ONTARIO SOCIETY OF PROFESSIONAL ENGINEERS

BEHIND EVERY GREAT ENGINEER.

RESEARCH REPORT

PROPEL YOUR CAREER IN THE SMART MOBILITY INDUSTRY:

A GUIDE FOR ENGINEERING STUDENTS AND RECENT GRADUATES

RESEARCH CONDUCTED BY:

PRISM ECONOMICS AND ANALYSIS

IN PARTNERSHIP WITH:

- CANADIAN URBAN TRANSIT RESEARCH AND INNOVATION CONSORTIUM (CUTRIC)
- ONTARIO CHAMBER OF COMMERCE (OCC)
- COMMUNITECH

WWW.PROPELUSOSPE.CA

JANUARY 2019

Partners:

The Ontario Society of Professional Engineers (OSPE) is grateful for the support of the project partners:

The Canadian Urban Transit Research & Innovation Consortium (CUTRIC)

CUTRIC supports projects that develop the next-generation of mobility and transportation technologies for Canadians. These advancements help grow the low-carbon and "smart" technology eco-system in the country, leading to job growth and economic development over the long-term. http://cutric-crituc.org/home

Ontario Chamber of Commerce (OCC)

The OCC's mission is to support economic growth in Ontario by defending business priorities at Queen's Park on behalf of its network's diverse 60,000 members. The OCC's vision is to foster a vibrant and economically sustainable province that is driven by an innovative, successful and ever-expanding business community. From innovative SMEs to established multinational corporations and industry associations, the OCC is committed to working with our members to improve business competitiveness across all sectors. The OCC represents local chambers of commerce and boards of trade in over 135 communities across Ontario, steering public policy conversations provincially and within local communities. http://www.occ.ca/

Communitech

Communitech was founded in 1997 by a group of entrepreneurs committed to making Waterloo Region a global innovation leader. At the time it was crazy talk, but somehow this community managed to pull it off. Today, Communitech is a public-private innovation hub that supports a community of more than 1400 companies — from startups to scale-ups to large global players. https://www.communitech.ca/

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Contents

Introduction and Outline of Report

This report was prepared for the Ontario Society of Professional Engineers (OSPE) and its partners – the Canadian Urban Transit Research and Innovation Consortium (CUTRIC), Ontario Chamber of Commerce (OCC) and Communitech. The purpose of the report was to provide content support for a digital resource that OSPE and its partners have developed a digital tool, propelusospe.ca. This digital resource provides engineering and technology students and recent graduates with up-to-date, industry-based information on Smart Mobility, skill needs and job search techniques in Canada's auto and transit industries. The digital resource is a unique tool for four reasons:

First: the digital tool is based on industry input that was gathered through a series of interviews with senior human resources and technology managers as well as a review of recent technology road maps;

Second: the digital resource provides up-to-date information on the technology trends that are re-shaping the auto and transit industries. In particular, the digital resource provides information on the increasing role of Smart Mobility technologies in the auto and transit industries as well as information on trends in materials, propulsion and manufacturing processes;

Third: the digital resource provides important, industry-based insight into the non-technical skills that employers seek when recruiting recent engineering and technology graduates; and

Fourth: the digital resource provides a database of leading companies and how to reach them.

The report's introductory chapter describes the emergence of the 'smart mobility industry' and its implications for engineering job-seekers.

Chapter 2 provides a brief overview of the auto industry. Chapter 3 describes some of the key technology trends in the sector.

Chapters 4 to 9 profile in more detail the technology trends that are changing the auto industry. Each of these chapters ends with a brief discussion of the implications of these trends for engineering graduates seeking technology careers.

Chapter 10 provides an overview of the transit sector, which is often less well understood than the auto sector. Chapter 11 is a capsule description of key technology trends in the transit sector. Chapter 12 provides a short description of two leading edge technologies: hyperloop and maglev. Chapter 13 reproduces a series of snapshots of leading Canadian companies in the transit sector. The snapshots were selected and developed by the Canadian Urban Transit Association. Chapter 14 identifies additional resources of use to engineering students interested in these technologies and related career opportunities.

Chapter 15 takes a closer look at the skills (technical and non-technical) that employers are seeking when they recruit recent engineering graduates. These are the skills that will make you stand out.

Chapter 16 sets out 25 tips on how to get an entry-level or junior engineering job.

Chapter 17 (separate cover) is a database of key companies organized by technology. This database can help you target your job search.

1. The Smart Mobility Industry

Technology is driving a transformation of the traditional auto and transit industries. Historically, these industries were focused on the design and manufacture of cars, trucks, buses, street cars, LRTs and subways. What is emerging in the wake of new technologies is the 'smart mobility industry'.

The smart mobility industry involves:

- New products
- New IT-based services,
- New business models,
- New production methods, and
- New design processes.

The emergence of the 'smart mobility industry' has major implications for engineering skills and for engineering career opportunities.

Eight technology trends are creating the smart mobility industry:

1. **New Mobility Products:**
   - Autonomous vehicles (personal, commercial and transit),
   - Internet-connected vehicles,
   - Electric vehicles,
   - Smart transit systems

2. **New Mobility Services:**
   - Advanced networks and data analytics technology are behind the platforms that support ride-sharing platforms (e.g., Uber and Lyft) and car-sharing programs (e.g., ZipCar and Car2Go).

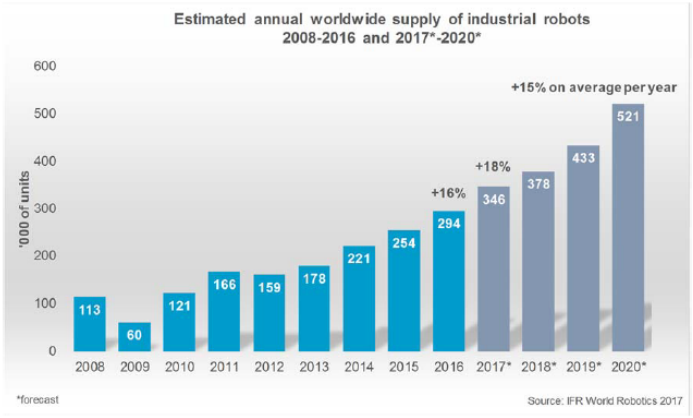
3. **New Infrastructure Systems:**
   - Smart infrastructure is sensors and connectivity systems that are built into infrastructure and vehicles to enable better traffic management and optimized systems that deliver mobility when it is needed and where it is needed. Smart infrastructure is also supported by 'big data' analytics.

4. **New Connectivity Systems:**
   - New connectivity systems (hardware and software) are needed to support connected vehicles and to connect vehicles to smart infrastructure systems.

5. **New Production Processes (Industry 4.0):**
   - Industry 4.0 integrates robotics, sensor technologies, 'big data' systems, artificial intelligence, additive manufacturing (3-D printing) and cloud-based networks.
   - These technologies require the redesign of production systems.

6. **New Materials:**
   - Nanotechnology and other materials technologies are supporting the development of durable, light-weight materials that are key contributors to reducing the amount of energy required to move vehicles,

Executive Summary World Robotics 2017 Industrial Robots 23



7. **Information Technologies:**
   - 'Big Data' analytics are fundamental to smart infrastructure and Industry 4.0 processes,
   - Applied artificial intelligence is the foundation of autonomous vehicles and one of the pillars of Industry 4.0

8. **New Design Processes:**
   - Virtual reality and augmented reality to create realistic, perfectly scaled, three-dimensional images or holograms to speed up product design, reduce iterations, and shorten time to market.

These changes are transformative. You can be part of this new industry. It is important to understand what is happening and what skills are needed.

There are also key societal and environmental drivers that are accelerating the emergence of the smart mobility industry. Climate change is inexorably forcing the traditional auto and transit industries to adapt and transform.

Vehicles account for around 35% of greenhouse gas (GHG) emissions. There will be no substantial progress on reducing GHG emissions without a radical change in the propulsion technology of vehicles.

The End of the Internal Combustion Engine is in Sight

The **United Kingdom** will ban sales of new gasoline and diesel cars starting in 2040. By 2050, *all* cars on the UK's road will need to have zero emissions.

France plans to end sales of gas and diesel-powered vehicles by 2040.

Germany is looking to set a deadline to end sales of cars fitted only with gas or diesel engines.

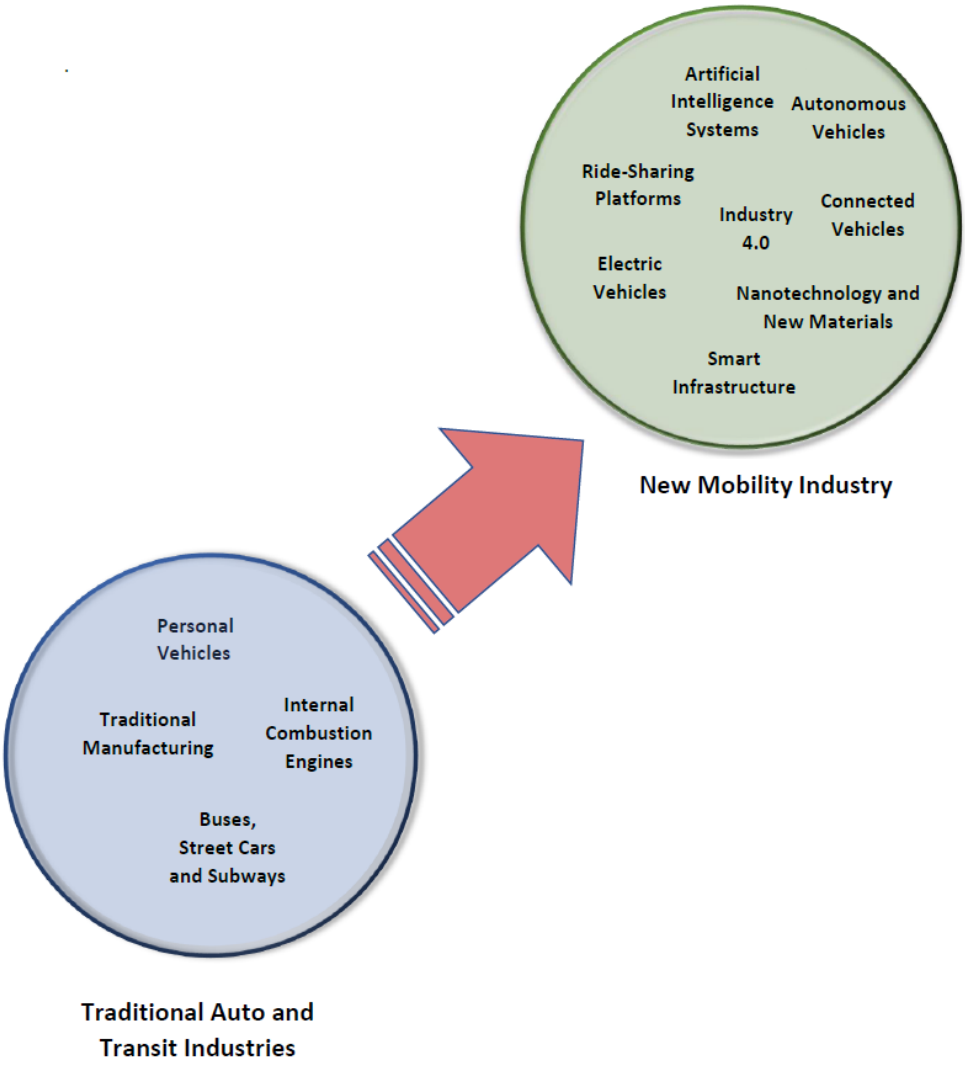
India will require every **v**ehicle sold in the country to be powered by electricity by 2030.

Norway will require all new passenger cars and vans sold in 2025 to be zero-emission vehicles. About 40% of all cars now sold in Norway are electric or hybrid vehicles.

Austria, Denmark, Ireland, Japan, the Netherlands, Portugal, Korea and Spain have set official targets for electric car sales.

Eight states in the **United States** also have set out goals.

