operations can be fully automated with the use of mobile robotics and automated conveyor routing systems<br>- Digital inventory management systems will assist in maintaining material inventory and filling in warehouse orders |

| Occupation | Potential Impact Details |
|---|---|
| 7511 - Transport truck drivers | **Number of Tasks:** 21<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 3<br>**Total Tasks Potentially Impacted:** 5<br>**Percentage of Tasks Potentially Impacted:** 23.8%<br>**Impact Level:** Minor<br>**Technologies Impacting:** Artificial Intelligence, Big Data and Analytics<br>**Remarks on Impact:**<br>- Increased data generation and exchange among transportation and logistics and across the broader manufacturing supply-chain implies the digitization of information communication and lowers the need for manual communication<br>- Smart planning and logistics software provide optimized trip planning and best shipping routes and eliminates the need for manual planning |

## Supervisors and Production Occupations

| Occupation | Potential Impact Details |
|---|---|
| 9221 - Supervisors, motor vehicle assembling | **Number of Tasks:** 11<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 7<br>**Percentage of Tasks Potentially Impacted:** 63.6%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Smart scheduling will assist in establishing schedules of workers and helpers<br>- Production reports will be automated through the data collected from various machinery and components<br>- Augmented reality will be used to train workers<br>- Data collected and shared across the manufacturing divisions will assist in coordinating production activities between divisions |
| 9222 - Supervisors, electronics manufacturing | **Number of Tasks:** 16<br>**Tasks Altered:** 4<br>**Tasks Partially Eliminated:** 6<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 11<br>**Percentage of Tasks Potentially Impacted:** 68.8%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Smart scheduling will assist in establishing work schedules of workers and helpers<br>- Production reports will be automated through the data collected from various machinery and components<br>- Augmented reality will be used to train workers<br>- Data collected and shared across the manufacturing divisions will assist in coordinating production activities between divisions |

| Occupation | Potential Impact Details |
|---|---|
| 9223 - Supervisors, electrical products manufacturing | **Number of Tasks:** 12<br>**Tasks Altered:** 3<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 8<br>**Percentage of Tasks Potentially Impacted:** 66.7%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Smart scheduling will assist in establishing work schedules of workers and helpers<br>- Production reports will be automated through the data collected from various machinery and components<br>- Augmented reality will be used to train workers<br>- Data collected and shared across the manufacturing divisions will assist in coordinating production activities between divisions |
| 9224 - Supervisors, furniture and fixtures manufacturing | **Number of Tasks:** 11<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 7<br>**Percentage of Tasks Potentially Impacted:** 63.6%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Smart scheduling will assist in establishing work schedules of workers and helpers<br>- Production reports will be automated through the data collected from various machinery and components<br>- Augmented reality will be used to train workers and new employees<br>- Data collected and shared across the manufacturing divisions will assist in coordinating production activities between divisions |

| Occupation | Potential Impact Details |
|---|---|
| 9226 - Supervisors, other mechanical and metal products manufacturing | **Number of Tasks:** 12<br>**Tasks Altered:** 3<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 8<br>**Percentage of Tasks Potentially Impacted:** 66.7%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Smart scheduling will assist in establishing work schedules of workers and helpers<br>- Production reports will be automated through the data collected from various machinery and components<br>- Augmented reality will be used to train workers<br>- Data collected and shared across the manufacturing divisions will assist in coordinating production activities between divisions |
| 9227 - Supervisors, other products manufacturing and assembly | **Number of Tasks:** 12<br>**Tasks Altered:** 3<br>**Tasks Partially Eliminated:** 4<br>**Tasks Fully Eliminated:** 1<br>**Total Tasks Potentially Impacted:** 8<br>**Percentage of Tasks Potentially Impacted:** 66.7%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Artificial Intelligence, Augmented Reality, Big Data and Analytics<br>**Remarks on Impact:**<br>- Smart scheduling will assist in establishing work schedules of workers and helpers<br>- Production reports will be automated through the data collected from various machinery and components<br>- Augmented reality will be used to train workers<br>- Data collected and shared across the manufacturing divisions will assist in coordinating production activities between divisions |

