AVIN Insights
Skills and Talent Series

Spotlights on Skills & Competencies

A brief guide to in-demand and emerging knowledge, use of tools, skills and abilities for the automotive and mobility sector in Ontario

Connected and Autonomous Vehicles (C/AVs) edition

Introduction

As Ontario's automotive and mobility sector continues to evolve, so too will the specific skills required to drive the growth and competitiveness of the sector.

Connected and autonomous vehicles (C/AVs) are considered one of the key drivers of change that are expected to shape the future workforce for the sector.

In the near to medium term, the key opportunities for Ontario's C/AV industry are likely to be centered around the development of the enabling technology that supports C/AVs, electrification, V2X communications, and smart and shared mobility solutions.

This fast-paced development of C/AVs requires a new generation of diverse talent with a broader mix of skills, training and experience to research, design, test and deliver prototypes and solutions.

Driven by insights from industry executives and primary research on labour market data for C/AV industry, we identified some of the key technical knowledge areas and tools and non-technical skills and abilities that are in high demand by C/AV employers in Ontario.

Within the current C/AV industry, technical knowledge such as functional safety, computer science and engineering, software development and implementation were found to be in high demand.

Additionally, industry consultation indicated that while specific technical knowledge is critical for C/AV technology development, what differentiates top talent in the sector are non-technical skills and abilities, such as communication skills, leadership, motivation, a continuous learning mindset, and a drive to solve problems.

About this Booklet

This booklet highlights **some** of the technical knowledge areas and tools and non-technical skills and abilities that are currently in-demand or forecast to grow in demand for the C/AV industry.

This booklet is intended to be used as a high-level guide. It forms part of a spotlights series to cover more segments of the automotive and mobility sector. More information on the highlighted knowledge, tools, skills, and abilities may be found in the cited references and/or other relevant sources including other AVIN insights.

For each of the highlighted knowledge, tools, skills, abilities, the urgency (in-demand vs. emerging) is indicated using the below graphic.

Now means currently in-demand and anticipated to remain in-demand.

New means emerging and forecast to be increasingly in demand (over the next 5 years).

Based on the Government of Canada's taxonomy[1], following are definitions of knowledge, tools, skills and abilities outlined in this booklet:

Knowledge: organized sets of information used for the execution of tasks and activities within a particular domain such as artificial intelligence (AI), computer engineering, computer science, etc.

Tools and Technology: tools and technology used to perform tasks such as Python, C++, CarSim, Harmony, etc.

Skills: developed capacities that an individual must have to be effective in a job, role, function, task, or duty such as problem solving, time management, and working with others.

Abilities: innate and developed aptitudes that facilitate the acquisition of knowledge and skills to perform at work such as motivation, leadership, and continuous learning

Technical knowledge & tools

This section highlights key technical knowledge and use of tools that are in-demand or emerging for the C/AV industry. These are usually acquired through specialized training or education.

- Algorithm Development
- Artificial Intelligence (AI)
- Big Data Analytics
- C++ Programming Language
- Computer Engineering
- Computer Science
- Data Science
- Deep Learning (DL)
- Functional Safety
- Internet of Things (IoT)
- Machine Learning (ML)
- Path Planning
- Python
- Simulation/ Modelling
- Software Development
- Software Engineering
- Software Product Management
- System Integration
- Telecommunication Engineering

Algorithm Development

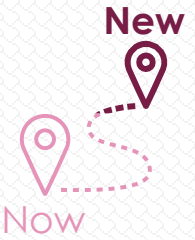
Algorithm development involves the development and analysis of algorithms using data from a system to generate actions, processes, or reports. It is fundamental to all aspects of computer science including artificial intelligence and subsets (i.e. Machine Learning, Deep Learning).

Algorithm developers should be able to understand the alternatives available for problems that a computer can solve, including the hardware, networking, programming language, and performance constraints[2].

Artificial Intelligence (AI)

Artificial intelligence (AI) is the foundation of autonomous vehicles and a paramount skill for talent working in this area. AI is commonly used so machines can perform tasks that humans perform. In autonomous driving, AI is necessary to replicate human senses and reaction to allow vehicles to be driverless.

AI knowledge coupled with enough industry context to apply it to radio and technology mobility solutions is immensely valuable with the growing development and deployment of C/AVs.



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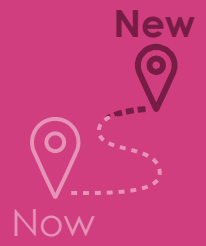
Big Data Analytics

Big data is a subset of data science which combines large and numerous sets of data to draw insights from data relationships. Experience and proficiency with big data analytics is a considerable asset, and in some cases a requirement to work on smart automotive systems.