Urbanization and demographic trends are also forcing the pace of change. As the population of cities grows, especially the population of inner cities where younger age groups tend to live, there is a shift away from private vehicle ownership to ride-sharing platforms (e.g., Uber and Lyft), car-sharing platforms (e.g., ZipCar or Car2Go) and smarter transit systems.



Canada and Ontario are well positioned to leverage the emergence of the smart mobility industry. For engineers, that means careers and opportunity… provided that you understand what is happening, are passionate about applying these technologies and know how to find entry points.

We are seeing major investments in Ontario's new economy, including major R&D investments. Ontario now has the second largest IT hub in North America. Canada is ranked number one for the availability of qualified engineers and skilled tradespeople. We are world leaders in AI.

Examples of Emerging Opportunities
In the Smart Mobility Industry

GM Canada launches Canadian Technical Centre in Markham

General Motors announced its plans to drive future car development at its new **Canadian Technical Centre – Markham Campus**, where the firm will develop new autonomous vehicle software and controls, active safety and vehicle dynamics systems, infotainment and connected vehicle technologies.

Quick Facts

- Canadian Technical Centre – Markham Campus is a 13,900 m^2. (150,000 ft^2.) facility featuring state-of-the-art test labs for end-to-end software development.
- Approximately 180 employees are currently working onsite with an estimated capacity of 700 employees once it is completed.
- GM is joining one of the largest ICT clusters in North America.

Ford Invests C$500 Million for R&D in Canada

Ford is expanding its Canadian research and development presence with an additional C$500 million investment.

Quick Facts

- A new R&D centre is being established in Ottawa.
- The focus is on engineering for telematics software and connected vehicle services.
- More than 300 software engineers are being hired for the centre.

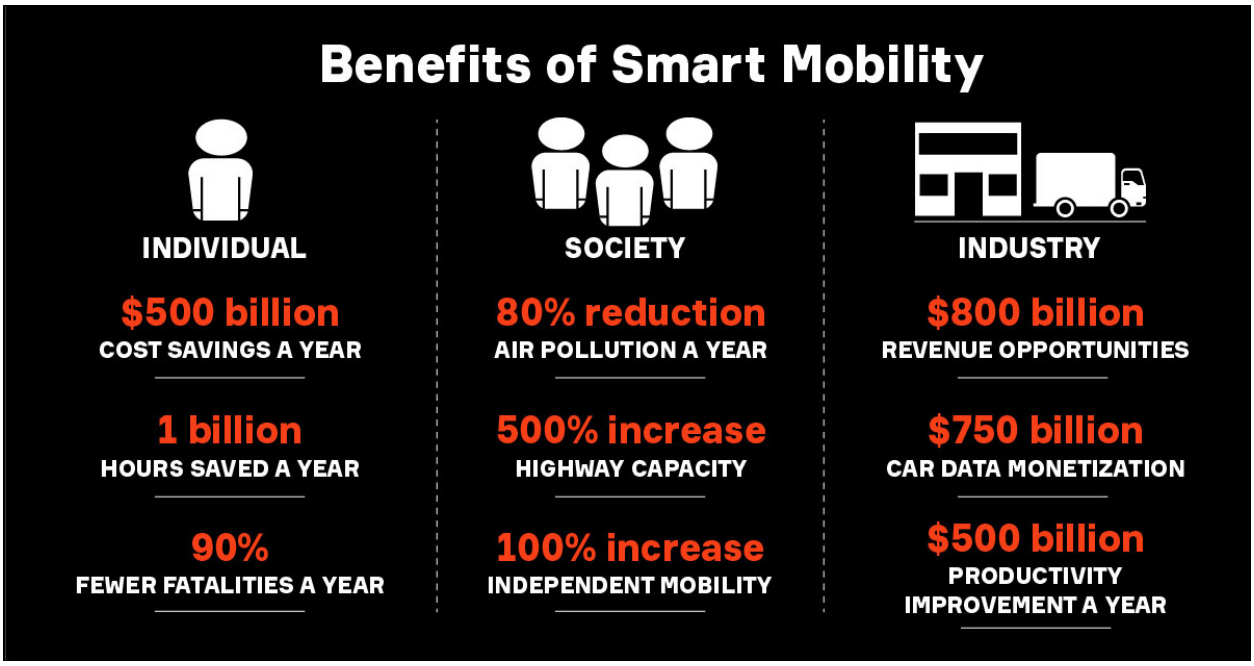
Apple Inc is developing its car operating system in Ottawa

Apple has dozens of software engineers in Canada building a car operating system, a rare move for a company that often houses research and development projects close to its Cupertino, California headquarters, according to people familiar with the matter.

The car operating system is the software core of a future Apple car platform, in the same way iOS powers the iPhone.

Why these Trends Matter to Engineering Students

- Smart mobility technologies are transforming the way we live.
- Smart mobility is critical to reversing the carbon emissions trend that is driving global warming and climate change.
- Smart mobility technologies are creating new skill needs and new types of cross-disciplinary engineering jobs. This is a great time to get in on the ground floor.
- Smart mobility technology career opportunities can be found in large, well-established companies as well as in leading-edge, new venture companies.
- The smart mobility industry is international.
- It's happening now.



Aptiv PLC (Dublin, Ireland)

The Smart Mobility Hub

https://www.smart-mobility-hub.com/

2. Overview of the Auto Industry

A Short History of the Automobile

1885: Karl Benz manufactured Benz Patent Motorwagen in Mannheim, Germany. Prior to Benz, there had been several inventors who had developed one-off, experimental vehicles using steam power, batteries, fuel cells and internal combustion engines. Benz was the first to develop a gasoline-powered car that was intended to be manufactured. His production process was based on workshops that produced one vehicle at a time. By 1899, his company was producing 572 units. This increased to only around 2,500 units in two factories by 1923. In 1926 the Benz company merged with Daimler. The new company commenced production of the Mercedes-Benz line of cars. (Mercedes was the daughter of Daimler's chief engineer).

Benz Patent Motorwagen

1908: Henry Ford began to produce the Model T which was the first car designed to be affordable. Until 1913, the Model T, like all other cars, was produced one at a time in workshops.

1913: Henry Ford started to manufacture his Model T using a moving assembly line at his Highland Park factory in Michigan. His assembly process broke production into 84 specialized tasks that were performed as the vehicle moved down the assembly line. His assembly line production method reduced costs by 60%. His factories were able to produce one Model T every three minutes. By 1924, the cost of a Model T was about two months of the average salary. More than 15 million Model T's were manufactured. Ford's assembly line revolutionized the manufacture of cars. His Highland Park factory is where modern mass production began.

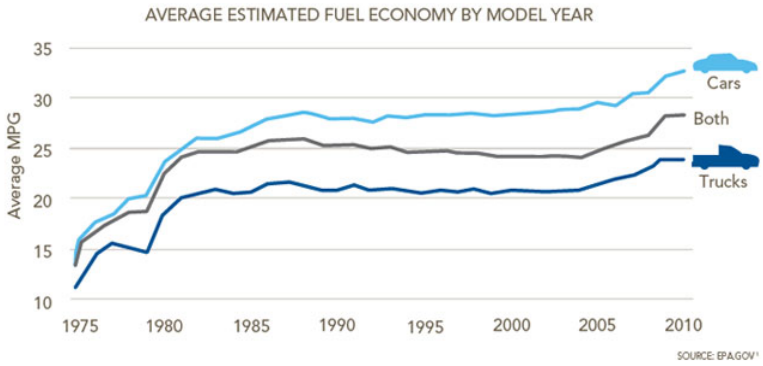
Ford Model T Assembly Line

1950s: After the Depression of the 1930s and World War II, the 1950s saw the spread of mass production and widespread car ownership. In North America, the major producers were: Ford, General Motors, Chrysler, American Motors (no longer operates) and Studebaker (no longer operates). In Britain, the major producers were Ford-UK, Vauxhall (owned by General Motors), and British Motor Corporation which produced Austin, Morris, MG, Riley and Wolseley product lines. In France, Peugeot, Renault and Citroen were the dominant companies. In Gemany, Mercedes-Benz, Audi (now owned by Volkswagen), Bayerische Motoren Werke (BMW) and Volkswagen dominated the market. Fiat was the

dominant producer in Italy. Volvo, Saab and Scania were produced in Sweden. Honda, Toyota, Mitsubishi and Nissan produced for the Japanese market. They entered the international market in the 1970s.

1950 Chevrolet Bel Air

Oil Price Shocks of 1973 and 1979: In the spring of 1973, the price of oil was around $20 per barrel. A year later, the price had been forced up to over $50. By 1980, the price had climbed to $120. Cars account for around 65% of oil consumption in North America. Faced with these facts, consumers and governments have demanded greater fuel efficiency as well as alternatives to the gasoline or diesel fueled internal combustion engine.

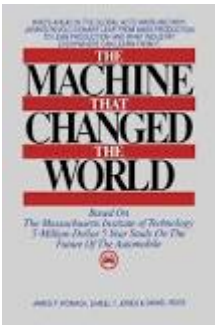


U.S Environmental Protection Agency[1]

1980s: Over the course of the 1960s and 1970s, Japanese manufacturers introduced cost reduction strategies that were based on "just-in-time" (JIT) delivery of components to assembly plants. JIT systems eliminated the need to maintain costly inventories of parts. The Japanese manufacturers also introduced advanced systems of quality control based on the theories of the American engineer Edwards Denning. Denning relocated to Japan in the 1950s. He is credited with laying the engineering foundation for Japan's international emergence as an exporter of high-quality manufactured products. In the 1980s, Japanese manufacturers captured a large share of the North American and European market, based on the reputation of Japanese vehicles for quality and reliability, as well as affordability. The loss of market share prompted a major re-think in the North American and European auto

[1] http://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2011/04/20/driving-to-545-mpg-the-history-of-fuel-economy

industries. The 1990s saw the introduction of new systems of quality control which continue to shape the way in which manufacturing processes are designed and managed. As a result of this shift, any engineer working on the production side of the manufacturing sector must understand how quality control systems are developed and applied.



The best book you can read on how the Japanese industry transformed the manufacturing of cars *is The Machine that Changed the World* by James Womack, Daniel Jones and Daniel Roos. Their book is based on the MIT's Future of the Automobile research report.

1990s: Korea became a volume producer. In 2004, Korea became No. 5 auto producer in the world, passing France.

2000s: China ramped up its auto industry. By 2009, China became the world's largest producing country.

Production Trends

Top Twenty Countries Producing Autos - 2017

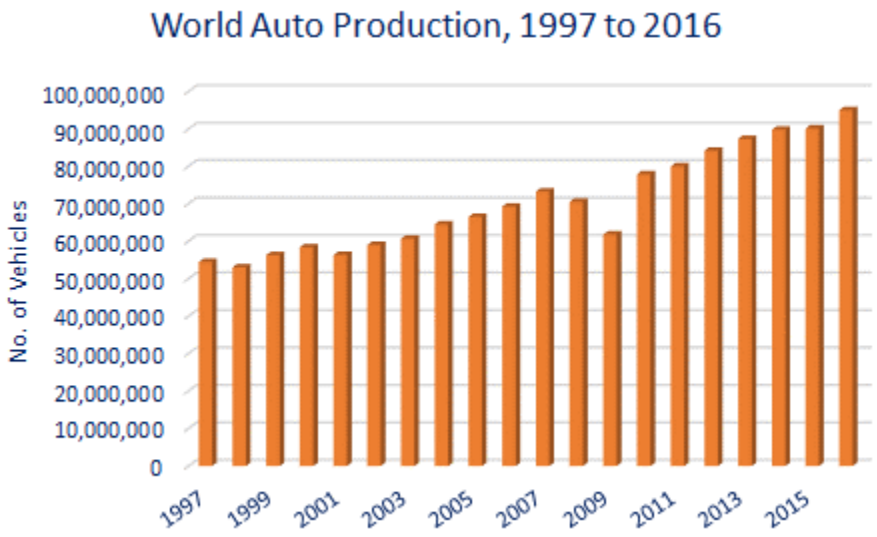
Country	Motor vehicle production (units)
China	29,015,434
United States	11,189,985
Japan	9,693,746
Germany	5,645,581
India	4,782,896
South Korea	4,114,913
Mexico	4,068,415
Spain	2,848,335
Brazil	2,699,672
France	2,227,000
Canada	2,199,789
Thailand	1,988,823
United Kingdom	1,749,385
Turkey	1,695,731
Russia	1,551,293
Iran	1,515,396
Czech Republic	1,419,993
Indonesia	1,216,615
Italy	1,142,210
Slovakia	1,001,520