| Occupation | Potential Impact Details |
|---|---|
| 9412 - Foundry workers | **Number of Tasks:** 15<br>**Tasks Altered:** 5<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 8<br>**Total Tasks Potentially Impacted:** 13<br>**Percentage of Tasks Potentially Impacted:** 86.6%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Additive Manufacturing, Autonomous Robotics<br>**Remarks on Impact:**<br>- Robotic milling can be utilized to cast specific mould geometries<br>- 3D printing or additive manufacturing can also form mould inserts<br>- Robotic arms and autonomous machinery are capable of casting, quenching and coating metal products |
| 9416 - Metalworking and forging machine operators | **Number of Tasks:** 36<br>**Tasks Altered:** 4<br>**Tasks Partially Eliminated:** 2<br>**Tasks Fully Eliminated:** 23<br>**Total Tasks Potentially Impacted:** 29<br>**Percentage of Tasks Potentially Impacted:** 80.5%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Additive Manufacturing, Autonomous Robotics, Big Data and Analytics, Simulation<br>**Remarks on Impact:**<br>- Generating G-code for setting up and operating CNC equipment can be performed through machining simulation<br>- Autonomous robotics will automate several metalworking operations including welding, soldering, bolting, screwing and riveting<br>- Production reporting will be digitized using the data collected from machinery and sensors<br>- For automotive parts and components, forging operations can be fully automated for mass production |

| Occupation | Potential Impact Details |
|---|---|
| 9417 - Machining tool operators | **Number of Tasks:** 12<br>**Tasks Altered:** 2<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 6<br>**Total Tasks Potentially Impacted:** 9<br>**Percentage of Tasks Potentially Impacted:** 75%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Additive Manufacturing, Autonomous Robotics, Simulation<br>**Remarks on Impact:**<br>- Simulation software will assist in performing machining operations<br>- Additive manufacturing can potentially replace some machining operations for the fabrication of some parts<br>- Predictive maintenance will reduce the routine maintenance requirements for machinery |
| 9422 - Plastics processing machine operators | **Number of Tasks:** 43<br>**Tasks Altered:** 6<br>**Tasks Partially Eliminated:** 9<br>**Tasks Fully Eliminated:** 20<br>**Total Tasks Potentially Impacted:** 35<br>**Percentage of Tasks Potentially Impacted:** 81.4%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Autonomous Robotics, Big Data and Analytics, Smart Sensors<br>**Remarks on Impact:**<br>- Autonomous plastic processing machinery with minimal input from operators will automate several operational tasks<br>- Smart sensors and data collected will identify and assist with quality assurance operations (Digital Quality Management)<br>- Predictive maintenance will reduce routine maintenance requirements and procedures for machinery<br>- Digital inventory management will automate maintaining inventories of materials and products |

| Occupation | Potential Impact Details |
|---|---|
| 9522 - Motor vehicle assemblers, inspectors and testers | **Number of Tasks:** 24<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 2<br>**Tasks Fully Eliminated:** 15<br>**Total Tasks Potentially Impacted:** 18<br>**Percentage of Tasks Potentially Impacted:** 75%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Augmented Reality, Autonomous Robotics, Smart Sensors<br>**Remarks on Impact:**<br>- Autonomous robotics are capable of fully performing certain production tasks including bolting, screwing, clipping, welding, soldering or fastening parts and components<br>- Smart sensors including proximity and vision sensors will guide robotic arms and machinery in performing several operations including positioning and installing<br>- In certain operations, collaborative robotics (Cobots) can assist production workers in assembly, lifting and moving operations while the worker guides the assistive robotic arm or machinery<br>- Inspection and testing operations can be partially assisted by smart sensors which can detect and keep track of defects and body dents |

| Occupation | Potential Impact Details |
|---|---|
| 9522-1 - Motor vehicle assemblers[11] | **Number of Tasks:** 14<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 11<br>**Total Tasks Potentially Impacted:** 13<br>**Percentage of Tasks Potentially Impacted:** 92.8%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Augmented Reality, Autonomous Robotics, Smart Sensors |
| 9522-2 - Motor vehicle inspectors and testers | **Number of Tasks:** 10<br>**Tasks Altered:** 0<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 4<br>**Total Tasks Potentially Impacted:** 5<br>**Percentage of Tasks Potentially Impacted:** 50%<br>**Impact Level:** Potentially Significant<br>**Technologies Impacting:** Smart Sensors |

[11] Motor vehicle assemblers and Motor vehicle inspectors and testers were assessed separately as this occupation has the highest number of employees in the sectors at 48,000 workers. The distinction between both groups is based on the description of main duties under the National Occupational Classification (NOC) system.