Additionally, knowledge of data management and storage in C/AV developments and operations are needed to build and manage high-performing and scalable data storage infrastructure to process and maintain data as required.



C++ Programming Language

C++ is a programming language commonly used to program the hardware systems of autonomous vehicles. It is widely popular due to its efficiency and high performance, which are two major considerations when dealing with systems that rely on real-time data such as those operating in autonomous vehicles.

In addition to coding, C++ developers should develop knowledge in optimizing coding techniques to achieve the desired high-performance operations of C/AVs[3].

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Computer Engineering

Computer engineering integrates electronic engineering and computer sciences with a focus on the design and development of computer systems and other technological devices[4].

Computer engineers should be able to design hardware and software and have knowledge of computer processes and system design. For computer engineers to work on C/AVs, additional knowledge in some specialized areas such as robotics and virtual reality are considered an asset[5].

Computer Science

Computer science is a **field of study** that covers theories and methods for calculation and information processing[6].

A wide range of knowledge areas covered in this booklet fall under the computer science field such as path planning, artificial intelligence, software development, and programming that form the basis for C/AV technologies.

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Data Science

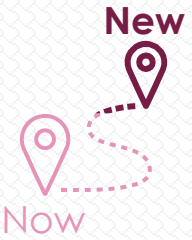
Data science covers the analysis and study of data to be used to make decisions and predictions. Data scientists undertake exploratory analysis to discover insights[7] from data and use various advanced machine learning algorithms to identify the occurrence of a particular event in the future.

There is a growing need for data scientists and analysts who can design better data compilation, visualization, and analysis algorithms that can efficiently handle the vast amounts of data produced and collected by C/AVs.

Deep Learning (DL)

Deep learning (DL) is a sub-class of machine learning based on artificial neural networks[8]. This methodology mimics the workings of the human brain in processing data[9] by using multiple layers to progressively extract higher-level features from the raw input.

DL has powered advances in image classification, speech recognition, language understanding and is being used now for computer vision in automotive systems. DL is one of the most sought-after knowledge areas when it comes to the talent for autonomous driving workforce.



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Functional Safety

Functional safety includes identifying and analyzing safety hazards, creating safety measures, and developing safety requirements, cases, and processes. This is important to reduce the level of risk in a device or system[10] due to hazards caused by malfunctioning behaviour[11] and allows corrective measures to avoid or reduce the impact of a hazard[10].

In autonomous vehicles, safety engineering measures are especially important and should consider the decision-making systems and validate their corresponding awareness of the environment[12].

Internet of Things (IoT)

Internet of Things (IoT) includes applying software development knowledge to connected smart devices, focusing on areas such as path following, sensor engineering and vision algorithms.

This also includes the development of mobile sensors and connected infrastructure which can connect and exchange data across various methods of communication.

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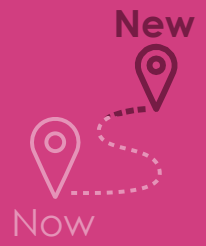
Machine Learning (ML)

Machine learning (ML) is utilizing streams of data continuously collected from on-the-vehicle sensors and communication technologies to develop models that observe vehicle surroundings and make informed driving and control decisions accordingly.

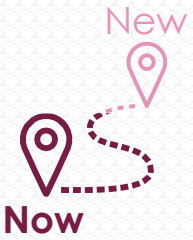
ML talent is required to fundamentally understand the core of ML methods and concepts to be able to interpret the results of the models they develop and optimize their performance and accuracy.



Path Planning

The planning of a vehicle's move from one state to another in real-time including finding a feasible geometric path. While path planning technologies for vehicle navigation are not new, the advances in localization and mapping technologies have called for advanced skills in this area.

In addition to knowledge of common path-finding algorithms, it is required to have knowledge in utilizing high-precision localization and mapping technologies for building a real-time path that can locally and dynamically maximize the distance between a vehicle and its surroundings, while abiding by the road infrastructure and traffic rules .



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Python

Python is a programming language that is suitable for use as a scripting language and web development and implementation language.

Python has become very popular in developing autonomous vehicle technologies with the availability of easy-to-use python libraries for mathematics, data organization and visualization, machine learning (ML), and computer vision[13]. Knowledge of programming basics is an asset to work on autonomous vehicles, even if not working directly on the software side of the technology.

Simulation/ Modelling

Predicting various scenarios through modeling techniques to assess the dynamic performance of C/AVs, with languages including CarSim, Harmony, MATLAB and MBSE Methodologies.