"Production Statistics". OICA

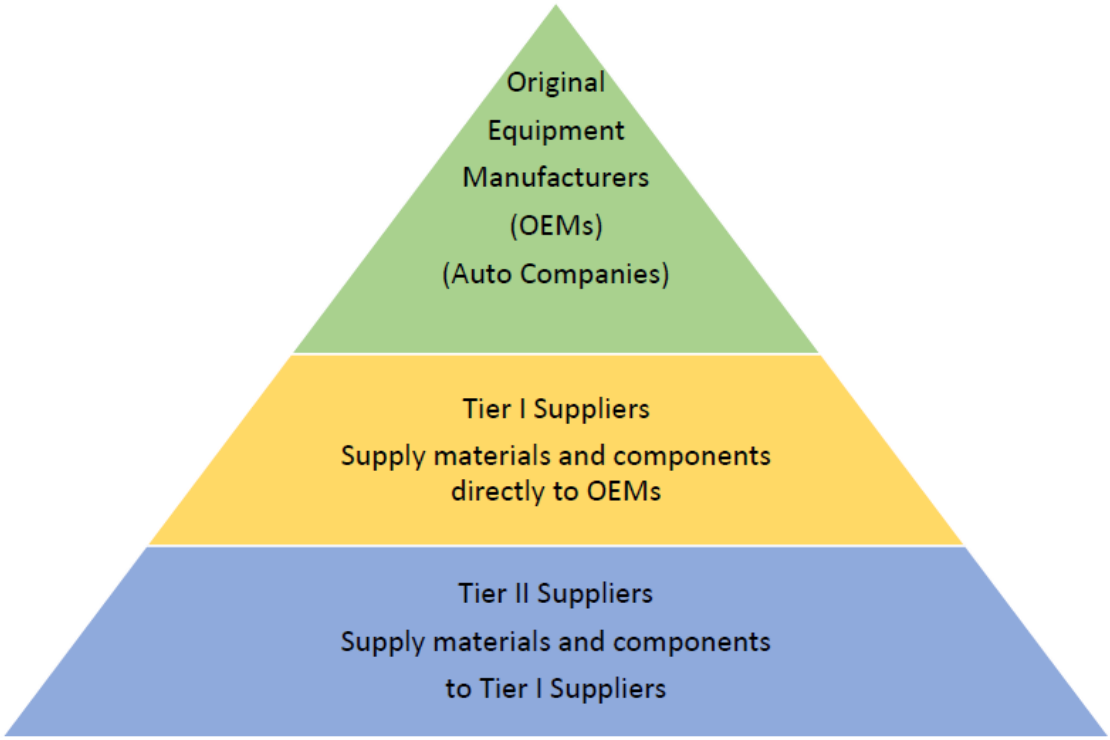
Top Auto Manufacturers - 2016

Group	Headquarters	Vehicles
Toyota	Japan	10,213,486
Volkswagen Group	Germany	10,126,281
Hyundai / Kia	South Korea	7,889,538
General Motors	United States	7,793,066
General Motors with SAIC-GM-Wuling	China	2,144,368
Ford	United States	6,429,485
Nissan	Japan	5,556,241
Honda	Japan	4,999,266
Fiat Chrysler	Italy/United States	4,681,457
Renault	France	3,373,278
Groupe PSA	France	3,152,787
Suzuki	Japan	2,945,295
SAIC	China	2,566,793
Daimler	Germany	2,526,450
BMW	Germany	2,359,756
Changan	China	1,715,871
Mazda	Japan	1,586,013
BAIC	China	1,391,643
Dongfeng Motor	China	1,315,490
Geely	China	1,266,456
Great Wall	China	1,094,360

World Production Trend

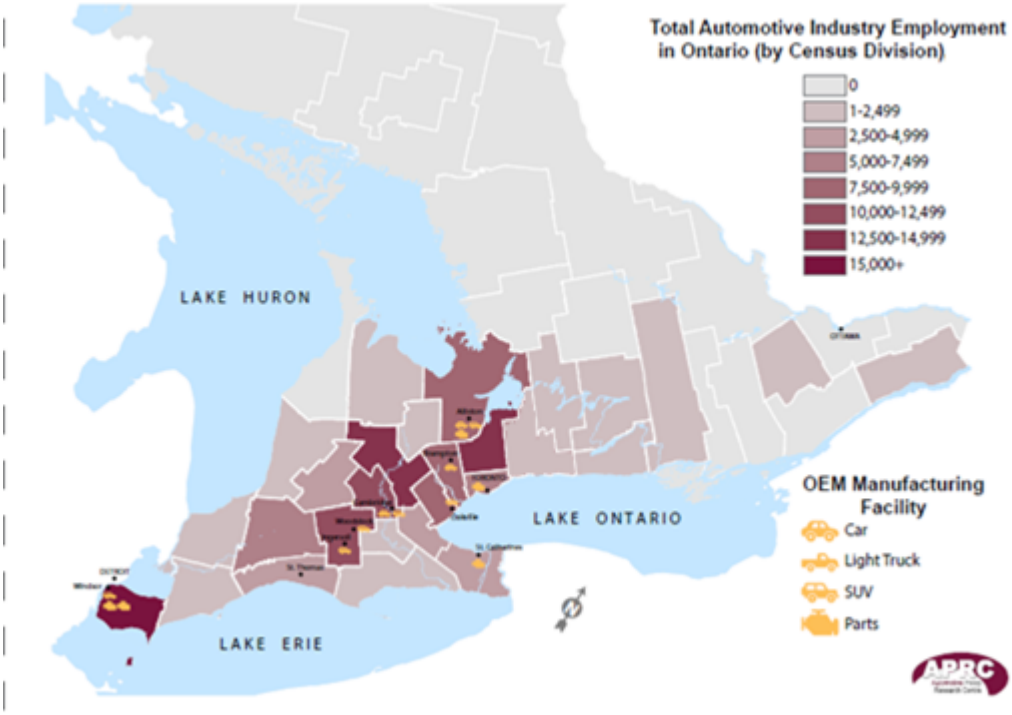


Structure of the Auto Industry

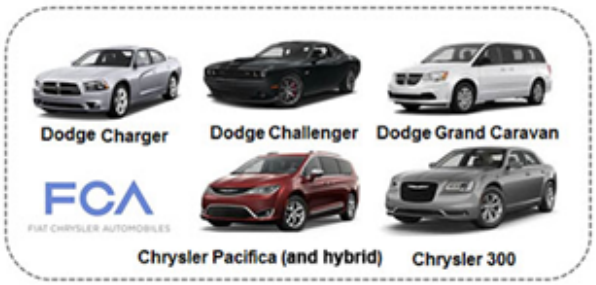


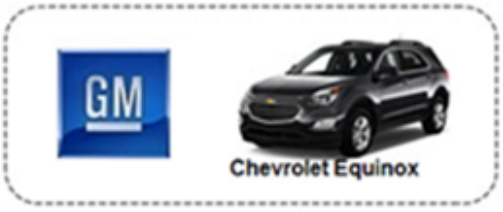
The Auto Industry in Ontario

OEM and Primary Supplier Employment in Ontario, 2018



Auto Models Made in Canada





3. Key Technology Trends

Major Technology Trends in the Auto Industry:

- New manufacturing processes
- Materials engineering: light weighting of vehicles through new material
- New propulsion systems: fuel cells, battery, hybrid, and enhanced internal combustion engines
- Driver assistance technologies and autonomous vehicles
- Vehicle connectivity
- New mobility platforms

Major Technology Trends in the Transit Industry:

- Autonomous vehicles
- Connectivity technologies
- Automated road technology
- Propulsion systems: fuel cells, battery, hybrid, and enhanced diesel engine
- Materials engineering: light weighting of vehicles and improved durability through new materials
- Hyperloop and Maglev

A good source to check out is the lectures by Tony Seba. Seba is a Silicon Valley entrepreneur, and an instructor in Entrepreneurship, Disruption and Clean Energy at Stanford's Continuing Studies Program.

Clean Disruption of Energy and Transportation
https://www.youtube.com/watch?v=duWFnukFJhQ

Clean Disruption - Energy & Transportation
https://www.youtube.com/watch?v=2b3ttqYDwF0

4. Manufacturing Processes

A. Overview of the Auto Manufacturing Process

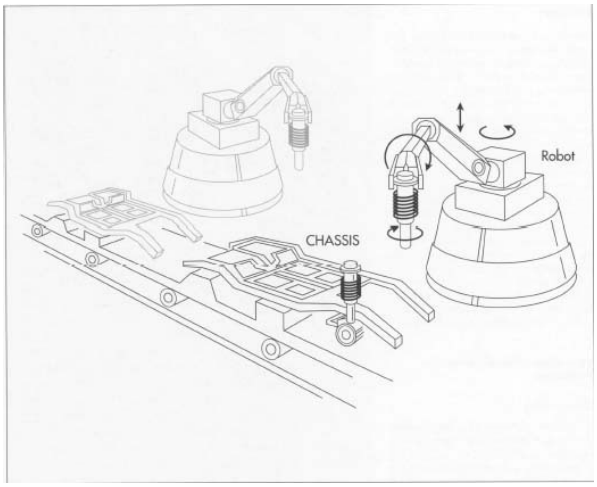
The assembly plant is the final phase in the process of manufacturing an automobile. Components are supplied by more than 4,000 outside suppliers, including company-owned parts suppliers. Since the 1980s, auto assembly plants have striven to implement "just-in-time" delivery of components so as to avoid the need to maintain stockpiles of components. The ability to manage a "just-in-time" supply system is a key skill in the auto manufacturing industry.

Pared down to its essentials the manufacturing process has six segments:

- Assembling the chassis with the transmission and the engine
- Assembly the body exterior
- Painting the body
- Assembly of the body interior
- Mating the body and the chassis
- Quality checking the final product

Assembling the Chassis

The typical car or truck is constructed from the ground up (and out). The frame forms the base on which the body rests and from which all subsequent assembly components follow. The frame is placed on the assembly line and clamped to the conveyer to prevent shifting as it moves down the line. From here the automobile frame moves to component assembly areas where complete front and rear suspensions, gas tanks, rear axles and drive shafts, gear boxes, steering box components, wheel drums, and braking systems are sequentially installed.



An off-line operation at this stage of production mates the vehicle's engine with its transmission. Workers use robotic arms to install these components inside the engine compartment of the frame.

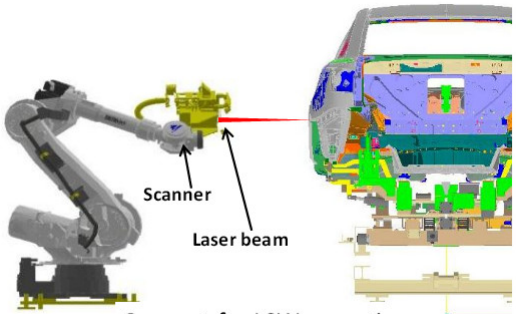
After the engine and transmission are installed, a worker attaches the radiator, and another bolts it into place. Articulating robots perform all of the lift and carry operations while assemblers using pneumatic wrenches bolt component pieces in place. Ergonomic studies of every assembly task have provided assembly workers with the safest and most efficient tools available.

Assembling the Body Exterior

The body is built up on a separate assembly line from the chassis.

The floor pan is the largest body component to which a multitude of panels and braces will subsequently be either welded or bolted. As the floor pan moves down the assembly line, held in place by clamping fixtures, the shell of the vehicle is built.

The left and right quarter panels are robotically disengaged from pre-staged shipping containers and placed onto the floor pan, where they are stabilized with positioning fixtures and welded. The front and rear door pillars, roof, and body side panels are assembled in the same fashion. Most of this process is handled by robots. Robots can pick and load 200-pound (90 kilograms) roof panels and place them precisely in the proper weld position with tolerance variations held to within .001 of an inch.