| Occupation | Potential Impact Details |
|---|---|
| 9523 - Electronics assemblers, fabricators, inspectors and testers | **Number of Tasks:** 47<br>**Tasks Altered:** 6<br>**Tasks Partially Eliminated:** 12<br>**Tasks Fully Eliminated:** 21<br>**Total Tasks Potentially Impacted:** 39<br>**Percentage of Tasks Potentially Impacted:** 83%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Autonomous Robotics, Big Data and Analytics, Smart Sensors<br>**Remarks on Impact:**<br>- Operations which include soldering, installing, mounting, fastening and assembly of electrical equipment can be fully automated through autonomous robotics and smart sensors<br>- Inspecting component positioning, identifying defective parts and carrying continuity tests can be partially assisted by machinery and vision sensors<br>- Data collected from sensors and machinery will be used for reporting production inventories along with electrical test results |
| 9526 - Mechanical assemblers and inspectors | **Number of Tasks:** 20<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 3<br>**Tasks Fully Eliminated:** 12<br>**Total Tasks Potentially Impacted:** 16<br>**Percentage of Tasks Potentially Impacted:** 80%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Autonomous Robotics, Big Data and Analytics, Smart Sensors<br>**Remarks on Impact:**<br>- Assembly, installation, aligning, positioning and fastening components and parts will be increasingly carried by autonomous Robotics with the assistance of smart sensors<br>- Statistical data and smart sensors will assist through statistical quality management of parts and subassemblies |

| Occupation | Potential Impact Details |
|---|---|
| 9535 - Plastic products assemblers, finishers and inspectors | **Number of Tasks:** 24<br>**Tasks Altered:** 4<br>**Tasks Partially Eliminated:** 1<br>**Tasks Fully Eliminated:** 18<br>**Total Tasks Potentially Impacted:** 23<br>**Percentage of Tasks Potentially Impacted:** 95.8%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Autonomous Robotics, Big Data and Analytics, Smart Sensors<br>**Remarks on Impact:**<br>- Autonomous robotics and machinery are capable of performing cutting, shaping, trimming, grinding, joining and assembling plastic materials and parts<br>- Vision and proximity sensors can assist in verifying the dimensions of parts and products and inspecting them for defects<br>- Reports on production, defects and rejected parts are digitized with the increased data generation and exchange |
| 9536 - Industrial painters, coaters and metal finishing process operators | **Number of Tasks:** 43<br>**Tasks Altered:** 5<br>**Tasks Partially Eliminated:** 9<br>**Tasks Fully Eliminated:** 20<br>**Total Tasks Potentially Impacted:** 34<br>**Percentage of Tasks Potentially Impacted:** 79.1%<br>**Impact Level:** Potentially Major<br>**Technologies Impacting:** Autonomous Robotics<br>**Remarks on Impact:**<br>- Robotic arms are capable of autonomously painting and coating surfaces, parts and components<br>- Automatic paint mixing equipment can mix and produce paint according to a predetermined formulas and color gradients<br>- Operations including etching, cleaning, sanding parts can be partially automated by machinery however still require operator's input |

| Occupation | Potential Impact Details |
|---|---|
| 9619 - Other labourers in processing, manufacturing and utilities | **Number of Tasks:** 10<br>**Tasks Altered:** 1<br>**Tasks Partially Eliminated:** 0<br>**Tasks Fully Eliminated:** 8<br>**Total Tasks Potentially Impacted:** 9<br>**Percentage of Tasks Potentially Impacted:** 90%<br>**Impact Level:** Potentially Extreme<br>**Technologies Impacting:** Autonomous Robotics, Smart Sensors<br>**Remarks on Impact:**<br>- Autonomous mobile robotics are capable of transporting materials and products across the facility<br>- Sorting and checking materials and products will be automated with the presence of smart sensors across the manufacturing line |

# APPENDIX D: LIST OF NEW JOB TITLES CREATED BY INDUSTRY 4.0 TECHNOLOGIES AND THEIR POTENTIAL NOC ASSOCIATION

| New Job Titles | Relevant Technology | Potential NOC Association |
|---|---|---|
| 3D printing machinist | Additive Manufacturing | 7201 – Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations<br>7231 – Machinists and machining and tooling inspectors |
| 3D printing technician / technical specialist | Additive Manufacturing | 2232 – Mechanical engineering technologists and technicians<br>2233 – Industrial engineering and manufacturing technologists and technicians<br>7201 – Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations<br>7231 – Machinists and machining and tooling inspectors |
| 3D scanning engineer | Smart Sensors | 2132 – Mechanical engineers<br>2141 – Industrial and manufacturing engineers |
| 3D scanning technician | Smart Sensors | 2232 – Mechanical engineering technologists and technicians<br>2233 – Industrial engineering and manufacturing technologists and technicians<br>7201 – Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations<br>7231 – Machinists and machining and tooling inspectors |
| Additive manufacturing engineer | Additive Manufacturing | 2132 – Mechanical engineers<br>2141 – Industrial and manufacturing engineers |
| Additive manufacturing technician | Additive Manufacturing | 2232 – Mechanical engineering technologists and technicians<br>2233 – Industrial engineering and manufacturing technologists and technicians<br>7201 – Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations<br>7231 – Machinists and machining and tooling inspectors |
| Augmented / Virtual reality engineer | Augmented Reality | 2133 – Electrical and electronics engineers |
| Augmented / Virtual reality scientist | Augmented Reality | 2241 – Electrical and electronics engineering technologists and technicians |