CarSim

A tool used to simulate the performance of vehicles in response to control inputs.

Harmony/SE

A model-based systems engineering process used to build systems specifications based on modelling use cases.

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Software Development

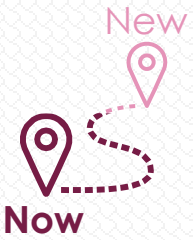
Software development involves creating, designing, deploying and supporting software[14] throughout the software development lifecycle.

Software developers use their skills to transform requirements into features. Software development also includes the implementation and integration processes and software maintenance and testing.

Software Engineering

The software systems in C/AVs depend on critical software engineering expertise especially with the continuous growth and increased complexity of the technology.

To develop software systems, software engineers should understand coding languages, be able to run and alter programs, and upload and download new software into the vehicle. This will ensure that software systems interact with one another in a seamless, precise, and reliable manner.



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Software Product Management

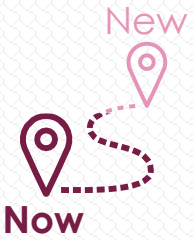
Software product management is the management of a software product at all stages of its development. Software product managers work on the engineering of the software product including architecture, infrastructure and operation.

Additionally, they are involved in developing user experience, client support, and product marketing and sales[15].

System Integration

System integration involves connecting different systems and software applications physically or functionally[16].

This enables data and functionality to flow seamlessly between systems and thus increase efficiency, optimize user experience and streamline data sources - reducing the overall complexity[17,18].



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Telecommunication Engineering

Telecommunication engineering is becoming more vital, demanding specialized and highly skilled talent with the growth in connectivity requirements in future vehicles. This includes in-vehicle systems that exchange data and information to control the vehicle operation.

In addition to in-vehicle communication networks, working on the external connectivity requirements of these vehicles requires a solid understanding and knowledge of the communication technologies between vehicles, including Dedicated Short-Range Communication (DSRC) and Cellular Vehicle-to-Everything (C-V2X).

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Non-Technical Skills and Abilities

Non-technical skills and abilities are also referred to sometimes as soft, interpersonal or human skills. These skills and abilities complement technical knowledge and expertise and allow for better communication, management, execution of tasks and projects to improve overall efficiency and effectiveness.

- Communication
- Continuous Learning
- Detail-Orientation
- Digital Skills
- Document Use
- Leadership
- Prioritization
- Problem Solving
- Resourcefulness
- Responsibility
- Self-Motivation
- Time Management
- Working with Others

Communication

Being able to give and receive different types of information is important in any job. It helps workers to work together as a team and share ideas and knowledge.

There are many skills that form the building blocks for effective communication skills such as active listening, feedback, empathy and respect.

Related Skills and/or Abilities

Active listening

Paying close attention to the person that you are speaking with.

Adaptive communication style

Knowing when and how to communicate in different scenarios.

Feedback

The ability to give and receive feedback.

Empathy

The ability to understand and share the emotions of others.

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Continuous Learning

Continuous learning requires workers in an occupational group to participate in an ongoing process of acquiring skills and knowledge.

This ability is used when learning as part of regular work or from co-workers and when accessing training in the workplace or off-site[19].

Detail-Orientation

The ability to pay close attention to and notice the small details when working on a task or project.

There is a growing demand for detail-oriented workers that can give full attention to the task and deliver it to the highest quality with minimal to no errors[20].

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Digital Skills

Digital skills are needed to understand and process information from digital sources, use digital systems, technical tools, and applications.

Digital sources and/or devices include word processing software, and computers to send emails and create and modify spreadsheets[19].

Document Use

Document use involves a variety of information displays in which words, numbers, icons, and other visual characteristics (eg. line, colour, shape) are given meaning by their spatial arrangement.

This skill is used when reading and interpreting graphs, charts, lists, tables, blueprints, schematics, drawings, signs, and labels[19].

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Leadership

Leadership refers to a combination of skills and abilities used when organizing other people to reach a shared goal[21]. This includes effective decision making, the ability to build and maintain a strong and collaborative team, dependability, and the ability to teach, mentor and empower others.

A leader should be self-motivated, responsible, resourceful, can prioritize their work and communicate efficiently with others to be able to motivate their team to achieve the desired outcome.

Prioritization

Prioritizing tasks based on their importance helps in organizing the time more efficiently and meeting project deadlines[22].

To be able to prioritize work, it is required to have the ability to identify work dependencies, recognize critical activities/timelines, utilize technology to increase efficiency, manage stakeholder expectations, and use a time management tool for maximized efficiency.