Concept for LSW operation

As the body moves from the isolated weld area of the assembly line, subsequent body components including fully assembled doors, deck lids, hood panel, fenders, trunk lid, and bumper reinforcements are installed. Although robots help workers place these components onto the body shell, the workers provide the proper fit for most of the bolt-on functional parts using pneumatically assisted tools.

Up to this stage the body is referred to as the 'body-in-white'. After assembly the body-in-white is ready for coating and painting.

Coating and Painting the Body

Prior to painting, the body must pass through a rigorous inspection process, the *body in white* operation. The shell of the vehicle passes through a brightly lit white room where it is fully wiped down by visual inspectors using cloths soaked in hi-light oil. Under the lights, this oil allows inspectors to see any defects in the sheet metal body panels. Dings, dents, and any other defects are repaired by body repairmen. After the shell has been fully inspected and repaired, the assembly conveyor carries it through a cleaning station where it is immersed and cleaned of all residual oil, dirt, and contaminants.

As the shell exits the cleaning station it goes through a drying booth and then through an undercoat dip—an electrostatically charged bath of undercoat paint (called the *E-coat).* This coat acts as a substrate surface to which the top coat of coloured paint adheres.

After the E-coat bath, the shell is again dried in a booth as it proceeds on to the final paint operation. In most automobile assembly plants today, vehicle bodies are spray-painted by robots.

Once the shell has been fully covered with a base coat of colou r paint and a clear top coat, the conveyor transfers the bodies through baking ovens where the paint is cured at temperatures exceeding 275 degrees Fahrenheit (135 degrees Celsius).

After the shell leaves the paint area it is ready for interior assembly.

Interior Assembly of the Body

The painted shell proceeds through the interior assembly area where workers assemble all of the instrumentation and wiring systems, dash panels, interior lights, seats, door and trim panels, headliners, radios, speakers, all glass except the automobile windshield, steering column and wheel, body weatherstrips, vinyl tops, brake and gas pedals, carpeting, and front and rear bumper fascias.

Robots equipped with suction cups remove the windshield from a shipping container, apply a bead of urethane sealer to the perimeter of the glass, and then place it into the body windshield frame. Robots also pick seats and trim panels and transport them to the vehicle for the ease and efficiency of the assembly operator. After passing through this section the shell is given a water test to ensure the proper fit of door panels, glass, and weatherstripping.

The body is now ready to mate with the chassis.

Mating the Body and the Chassis

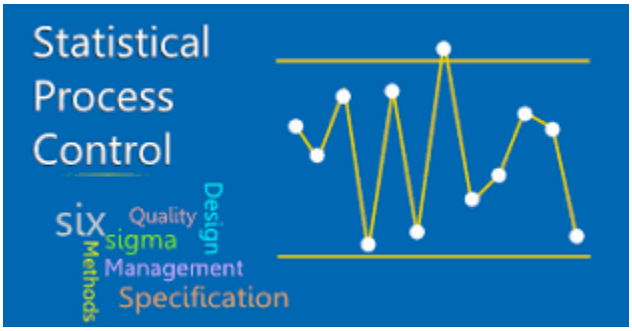
The chassis assembly conveyor and the body shell conveyor meet at this stage of production. As the chassis passes the body conveyor the shell is robotically lifted from its conveyor fixtures and placed onto the car frame. Assembly workers, some at ground level and some in work pits beneath the conveyor, bolt the car body to the frame. Once the mating takes place the automobile proceeds down the line to receive final trim components, battery, tires, anti-freeze, and gasoline.

The vehicle can now be started. From here it is driven to a checkpoint off the line, where its engine is audited, its lights and horn checked, its tires balanced, and its charging system examined. Any defects discovered at this stage require that the car be taken to a central repair area, usually located near the end of the line. A crew of skilled trouble-shooters at this stage analyze and repair all problems. When the vehicle passes final audit it is given a price label and driven to a staging lot where it will await shipment to its destination.

Quality Control

All of the components that go into the automobile are produced at other sites. Auto manufacturers require outside parts vendors to subject their component parts to rigorous testing and inspection audits similar to those used by the assembly plants. In this way the assembly plants can anticipate that the products arriving at their receiving docks are *Statistical Process Control (SPC)* approved and free from defects.

Once the component parts of the automobile begin to be assembled at the automotive factory, production control specialists can follow the progress of each embryonic automobile by means of its *Vehicle Identification Number (VIN),* assigned at the start of the production line. In many of the more advanced assembly plants a small radio frequency transponder is attached to the chassis and floor pan. This sending unit carries the VIN information and monitors its progress along the assembly process. Knowing what operations the vehicle has been through, where it is going, and when it should arrive at the next assembly station gives production management personnel the ability to electronically control the manufacturing sequence. Throughout the assembly process quality audit stations keep track of information concerning the integrity of various functional components of the vehicle.



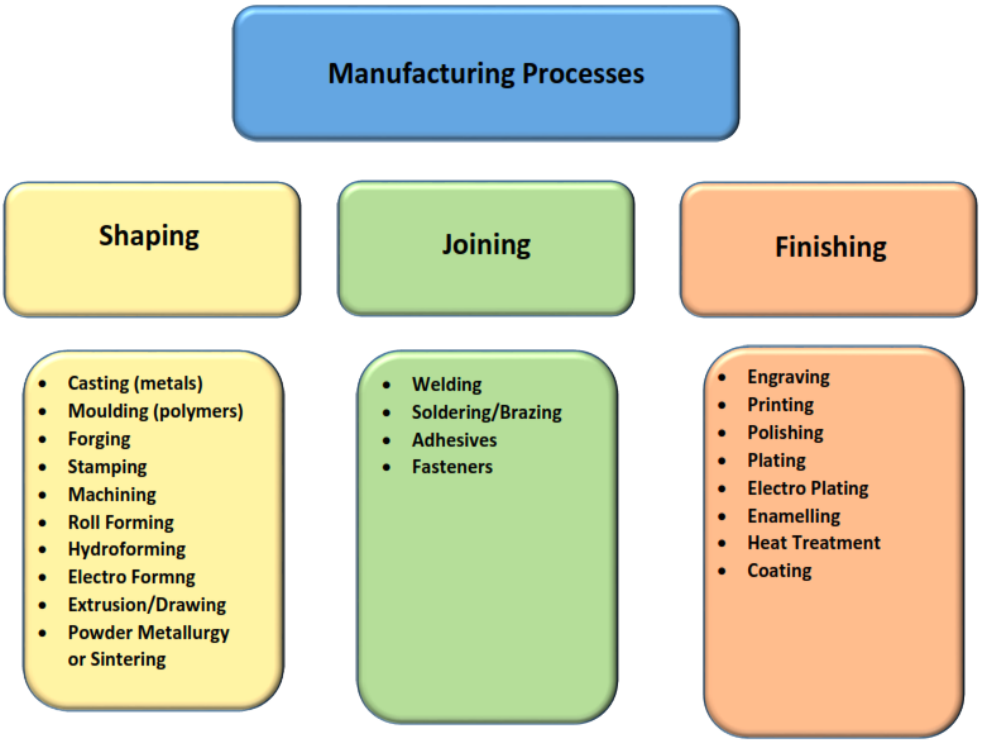
Formerly, quality control was seen as a final inspection process that sought to discover defects after the vehicle was built. In contrast, today quality is seen as a process built right into the design of the vehicle as well as the assembly process. In this way assembly operators can stop the conveyor if workers find a defect. Corrections can then be made, or supplies checked to determine whether an entire batch of components is flawed.

After the vehicle is assembled a validation process is conducted at the end of the assembly line to verify quality audits from the various inspection points throughout the assembly process. This final audit tests for properly fitting panels; dynamics; squeaks and rattles; functioning electrical components; and engine, chassis, and wheel alignment. In many assembly plants vehicles are periodically pulled from the audit line and given full functional tests.

B. Key Manufacturing Processes

Manufacturing is the process of converting raw materials into finished products. Manufacturing is divided into two sectors: primary manufacturing and secondary manufacturing. Companies engaged in primary manufacturing convert raw materials (*e.g.*, metallic ore) into standard primary products (*e.g.*, steel bars or rolls of sheet metal). Companies engaged in secondary manufacturing convert these standard primary products into components of finished products or directly into finished products.

Secondary manufacturers undertake three types of manufacturing processes: shaping, joining and finishing. Within each of these three broad categories there are many types of specific manufacturing technologies. The following graphic illustrates some of the key manufacturing processes within each of the three main categories. However, this is by no means a complete list of secondary manufacturing processes.



Shaping converts a standard primary product into a particular shape.

- Casting is a process in which a liquid metallic material is poured into a mould.
- Moulding is a process in which a non-metallic material (usually a polymer) is heated to a liquid state and poured, injected, pushed or blown into a mould.
- Forging shapes using compressive forces. The blows are delivered with a power hammer or a die.
- Stamping is the process of placing sheet metal (in either flat blanks or coils) into a stamping press where a tool and die surface forms the metal into a specific shape. This can be a single stage operation or a multi-stage process. Stamping is usually done on cold sheet metal.
- Machining involves using a machine tool to cut, mill, bore or drill a piece of metal.
- Roll Forming involves the continuous bending of a long strip of sheet metal (typically coiled steel).
- Hydroforming is a specialized type of die forming that uses high pressure fluid to press material into a die.
- Electro Forming is the metal forming process where metal is grown by electrodeposition onto a substrate. An electrolytic bath is used to deposit metal (for example nickel, gold or copper) onto a conductive patterned surface. The metal can be grown to any thickness. A unique feature of the electroforming process is that the metal part grows atom by atom. This process imparts absolute accuracy and high aspect ratios in a new metal.

- Powder metallurgy / sintering manufactures materials or components from metal powders that are heated, but not to the point of liquification.

Joining binds two or more components.

- Welding is a process of joining materials (usually metals, but also some types of plastics) through fusion. The principal types of welding are oxy-fuel welding, shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), flux-cored arc welding (FCAW), submerged arc welding (SAW), electroslag welding (ESW) and electric resistance welding (ERW). In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that can be stronger than the base material (the parent metal).
- Soldering/Brazing. Soldering is a process in which two or more items (usually metal) are joined together by melting and putting a filler metal (the solder) into the joint. The filler metal has a lower melting point than the parent metal. Soldering differs from welding in that soldering does not involve melting the parent metal pieces. In brazing, the filler metal melts at a higher temperature, but the work piece metal still does not melt.
- Adhesives are non-metallic materials in liquid state that bind two materials together and then harden. Reactive adhesives comprise two or more chemical compounds which trigger a hardening process when mixed.
- Fasteners are mechanical devices for joining components, including screws, nuts and bolts, buckles, clamps, clips, pines, staples, etc. There are scores of fastening devices.

Finishing is the treatment applied to create the visible exterior of a product.

- Engraving incises a design into a hard surface.
- Printing uses inks to impose a design on a surface.
- Polishing creates a smooth and shiny surface by rubbing the surface or using a chemical, leaving the surface with a specular reflection.
- Plating covers a surface with a metallic material. There are both electroplating and electroless plating processes. Electroless plating relies on chemical reactions.
- Enamelling fuses powdered glass to a surface through a firing process.
- Heat Treatment alters the physical properties of a material by heating materials to a high temperature and controlling the rate of cooling.
- Coating applies a liquid chemical (*e.g.,* paint, varnish or lacquer) to a surface.

C. New Manufacturing Processes

1. New Materials ➔ New Manufacturing Processes

Among the most important trends in materials will be the increased use of aluminum, magnesium, carbon fibre and other polymer-based composites in place of steel alloys. These changes in materials and in manufacturing processes will affect OEMs, Tier I and Tier II suppliers. Engineers looking to work in the auto industry need to be aware of the trends in new materials and the need to adapt manufacturing processes to these materials.

Industry experts point to a number of new manufacturing technologies that you may want to explore:

- High pressure thin walled aluminum die casting
- Resin transfer moulding
- Warm form aluminum
- Hot formed steel

2. 3-D Printing (Additive Manufacturing)

3-D printing is a potential game-changer in the manufacturing industry. Currently the technology is more costly that the standard mass production manufacturing processes. However, the technology is still evolving. 3-D printing is widely used in designing prototypes. 3-D printers produce components based on a CAD model. Understanding how 3-D printing systems operate is a key technical skill that will differentiate you.