| New Job Titles | Relevant Technology | Potential NOC Association |
|---|---|---|
| Augmented reality developer | Augmented Reality | 2241 – Electrical and electronics engineering technologists and technicians |
| Autonomous driving simulation engineer | Simulation / Robotics | 2132 – Mechanical engineers<br>2141 – Industrial and manufacturing engineers |
| Autonomy engineer | Autonomous Robotics | 2132 – Mechanical engineers<br>2141 – Industrial and manufacturing engineers |
| Cloud computing engineer | Cloud Computing | 2173 – Software engineers and designers |
| Cloud infrastructure architect | Cloud Computing | 2173 – Software engineers and designers |
| Cloud security analyst | Cyber Security | 2171 – Information systems analysts and consultants |
| Cloud security engineer | Cloud Computing / Cyber Security | 2171 – Information systems analysts and consultants<br>2173 – Software engineers and designers |
| Computer integrated manufacturing engineer (CIM) | Simulation | 2132 – Mechanical engineers<br>2141 – Industrial and manufacturing engineers |
| Computer vision developer | Augmented Reality / Smart Sensors | 2241 – Electrical and electronics engineering technologists and technicians |
| Computer vision engineer | Augmented Reality / Smart Sensors | 2133 – Electrical and electronics engineers |
| Computing software engineer | Cloud Computing | 2172 – Database analysts and data administrators<br>2173 – Software engineers and designers |
| Cyber security analyst | Cyber Security | 2173 – Software engineers and designers |
| Cyber security consultant | Cyber Security | 2171 – Information systems analysts and consultants |
| Cyber security engineer | Cyber Security | 2171 – Information systems analysts and consultants<br>2173 – Software engineers and designers |
| Cyber security firmware developer | Cyber Security | 2173 – Software engineers and designers |
| Cyber security specialist | Cyber Security | 2171 – Information systems analysts and consultants |
| Digital marketing and strategy specialists | Internet of Things | 2174 – Computer programmers and interactive media developers |
| Digital service and solutions designers | Internet of Things | 2174 – Computer programmers and interactive media developers |
| Discrete event simulation specialist | Simulation | 2233 – Industrial engineering and manufacturing technologists and technicians |
| Field robotics operator | Robotics | 9227 – Supervisors, other products manufacturing and assembly<br>9522 – Motor vehicle assemblers, inspectors and testers<br>9526 – Mechanical assemblers and inspectors |
| Frontend developer | Internet of Things | 2174 – Computer programmers and interactive media developers |
| Human machine interface developer | Internet of Things | 2174 – Computer programmers and interactive media developers |

| New Job Titles | Relevant Technology | Potential NOC Association |
|---|---|---|
| Industrial robotics and simulation engineering technologist | Robotics / Simulation | 2232 – Mechanical engineering technologists and technicians<br>2233 – Industrial engineering and manufacturing technologists and technicians |
| Internet of things developer | Internet of Things | 2174 – Computer programmers and interactive media developers |
| Internet of things engineer | Internet of Things | 2173 – Software engineers and designers |
| Machine learning engineer / scientist / developer | Data Analytics | 2173 – Software engineers and designers |
| Mechanical design simulation engineer | Simulation | 2132 – Mechanical engineers |
| Mechanical simulation and modeling engineer | Simulation | 2132 – Mechanical engineers<br>2141 – Industrial and manufacturing engineers |
| Mechatronics engineer | Robotics | 2132 – Mechanical engineers |
| Predictive maintenance engineer | Smart Sensors / Big Data and Analytics | 2132 – Mechanical engineers<br>2141 – Industrial and manufacturing engineers |
| Predictive maintenance technician | Smart Sensors / Big Data and Analytics | 2232 – Mechanical engineering technologists and technicians<br>2233 – Industrial engineering and manufacturing technologists and technicians |
| Robotic welding operator | Robotics | 7237 – Welders and related machine operators |
| Robotic welding technician | Robotics | 2233 – Industrial engineering and manufacturing technologists and technicians<br>7237 – Welders and related machine operators |
| Robotics operations integrator | Robotics | 2233 – Industrial engineering and manufacturing technologists and technicians |
| Robotics process automation specialist | Robotics | 2233 – Industrial engineering and manufacturing technologists and technicians |
| Robotics programmer | Robotics | 2232 – Mechanical engineering technologists and technicians<br>2233 – Industrial engineering and manufacturing technologists and technicians |
| Welding robot programmer | Robotics | 2233 – Industrial engineering and manufacturing technologists and technicians |