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Problem Solving

Problem solving refers to using logic, as well as imagination, to make sense of a situation and derive an intelligent solution. Problem solvers can also actively anticipate potential future problems and act to prevent them or to mitigate their effects.

Problem solving abilities are connected to a number of other skills, such as analytical skills, innovative and creative thinking, adaptability and flexibility[23].

Resourcefulness

Resourcefulness is the ability to find and use available resources to solve problems and achieve goals[24].

A resourceful person not only strives to optimize new tasks but also thinks of better ways to do recurring tasks.

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Responsibility

A responsible worker is able to accept the outcomes of their work and consequences of their actions as well as the rewards of delivering outstanding results[25].

Responsibility also entails the ability to learn from previous experiences and continue to look for new ways to improve performance.

Self-Motivation

Having the drive and motivation allows workers to complete the task in hand more efficiently.

This requires setting a clear goal which encourages the successful completion of the task and the associated feeling of satisfaction and pride[26].

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Time Management

The efficient management of time creates a more structured work approach which supports in achieving goals in a timely manner.

The time management skills include but are not limited to organization, prioritization, planning, delegation, and stress management[27].

Working with Others

Working with others examines the extent to which employees work with others to carry out their tasks.

This skill is used when working as a member of a team or jointly with a partner, and when engaging in supervisory or leadership activities[19].

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Industry Perspectives

AVIN Skills and Talent Strategy

Ontario's Autonomous Vehicle Innovation Network (AVIN) is undertaking work on skills and talent, which focuses on ensuring the sector's workforce is prepared to meet the needs of the future and maintain its global competitiveness.

Through this work, AVIN aims to support the futureproofing of the automotive and mobility sector's workforce, drive collaboration between industry, educational and post-secondary institutions and government, and support an approach to strengthening and diversifying the next generation talent pipeline and building capacity within all regions of Ontario.

In addition to this spotlight series, AVIN is releasing regular insights pieces on skills and talent. Check out the below channels to access these insights and other regular updates on this work and more:

Access to AVIN Insights

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About AVIN

The Autonomous Vehicle Innovation Network (AVIN) is a key component of Driving Prosperity, the Government of Ontario's initiative to ensure the automotive sector remains competitive and continues to grow and thrive. The Government of Ontario has committed $85 million in innovative programming to support research and development (R&D) funding, talent development, technology acceleration, business and technical supports, and testing and demonstration sites.

These programs support small- and medium-sized enterprises (SMEs) to develop, test and commercialize new automotive and transportation products and technologies, and cultivate the capacity of a province-wide network to drive future mobility solutions, reinforcing Ontario's position as a global leader.

The AVIN Central Hub is the driving force behind the programming, province-wide coordination of activities and resources, and Ontario's push to lead in the future of the automotive and mobility sector globally. Led by a dedicated team, the Central Hub is the focal point for all stakeholders across the province, a bridge for collaborative partnerships between industry, post-secondary institutions, broader public sector agencies, municipalities and the government, all while serving as a concierge for new entrants into Ontario's thriving ecosystem.

The Central Hub drives public education, research, analysis, and thought leadership activities, convenes stakeholder groups, and raises awareness around the potential of these technologies, the opportunities for Ontario and for its partners.

AVIN, led by the Ontario Centre of Innovation (OCI), is supported by the Government of Ontario's Ministry of Economic Development, Job Creation and Trade and Ministry of Transportation (MTO).

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Glossary of Terms

Algorithm: a set of instructions designed to perform a specific task.

Artificial neural network: computing units that loosely model the neurons in a biological brain.

Cellular Vehicle-to-Everything (C-V2X): the umbrella term for the car's communication system, where information from sensors and other sources travels via cellular network. V2X includes vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-pedestrian (V2P), and vehicle-to-network (V2N) communications[28].

Coding: using the programming language to get the computer to behave as desired through the creation of computer software, apps and websites.

Computer vision: a sub-field of computer science that aims at making machines see and process images and videos the same way humans do.

Dedicated Short-Range Communication (DSRC): wireless communication technology that enables highly secure, high-speed direct communication between vehicles and the surrounding infrastructure, without involving any cellular infrastructure.

Scripting: working with scripting languages to automate processes. Languages include Python, JavaScript, Perl, PHP, Ruby, etc.

Sensor engineering: the design and development of sensors, sensor systems and products that are equipped with sensors.

Real-time data: information that is delivered immediately after collection.