3D printing substantially increases the importance of strong CAD skills – both autoCAD and SolidWorks.

3. Adhesives and Fasteners

Spot welding is currently the dominant joining technology. As materials change, the auto industry will rely less on spot welding and more on adhesives and fasteners. Engineers working in this environment will need to understand the chemistry and properties of adhesives. One study projects that the use of adhesives for joining will grow by more than 8% per year and will be the dominant joining technology by 2030. Epoxies, polyurethanes and acrylics are the major adhesives. This trend is especially important for chemical and materials engineers.

D. New Production Systems: Industry 4.0

Industry 4.0 is the next stage in the evolution of production systems. Every engineer or technology graduate who seeks a career in the manufacturing industry will need to understand the implications of industry 4.0.

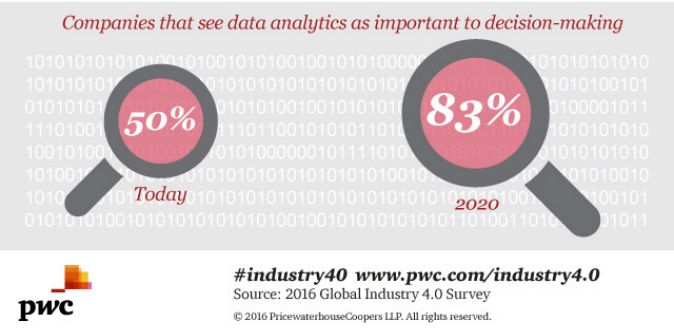
Industry 1.0 was the mechanization of production using steam power. This occurred in the latter part of the 18th century.

Industry 2.0 was the introduction of mass production through assembly line processes. This started in the early decades of the 20th century.

Industry 3.0 refers to the use of robotic technologies. This began in the 1980s and accelerated rapidly.

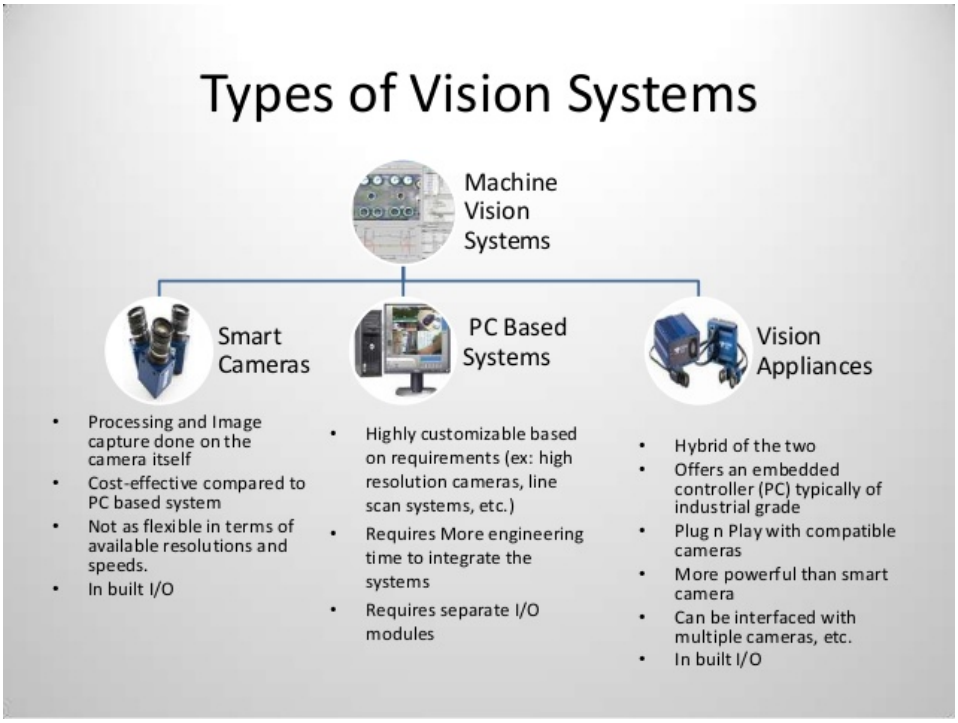
Industry 4.0 refers to "smart factories". In essence, smart factories use information technologies in more radical and intensive ways. There are two key characteristics of a smart factory. The first is interoperability which means the ability of machines, devices, sensors, and people to connect and communicate with each other. The second is cyber-physical systems that link real world environments with precise digital counterparts.

Industry 4.0 requires advanced use of machine learning (artificial intelligence), augmented reality technologies, 'big data' analytics, neural networks and intensive use of cloud computing.



A key technology in Industry 4.0 is vision systems. Vision systems are especially important in process control and inspection. The basic components of a machine vision system consist of:

- One or more digital or analog camera(s) with the capacity to take close-ups.
- A frame grabber which digitizes the image.
- An embedded processor or link to a PC processor.
- Specialised light sources.
- Algorithms to instruct the system to identify defects.



Industry 4.0 blurs the boundaries between traditional manufacturing engineering and computer systems engineering. Industry 4.0 will significantly increase the need for companies to recruit engineering and technology graduates who have strong skills in computer and software engineering, especially as those skills are applied to controlling manufacturing processes.

Top 5 Contributing Technologies for Industry 4.0

Cloud Computing	the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer.
Internet of things	The Internet of things (IoT) is the internetworking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data.
3D printing	3D printing, also known as additive manufacturing (AM), refers to processes used to synthesize a three-dimensional object in which successive layers of material are formed under computer control to create an object.
Big data analytics	Big data analytics is the process of examining large data sets to uncover hidden patterns, unknown correlations, market trends, customer preferences and other useful business information.
Augmented reality/wearables	Augmented Reality (AR) is a technology enriching the real world with digital information and media, such as 3D models and videos, overlaying in real-time the camera view of smartphone, tablet, PC or connected glasses.

BCG; Delloite; PWC; Mckinsey; Roland Berger, Wiki

CAR
CENTER FOR AUTOMOTIVE RESEARCH

What These Trends Mean for Engineering Graduates

Employers identify four common, technical skill gaps that are accentuated by the transition to Industry 4.0:

- Basic knowledge of quality control systems including:
    - Statistical Process Control (SPC),
    - Root Cause Analysis (RCA), and
    - Multi-variate analysis (not just univariate correlation).
- Basic knowledge of circuit design and programmable logic controllers,
- Strong CAD skills (autoCAD and SolidWorks),
- Cross-disciplinary complementarity of skills, *e.g.,* electro-mechanical (mechatronics), electro-chemical, *etc*.

5. Materials and Materials Engineering

Three factors drive the choice of materials in the auto sector: durability, weight and cost.

Today the most widely used materials are:

- Various types of steel
- Aluminum
- Plastics and Polymer Compounds
- Adhesives

The main types of steel used are:

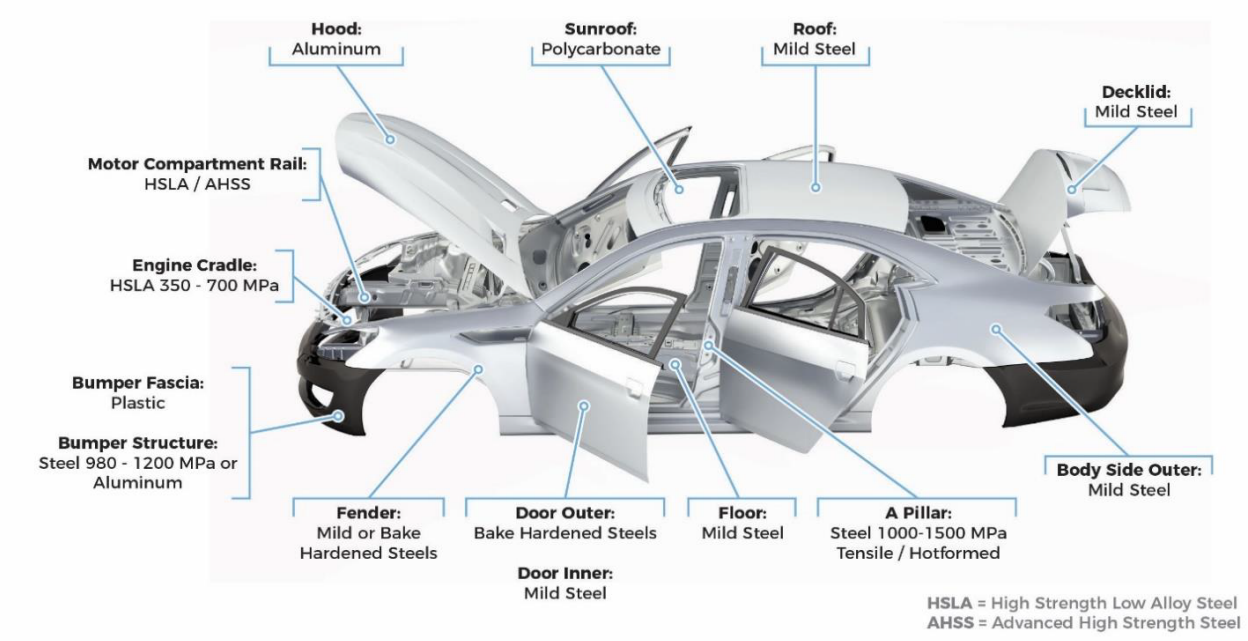
Mild Steel: Mild steel is a type of carbon steel with a low amount of carbon – typically 0.05% to 0.25%, whereas higher carbon steels have a carbon content from 0.30% to 2.0%. Mild steel is not an alloy steel, i.e., it does not contain elements other than iron. Less carbon means that mild steel is more ductile, machinable, and weldable than high carbon steel. It has less tensile strength than high carbon and alloy steels. Mild steel also has a high amount of iron and ferrite, making it magnetic. Mild steel is subject to oxidation (rust) if not properly coated. The absence of alloying elements helps keep mild steel relatively affordable when compared with other steels. It is the affordability, weldability, and machinability that make it a popular choice for manufacturers.

Bake Hardening Steel: Bake hardening is an advanced processing technique that produces low carbon steels with higher strength than mild steel.

High Strength Low Alloy Steel: High-strength low-alloy steel (HSLA) is a low carbon steel that provides better mechanical properties and greater resistance to corrosion than mild steel. HSLA steels vary from other steels in that they are not made to meet a specific chemical composition but rather to specific mechanical properties. Various alloying elements are added to achieve these properties. HSLA steels are 20 to 30% lighter than a carbon steel with the same strength. HSLA steels are also more resistant to rust than most carbon steels.

Dual Phase Steel: Dual phase steel (DP Steel) is a high-strength steel produced from low or medium carbon steels that are quenched. DP steels have high ultimate tensile strength. These features render DP steels ideal materials for automotive-related sheet forming operations.

Hot Formed Steel: Sheet steel can be either hot-rolled or cold rolled. Hot formed steel (HF steel) is heated above the recrystallization temperature. Cold rolling produces thinner products, but is a more costly process.



The most common materials currently used in vehicle production are lower grade steels – chiefly Mild Steel and High Strength Low Alloy Steel. Currently, these types of steel represent about 80% of the materials content of a vehicle. The need to achieve lighter weights to meet fuel efficiency targets is driving a significant shift in materials. Over the next 10-15 years, vehicles must reduce their curb weight by around 15%. To achieve this, we will see:

- Increased use of Advanced High Strength Steel and Ultra High Strength Steel
- Increased use of boron/martensite and magnesium
- More use of alloys
- More use of aluminum
- More use of carbon fibre composites

Studies also suggest a shift in polymer-based materials (plastics) from a petroleum base to organic sources (bio-materials) if the price of oil (or regulatory requirements) makes this shift supportable.

What these Trends Mean for Engineering Graduates

The transition to new materials means that there will be increased need for materials engineering skills, both as a specialized skill, but also as a basic engineering skill. Opportunities include developing and using materials to build safer cars, develop high performance batteries and fuel cells, and make travel safer.