References

AVIN acknowledges the labour market data contributions of **Accenture** in partnership with **SkyHive.**

1. Employment and Social Development Canada(2020). National Occupational Classification - Skills and Competencies Taxonomy. Accessed through https://noc.esdc.gc.ca/SkillsTaxonomy/TheTaxonomy/3e5b4a88f87b482a9b103a7c37ca5d3b 17
2. Britannica (2021). Algorithms and Complexity. Accessed through https://www.britannica.com/science/computer-science/Algorithms-and-complexity
3. Morales, M. (2017). But, Self-Driving Car Engineers don't need to know C/C++, right? Retrieved from https://medium.com/@mimoralea/but-self-driving-car-engineers-dont-need-to-know-c-c-right-3230725a7542
4. Live Science (2014). What is Computer Engineering. Accessed through https://www.livescience.com/48326-computer-engineering.html
5. York University (2021). Computer Engineering Program. Accessed through https://futurestudents.yorku.ca/program/computer-engineering
6. Britannica (2021). Computer Science. Accessed through https://www.britannica.com/science/computer-science
7. Edureka (2020). What Is Data Science? A Beginner's Guide To Data Science. Accessed through https://www.edureka.co/blog/what-is-data-science/#whatisdatascience
8. Josh. (2015). Everything You Need to Know About Artificial Neural Networks. Retrieved from https://medium.com/technology-invention-and-more/everything-you-need-to-know-about-artificial-neural-networks-57fac18245a1
9. Investopedia (2020). Deep learning. Accessed through https://www.investopedia.com/terms/d/deep learning.asp#:~:text=Deep%20learning%20is%20an%20AI,is%20both%20unstructured%20and%20unlabeled.
10. International Electrotechnical Commission (2021). Safety and functional safety. Accessed through https://www.iec.ch/safety
11. Blackberry QNX. Ultimate Guide to Functional Safety and Safety Certification. Accessed through https://blackberry.qnx.com/en/safety-certification/functional-safety/
12. Adler, R.; Feth, P.; Schneider, D. (2016). Safety Engineering for Autonomous Vehicles. Retrieved from https://ieeexplore.ieee.org/document/7575374
13. scikit-learn: Machine Learning in Python. Retrieved from https://scikit-learn.org/stable/
14. IBM (2021). Software Development. Accessed through https://www.ibm.com/topics/software-development
15. Torres, J. (2016). What is software product management. Accessed through https://www.linkedin.com/pulse/what-software-product-management-joaquim-torres/
16. Wikipedia (2021). System integration. Accessed through https://en.wikipedia.org/wiki/System_integration
17. Be informed (2020). What is System Integration?. Accessed through https://www.beinformed.com/blog/what-is-system-integration/
18. Monsanto, C. (2020). Software Integrations: A Beginner's Guide. Accessed through https://blog.hubspot.com/website/software-integration
19. Skills Competences Canada (2021). What are the nine essential skills. Accessed through https://www.skillscompetencescanada.com/en/essential-skills/what-are-the-nine-essential-skills/
20. Indeed (2020). Detail-Oriented Skills: Definition and Tips. Accessed through https://www.indeed.com/career-advice/resumes-cover-letters/detail-oriented
21. Indeed (2021). Leadership skills: definitions and examples. Accessed through https://www.indeed.com/career-advice/resumes-cover-letters/leadership-skills
22. Indeed (2021). How to prioritize tasks in the workplace. Accessed through https://www.indeed.com/career-advice/career-development/prioritize-tasks-in-the-workplace
23. Target Jobs (2021). Problem Solving: The Mark of an Independent Employee. Accessed through https://targetjobs.co.uk/careers-advice/skills-and-competencies/300766-problem-solving-the-mark-of-an-independent-employee
24. Towards data science (2018). Be Resourceful — One Of The Most Important Skills To Succeed In Data Science. Accessed through https://towardsdatascience.com/be-resourceful-one-of-the-most-important-skills-to-succeed-in-data-science-6ed5f33c2939#:~:text=Being%20resourceful%20is%20the%20ability,data%20science%2C%20and%20in%20life.
25. Indeed (2021). The Difference Between Accountability and Responsibility. Accessed through https://www.indeed.com/career-advice/career-development/difference-accountability-difference
26. Indeed (2021). How to apply self motivation in the workplace. Accessed through https://www.indeed.com/career-advice/career-development/self-motivation-in-the-workplace
27. Indeed (2020). Time Management Skills: Definition and Examples. Accessed through https://www.indeed.com/career-advice/career-development/time-management-skills
28. ZDNet (2019). What is V2X communication? Creating connectivity for the autonomous car era. Accessed through https://www.zdnet.com/article/what-is-v2x-communication-creating-connectivity-for-the-autonomous-car-era/

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