6. Propulsion Systems

Studies anticipate that gasoline-powered internal combustion engines will continue to dominate the auto market until at least 2030.

Electric vehicles (EVs) currently account for about 1% of the world market. In Canada, the EV share is currently around 1.4%. In California, which is the North American leader in promoting EVs, the EV share is approaching 5%. In Silicon Valley, the EV share is around 30%. The international leader is Norway with a share of 40%.

The Technology Road Map prepared by the Center for Automotive Research expects the EV share to reach 30% by 2030 and to continue increase thereafter. Changes in the price of oil or in the regulatory environment could accelerate that transition.

Internal Combustion Engines

The key technology trends are:

- Gasoline Direct Injection (GDI) is a variant of the fuel injection technology used in modern two-stroke and four-stroke engines. In a GDI engine the gasoline is highly pressurized and injected via a common rail fuel line directly into the combustion chamber of each cylinder. This contrasts with the current technology that uses low pressure to inject fuel into the intake tract or cylinder port. The major advantages of a GDI engine are increased fuel efficiency and high-power output. This video explains GDI: https://www.youtube.com/watch?v=LjJSbHxIvnM

- Mechanical Turbocharging forces additional air into an engine which enables the engine to draw additional fuel and produce more power.

- Atkinson Cycle is a type of internal combustion engine designed in the 1880s. In recent years, the Atkinson Cycle engine was adapted to hybrids, such as the Prius. It is also used in some models as an alternative to conventional internal combustion engines. Atkinson Cycle engines reduce the amount of fuel used. This video explains the technology: https://www.youtube.com/watch?v=gD2AQuhbHdk

- Variable Compression Ratio (VCR) is a technology that adjusts the compression ratio of an internal combustion engine while the engine is in operation. VCR technology increases fuel efficiency. This video explains the technology: https://www.youtube.com/watch?v=A6H66xfEZC4

- Homogenous Charge Compression Ignition (HCCI) is a form of internal combustion in which gasoline and air are compressed to the point of auto-ignition. HCCI injects fuel during the intake stroke. However, rather than using an electric discharge to ignite the mixture of gasoline and air, HCCI raises density and temperature by compression until the entire mixture reacts spontaneously. This video explains the technology: https://www.youtube.com/watch?v=OVWZFdb_AGc

- 12-Volt Stop/Start Systems automatically shut down and restart an internal combustion engine to reduce the amount of time the engine spends idling, thereby reducing fuel consumption and emissions. This is particularly important for urban driving. This video explains the technology: https://www.youtube.com/watch?v=-Yv72Xarick

Electric Vehicles (EVs)

There are five types of EVs:

1. 48-Volt Stop/Start Mild Hybrid
2. Hybrid Electric Vehicle (HEV)/Power Split
3. Plug-In Electric Vehicle
4. Battery Electric Vehicle
5. Fuel Cell Electric Vehicle

- Hybrid Electric Vehicle (HEV)/ Power Split is the currently dominant technology in HEVs.
- 48-Volt Stop/Start Mild Hybrid is an emerging challenger to the dominant HEV technology. A new electric motor and 48-volt battery are added onto the combustion engine and normal 12-volt battery. Mild hybrids take some load off an internal-combustion engine by powering accessories or providing an extra boost of power to the wheels, but generally can't propel a car solely on electricity.
- Plug-In Electric Vehicles are any vehicle that can be recharged from any external source of electricity. This includes: all-electric or battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs). Conventional HEVs are not included. There are now more than 70 Plug-In Electric Vehicle models on the market. Ontario's Building Code will require most new buildings to include charging stations if they incorporate parking.
- Battery Electric Vehicles (BEV) use chemical energy stored in rechargeable battery packs. BEVs use solely electric motors for propulsion. They derive all power from battery packs and thus have no internal combustion engine, fuel cell, or fuel tank. As of 2018, the world's top selling highway legal all-electric car in history is the Nissan Leaf with global sales of over 300,000 units, followed by the Tesla Model S with more than 200,000 units delivered worldwide.
- Fuel Cell Electric Vehicle (FCEV) use a fuel cell, instead of a battery, or in combination with a battery or supercapacitor, to power its on-board electric motor. Fuel cells in vehicles generate electricity to power the motor, generally using oxygen from the air and compressed hydrogen. Most fuel cell vehicles are classified as zero-emissions vehicles that emit only water and heat. Fuel cell technology has not yet proven to be commercially viable. However, there are numerous demonstration units in public transit systems. Ballard Power Systems in Burnaby, B.C. is a major developer of this technology: www.ballard.com

Closely related to the market adoption of Plug-In Electric Vehicles is the development of charging infrastructure. There are currently three major configurations:

- Combined Charging System / SAE (Society of Automotive Engineers)

- Supercharger (developed by Tesla)
- CHAdeMO

Battery technology is a major hold-back in the adoption of electric vehicles. Lithium Ion batteries currently have an expected life of four years. There is no engineering consensus on which type of battery technology will prevail. To learn more about battery technology visit: http://batteryuniversity.com/

What these Trends Mean for Engineering Graduates

The shift in propulsion systems is driving a need for new skill requirements, including understanding of the relevant science principles. This includes:

- Electro-chemistry
- Energy storage
- Charging technology
- Electro-mechanics

The technologies that will drive the shift in propulsion systems are still in their developmental stage. This means that many companies will be giving even greater priority when hiring to candidates who can demonstrate adaptability and a keenness to learn.

7. Driver Assistance Systems and Autonomous Vehicles

The auto industry identifies five levels of automation – six, if Level 0 is counted.

Level 0 (No Automation) – Automated system issues warnings and may momentarily intervene but has no sustained vehicle control.

Level 1 (Driver Assistance) – The driver and the automated system share control of the vehicle. With Adaptive Cruise Control (ACC), the driver controls steering and the automated system controls speed. With Parking Assistance, steering is automated while speed is under manual control. The driver must be ready to retake full control at any time. Lane Keeping Assistance warns the driver when the vehicle begins to move out of its lane on a highway or arterial road without a signal.

Level 2 (Partial Automation) – The automated system takes full control of the vehicle (accelerating, braking, and steering) based on information relayed by sensors. The driver must monitor the driving and be prepared to intervene immediately at any time if the automated system fails to respond properly. Although the shorthand for this level of automation is "hands off" driving, regulations usually require that the driver keep his or her hands on the steering wheel and be ready to intervene at any time.

Levels 3 and higher are demarcated by the driver assistance system, taking full responsibility for monitoring the driving environment

Level 3 (Conditional Automation) - The driver can safely turn his or her attention away from driving tasks, *e.g.* the driver can text or watch a movie. The vehicle will handle situations that call for an immediate response, like emergency braking. The driver must still be prepared to intervene within some limited time, specified by the manufacturer. The 2018 Audi A8 was the first commercial car that the manufacturer claimed is capable of level 3 self driving. The Audi A8 has a “Traffic Jam Pilot”. When activated by the driver, the Traffic Jam Pilot takes full control of all aspects of driving in traffic at up to 60 kilometres per hour. The function works only on highways with a physical barrier separating one stream of traffic from oncoming traffic.

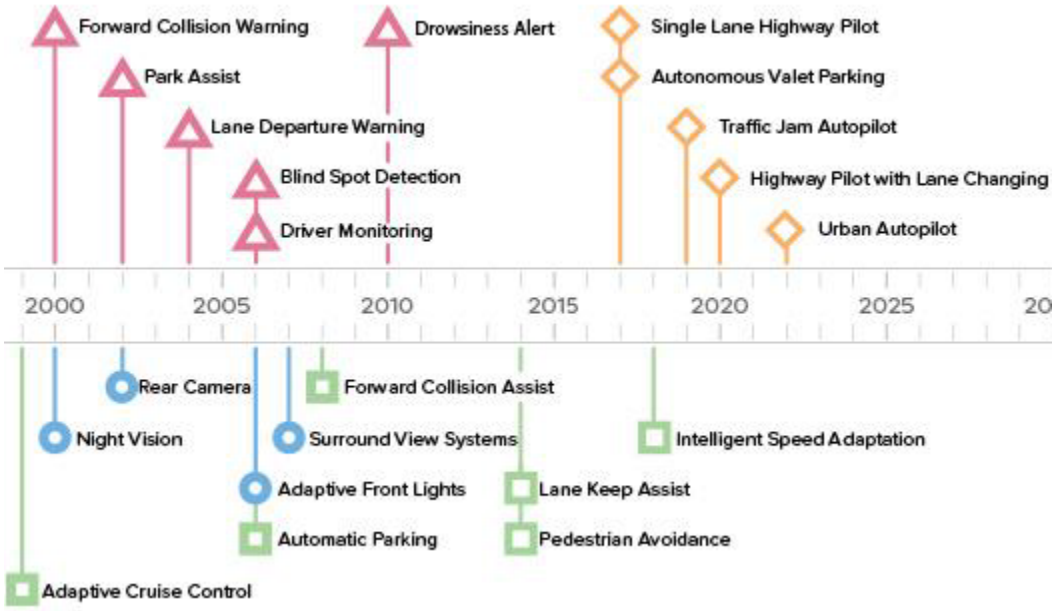
Level 4 (High Automation) – Level 4 automation is similar to level 3, except that the driver’s attention is never required for safety. The driver can go to sleep or leave the driver's seat. This level of automation is supported only in limited spatial areas (geofenced). The system may request driver intervention in certain circumstances, e.g., merging or traffic jams.

Level 5 (Full Automation) – No driver intervention is required at all. An example would be a robotic taxi.

In the near term, the primary functions that the manufacturers have developed to levels that can be incorporated into product launches are:

- Automated emergency braking,
- Lane departure warning,
- Blind spot monitoring,
- Parking assist, and
- Adaptive cruise control.

The following chart depicts the recent trend in driver assistance technologies.



There are numerous sources of technology development in the autonomous vehicle sector.

- Ford is aiming to deploy at Level 4 by 2021.
- GM plans to deploy at Level 2 and Level 4 by 2020.
- FiatChrsylerAutos (FCA) is targeting Levels 1, 2 and 3 by 2019.
- Toyota is targeting Level 3 by 2020.
- Honda is also aiming for Level 3 by 2020.

Other manufacturers which do not have operations in Canada have similar targets.

- Google (now Waymo) and nuTonomy (an MIT spin-off) are targeting Level 4 vehicles.
- nuTonomy is also testing robotic taxis.
- Both Uber and Lyft are also investing in autonomous vehicle technology.
- Major parts and technology suppliers to the manufacturers are also investing in autonomous vehicle technology. These include: Bosch, Valeo, Delphi and Continental.
- Other companies investing in this technology include: Navya (France), EasyMile (France) and 2getthere (Netherlands)

https://waymo.com

https://www.nutonomy.com

What these Trends Mean for Engineering Graduates

The incorporation of information technologies into vehicle design and operation will take a quantitative leap over the next decade. The auto industry will be a major user and developer of these technologies. These trends will generate a demand for software design skills and especially system integration skills.

Companies will receive many applications from individuals who have computer science, software engineering or computer engineering qualifications. The candidates that companies will want to recruit will be individuals who can demonstrate that they know how (or can learn how) to apply those abstract skills to vehicle design and operation. Application experience or the ability to demonstrate an aptitude for application will be key attributes that employers will seek. Job applicants who stress their application experience will take precedence over applicants who stress their educational qualifications.

8. Vehicle Connectivity

The auto industry uses the terms **vehicle connectivity** or the **connected car** to describe a vehicle that optimizes operation, maintenance and passenger safety by using onboard sensors and Internet connectivity.

Vehicle connectivity can be classified into 8 categories.

1. Mobility Management: These are functions that allow the driver to reach a destination quickly, safely, and in a cost-efficient manner. They provide information on current traffic conditions, weather conditions and the location of important services such as parking, re-fueling or re-charging.

2. Commerce: These functions enable a driver to purchase goods or services while in transit, e.g., parking, tolls, take-out food services, *etc.*

3. Vehicle Management: These functions support a driver in reducing operating costs by encouraging fuel economy, timely maintenance, etc.

4. Breakdown Prevention: These functions predict breakdowns based on usage or stress.

5. Safety: These functions warn drivers of hazards.

6. Entertainment: These functions deliver entertainment and internet connectivity.

7. Driver assistance: These function support automation of the driving process (see previous chapter).

8. Well being: These functions keep drivers alert to combat fatigue and can contact medical assistance in an emergency.

There are five ways a vehicle can connect to and communicate with its environment:

Level I: Vehicle to Infrastructure (V2I)

Vehicle-to-Infrastructure (V2I) is the next generation of Intelligent Transportation Systems (ITS). V2I is a two-way communications system between a vehicle and an infrastructure system. V2I technology captures data generated by the vehicle and transmits that data to the infrastructure system. At the same time the V2I technology also provides information to the vehicle driver about traffic, safety or environmental conditions.

https://www.its.dot.gov/v2i/

Level 2: Vehicle to Vehicle (V2V)

Vehicle-to-vehicle (V2V) communication enables vehicles to wirelessly exchange information about their speed, location, and where they are heading so as to avoid accidents and ease traffic congestion. The technology behind V2V communication allows vehicles to broadcast and receive omni-directional messages (up to 10 times per second), creating a 360-degree "awareness" of other vehicles in their proximity. Vehicles equipped with appropriate software (or safety applications) can use the messages from surrounding vehicles to determine potential crash threats as they develop. Cars can then use visual, tactile, and audible alerts—or, a combination of these alerts—to warn drivers. This video from the U.S. Department of Transportation describes the technology: https://www.nhtsa.gov/technology-innovation/vehicle-vehicle-communication

Level 3: Vehicle to Cloud (V2C)

V2C technologies exchange information between vehicles and other sources of information using cloud technologies. Unlike V2I technology, V2C technology is open, meaning that any supplier of data can access the cloud platform to enable a vehicle to utilize its data. For example, a V2C system can inform drivers of electric vehicles of the location of the nearest charging station.

Level 4: Vehicle to Pedestrian (V2P)

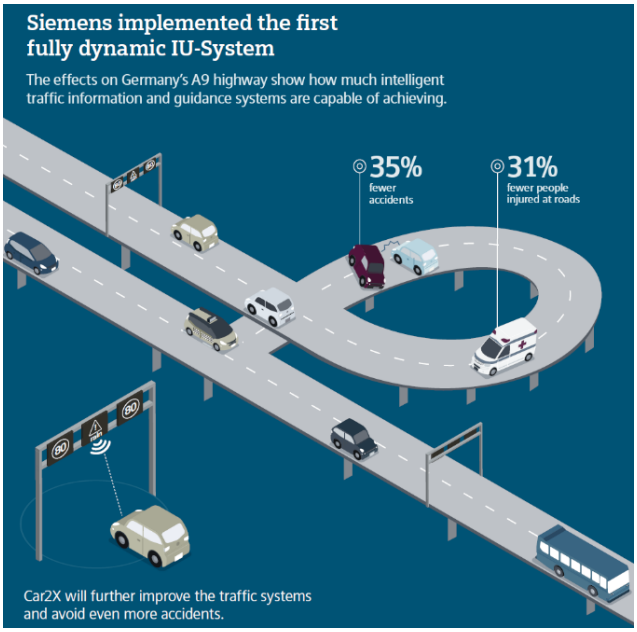
Vehicle to Pedestrian (V2P) technologies are intended to increase safety for a broad set of road users including people walking, children being pushed in strollers, people using wheelchairs or other mobility devices, passengers embarking and disembarking buses and trains, and people riding bicycles. In-vehicle systems detect the presence of a pedestrian and warn the driver. They may also connect to a vehicle's automation systems. Handheld devices provide warning to a pedestrian. These technologies have particular relevance for pedestrians who are mobility or vision-impaired.

https://www.its.dot.gov/infographs/pedestrian_signalized_crosswalk.htm

Level 5: Vehicle to Everything (V2X)

Vehicle to Everything (V2X) encompasses all types of vehicle communication. V2X communication is currently based on WLAN technology and works directly between vehicles, which form a vehicular ad-hoc network as two V2X senders come within each other's range.

V2I and V2V are currently the focus of most development work. V2V connectivity is expected to be a feature of all new light vehicles by 2025. V2I connectivity is a longer-term development as it depends on government investment in the communications infrastructure.



https://www.mobility.siemens.com/mobility/global/SiteCollectionDocuments/en/road-solutions/urban/trends/siemens-vehicle-to-x-communication-technology-infographic.pdf

What these Trends Mean for Engineering Graduates

The application of connectivity technologies to the auto industry will be one of the major technology tends of the next decade. The auto industry will be both a major user and developer of these technologies. Companies, such as Blackberry, that had no previous connection to the auto industry, will become major technology suppliers. These trends will generate a demand for skills focused on internet-based connectivity and the integration of sensor-based information with vehicle systems.

There will be an influx of job applicants with qualifications in the relevant connectivity platforms. Successful candidates will be individuals who can demonstrate that they know how (or can learn how) to apply their technical knowledge to the connectivity challenges of vehicle operation. Application experience or the ability to demonstrate an aptitude for application will be key attributes that employers will seek. Job applicants who stress their application experience will take precedence over applicants who stress their educational qualifications.

9. Mobility Services (Ride Sharing, Car Sharing)

Until recently the dominant modes of urban transportation were public transit and private vehicles. Except in places like central New York (Manhattan) and central London, taxis held a small share of the total market. That is changing.

The new mobility services that are emerging include:

- **Ride Hailing** (e.g., Uber and Lyft in North America, Didi in China, Ola in India and Gett in Israel)
- **Car Sharing** (e.g., car2go, Zipcar, AutoShare)
- **Ride Sharing / Car Pooling** (BlancRide, Smart Commute, Kanga Ride, eRide Share, Pool My Ride and many others)
- **Microtransit** – small, privately operated transit companies (not common in Canada)
- **Shared Autonomous Vehicles / Robo-Taxis** (still in development, *e.g.*, Waymo)
- **Mobility-as-a-Service** which integrates different transportation modes, *e.g.*, London's Oyster Card
- **Bike Sharing** services are now common in major cities, e.g., Bike Share Toronto, VeloGO in Ottawa and MObi in Vancouver.

Market Characterstics of New Mobility Services

Service	Markets	Examples
Ridehailing	More than 75 countries globally. In the United States, 650,000 driver-partners work with the two biggest operators, Uber and Lyft	Uber Lyft Didi Ola Gett
Ridesharing	Europe is the primary market globally. The biggest operator, BlaBlaCar, has 25 million members across 22 European and South American countries. Limited presence in the United States.	BlaBlaCar vRide Commutr
Carsharing	26 countries in North and South America, Europe, Asia, and Oceania. 1.2 million members and 16,700 vehicles in the United States.	Zipcar Car2go Enterprise CarShare
Bikesharing	Almost 1000 cities worldwide. 104 cities, 30,700 bicycles in the United States.	Motivate DecoBike Zagster
Microtransit	Many development exist in Europe, where the concept was developed. In the United States, service currently is limited to six major cities.	Bridj Chariot Via
Mobility-as-a-Service	Pilot projects in Europe and the United States. 70 cities in the United States and Canada have MaaS-like solutions from moovel N.A.	MaaS Global UbiGo Transloc Xerox moovel
Shared Autonomous Vehicles	Technology remains in-development. Some companies are testing their technology, especially via private shuttles on campuses.	Google EasyMile Uber Ford GM

https://www.cargroup.org/wp-content/uploads/2017/02/New-Mobility-Services-White-Paper.pdf

The Center for Automotive Research estimates that by 2030, a quarter of miles travelled in cars in the United States will be through ride hailing, car sharing or car pooling.

The auto industry recognizes the importance of new mobility services that could account for a quarter of miles travelled within less than 15 years. For this reason, all of the major auto producers have entered this market through acquisitions, subsidiaries or partnerships.

All of these new mobility services have one thing in common: they are based on information technology platforms.

What these Trends Mean for Engineering Graduates

Platform design and maintenance are the keys to the new mobility services. Specialized knowledge of these platforms and a demonstrated ability to apply programming and design skills to these platforms will be key assets for job seekers.

10. Overview of the Transit Sector

Who Makes Up the Transit Sector?

The transit sector comprises:

- Operators of public transit systems: buses, trams (streetcars), subways and LRTs (Light Rapid Transit systems),
- Operators of passenger transfer systems in airports,
- Companies that manufacture the rolling stock for transit systems,
- Companies that manufacture key components for rolling stock, e.g., battery and fuel cell manufacturers,
- Companies that design the software and signalling systems for transit systems,
- Engineering consultants that design transit systems and assess the economic feasibility of proposed designs,
- Companies that construct and maintain transit systems,
- Technology research centres focussed on developing new technologies for transit systems.

The Transit Sector is a Technology Leader

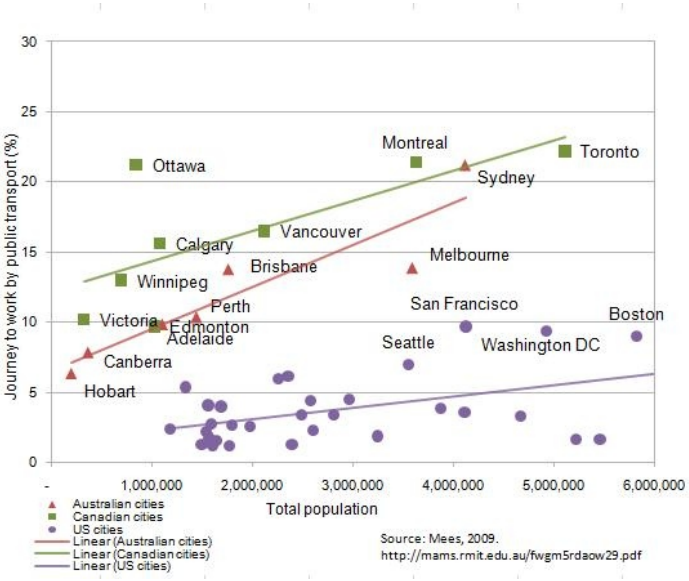
Compared to the auto sector, there is much less advertising associated with the transit sector. As a result, many engineering students and recent engineering graduates are less aware of the cutting-edge technologies and career opportunities in this sector.

- The transit sector is far and away, the leader in adopting alternative propulsion technologies: fuel cells, hybrid engines, natural gas engines, and battery-powered propulsion.
- Transit system builders are leaders in implementing ground-breaking autonomous vehicle technology (driverless systems), *e.g.*, the transit systems that move passengers between terminals at airports.
- Transit systems design and maintain sophisticated signalling and software systems that co-ordinate the operation of hundreds, sometimes thousands, of vehicles.
- Transit manufacturers are leaders in applying new materials to achieve lighter body weights without sacrificing durability.

- Many transit manufacturers are leaders in applying sustainability principles to the design and manufacture of their products.

Comparing Canada and the United States

Compared to the United States, Canadian cities are much more committed to transit. On a usage basis, Canadian cities typically have two to five times as much public transit use as American cities. All seven of Canada's largest cities (Vancouver, Calgary, Edmonton, Toronto, Ottawa, Montreal and Quebec City) have transit ridership in the double digits. In the US, only San Francisco, Washington, D.C and New York City have transit usage in the double digits.

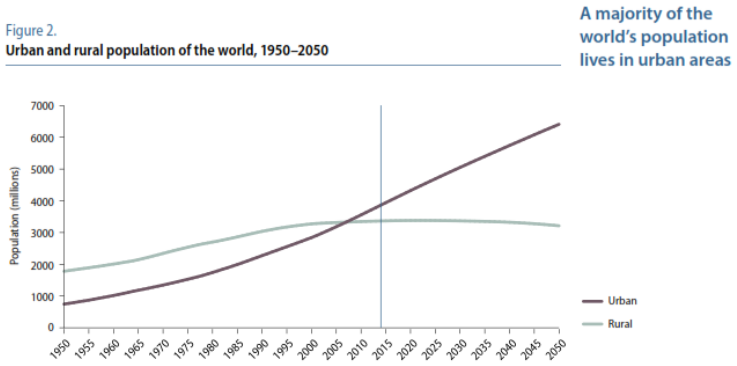


http://www.cat-bus.com/2010/10/transit-ridership-higher-in-canada-than-in-us-australia/

Demand for Transit is Growing

Three factors are behind the growing demand for transit:

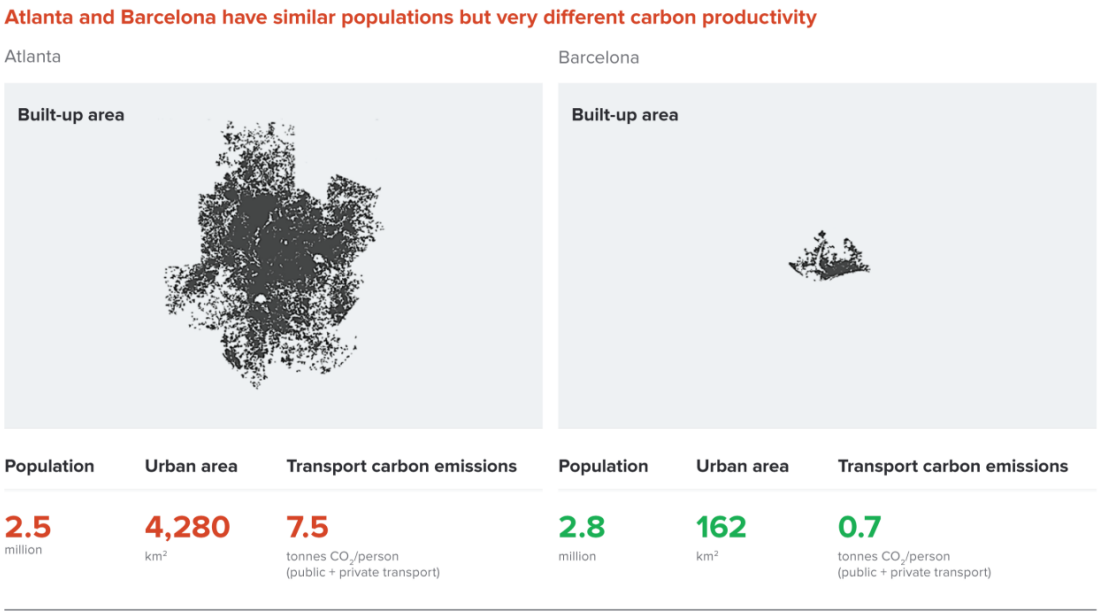
- Urbanization: In 2008, around half of the world's population lived in urban areas. By 2050, the number of persons living in urban areas will double. Cities will account for two-thirds of the world's population. Urbanization is the number one driver of the demand for public transit. [2]



- In North America, car ownership is declining among millennials and is lower than for previous generations of their age.

[2] United Nations Department of Economic and Social Affairs, *Word Urbanization Prospects*, p 7 https://esa.un.org/unpd/wup/publications/files/wup2014-highlights.pdf
See also:
http://www.un.org/en/development/desa/population/events/pdf/expert/27/presentations/I/presentation-Henning-final.pdf - Slide 10

- Climate Change: It is increasingly clear that cities designed for cars have a vastly greater carbon footprint than cities designed around public transit systems. The following info-graphic compares the transportation carbon footprints of Atlanta in the United States where personally-owned cars are the dominant form of individual transportation and Barcelona in Spain where public and shared transit predominate. The two cities have similar populations, but the transportation-related carbon emissions in Barcelona are less than 10% of the emissions in Atlanta.[3]



https://morphocode.com/global-trends-urbanisation/

Canadian Companies are Key Players

Consulting: Canadian consulting firms are among the leading international suppliers of analytical expertise in the transit field. The most active firms include: AECOM, DelcanCorporation, Dessau, Dillon Consulting, ENTRA Consultants, Hatch, IBI Group, iTRANs Consulting, McCormick Rankin Corporation, MMM Group, Morrison Hershfield, Roche-Deluc, Stantec and WSP.

Manufacturing: Canada is one of the world's leading centres for transit vehicle manufacturing. Bombardier is the largest global supplier of rail cars, with substantial design, research and development and production facilities in Ontario and Quebec. New Flyer, Nova Bus and Orion (a line of Daimler Buses North America) are three of North America's largest urban transit bus manufacturers, and together they supply nearly 70% of the entire North American market from their Canadian roots. All three companies are headquartered in Canada. Canada is also home to leading specialists in bus refurbishment such as Eastway and MTB Truck & Bus Collision. The strength of Canadian bus manufacturers has fostered a

[3] *The New Climate Economy Report*, Chapter 2, Cities

number of tier-two suppliers, *i.e.* companies that manufacture components such as bumpers, frames, flooring, seats, multiplex wiring systems, mirrors and other components. These companies include Amobi, Baultar Concept, Lucerix International, T-Ji Talfourd-Jones and the Electronics Control Division of Parker Hannifin's Hydraulics Group.

Software and Systems: Giro and Trapeze – both based in Canada – are international leaders in developing systems to schedule and operate transit systems. Other Canadian companies active in designing software applications for the transit sector include: Grey Island Systems, Infodev, Novax, seon Design and Thales Rail Signalling.

Customer Information Systems: Axion technologies supplies software and hardware for audio and visual communication systems.

Shelters: Daytech and Enseicom – both based in Canada - have become internationally renowned for their innovations in design and technology for transit shelters.

R&D

Both governments and companies make substantial investments in R&D. This is especially important for engineering graduates as a large number of engineering design jobs are tied to capital spending and R&D. A study by the Canadian Urban Transit Association found that manufacturing companies in the transit sector invest approximately $100-$125 million per year in R&D. The Canadian Urban Transit Research and Innovation Consortium (CUTRIC) brings together industry, governments and universities to support development of the next-generation of mobility and transportation technologies. CUTRIC's projects focus on (1) zero and low emission propulsion technologies, (2) smart vehicles and smart infrastructure to support autonomous and connected vehicles, (3) use of big data and data analytics to optimize system management, and (4) cybersecurity to protect intelligent systems.

Canadian Manufacturing Companies in the Transit Sector

AAA Canada Inc	Counteract Balancing Beads	GIRO Inc.
Alexander Dennis (Canada) Inc.	CPI Crane Payment Innovations	Global Traffic Technologies
Alltrade Industrial Contractors Inc.	Creative Carriage Ltd.	Glory Global Solutions
Alstom Transport Canada Inc.	Crestline Coach Ltd.	Grande West Transportation International
Altro Transflor	Cummins Canada ULC	Great Northern Battery Systems
American Seating	Cummins Western Canada	Groeneveld Lubrication Solutions Inc.
AMF-Bruns of America	Cummins Westport Inc.	H. L. Blachford Ltd.
Apollo Video Technology	Cummins-Allison ULC	Hamsar
ARBOC Specialty Vehicles	Daktronics Inc.	Handi-Hut, Inc.
Associated Industrial Brush Co Ltd.	Daytech Limited	Horizon Occupational Health Solutions

Atlas Copco Tools & Assembly Systems	Delerrok Inc.	Infodev Electronic Designers Inc.
Avigna Systems	Denso Sales Canada Inc.	INIT Inc.
BAE Systems	DiCAN Inc.	InnuScience Canada inc.
Baker Transit Parts Inc.	Distribution International HP. Inc.	Interac Association
Baultar Mechanical Solutions Inc.	Dixie Electric Ltd.	ISR Transit - ISR Fleettrack
Bewell Vehicle System Ltd.	DoubleMap, Inc.	ITSMAX Solutions Inc.
Bombardier Transportation, North America	DriveABLE Assessment Centers Inc.	IVU Traffic Technologies AG
BRC Group (Big Rig Collision)	Eastway Inc.	Karsan
Bridge Access Specialties, LLC	ElDorado National	Kelderman Air Suspensions
BusStuf, Inc.	ELERTS Corporation	Keolis Canada Inc.
BYD Motors Inc.	Elreg Distributors Ltd.	Kidde Technologies
C.E. Niehoff & Company	Emco Wheaton Corp.	Kiepe Electric Corp.
Cancore Industries, Inc.	Enbridge Gas Distribution Inc.	Kinesik Engineered Products
Carlisle Brake and Friction	Énergir	Kleenoil Filtration Canada Ltd.
CBM NA Inc.	Enghouse Transportation Limited	Krown Corporate
Cerco Cable Canada Inc.	Engie Ineo	Lazzerini Corporation
City View Bus Sales & Service Ltd.	Enseicom Inc.	Leeds Transit Inc.
Cityway Canada Inc.	Esri Canada	Lucerix International Corporation
Clean Air Technologies O/A Eurovac	FAAC Incorporated	Lucid Management Group Ltd.
Clean Energy Fuels	Forster Instruments Inc.	Luminator Technology Group
Clever Devices Ltd.	FortisBC Energy Inc.	Luxtronix Technologies Inc
Complete Coach Works	Freedman Seating Company	Maestronic Canada INC
Computrol Fuel Systems Inc.	Future Systems Inc.	MAN Engines & Components Inc.
Condor Signal & Communications Inc.	G+D Mobile Security	Marathon Brake Systems
Connexionz Ltd	Garival Inc.	March Networks Corporation
Consat Canada Inc.	Gatekeeper Systems Inc.	Martin & Levesque Uniformes / Blauer
ContiTech North America	GERFLOR	Masabi
MASATS LLC	Proterra, Inc.	Tokmakjian Group
McCANN Equipment Ltd.	Provincial Sign Systems	Traction (a division of UAP Inc.)
MGM Brakes	Pseco Inc.	Trans-Canada Energies
MICRO BIRD (Girardin)	Q'Straint/Sure-Lok	Transaxle Parts Inc.
Mississauga Bus, Coach & Truck Repair Inc.	Remix Software, Inc	Transit App
Mobile Climate Control	RFID Canada	TransitFare & Systems
Mohawk Mfg. & Supply Co.	RouteMatch Software	Trapeze Group Inc.
moovel North America	Safe Fleet / SEON	Union Gas Ltd.
MoveMobility	Safety Vision	Universal Rail Systems
MTB Transit Solutions Inc.	Safra Inc.	USSC LLC/ 4ONE LLC/ Fogmaker North

Nanov Display, Inc	Schaefer Inc.	Van Hool N.V.
NATSCO Transit Solutions	Scheidt & Bachmann	Vapor Bus International (a Wabtec
New Flyer Industries Canada ULC	Siemens Canada Ltd.	VenTek International
NextBus Inc.	SKL Aluminium	Ventura Systems Inc. North America
No-Spill Systems, Inc.	SNC-Lavalin Inc.	Vix Technology
Nova Bus	Solari Corp.	Voith Turbo Inc.
Optibus Inc.	Southwire Company Canada	Wajax Power Systems
OUTFRONT Media	Stemco	Walter Surface Technologies & Bio-Circle
Overland Custom Coach (2007) Inc.	Strategic Mapping Inc.	Wash-Bots Canada Ltd
Pattison Outdoor Advertising	Syncromatics Corporation	WaySine LLC
Payment in Motion Inc	T.G. Baker Americas, Inc	Western Sierras
Plan Group	TerraClean (CPS Products Canada Ltd.)	Westmatic Inc.
PNR RailWorks Inc.	Thales Canada Inc.	Westvac Industrial Ltd.
Poitras Industries	The Energy Conservation Group Corporation	Willowglen Systems Inc.
PowerTrunk Inc.	Thermo King	ZF North America, Inc.

Canadian Consulting Companies in the Transit Sector

Acart Communications Inc.	Dillon Consulting Limited	Parsons Inc.
Accenture	Entro Communications	Perkins+Will Canada
Advanced Symbolics Inc.	EY	PricewaterhouseCoopers LLP
AECOM Canada Ltd.	Gannett Fleming Inc.	Stantec Consulting Ltd.
Altus Group Limited	GEC Architecture	Steer
BA Consulting Group Ltd.	Hatch	STV Canada Consulting Inc.
Bytemark, Inc.	Hyperlight Systems	The Barrington Consulting Group Inc.
Cardtek USA Inc	IBI Group	The Stewart Group
CH2M HILL	KPMG LLP / srl/S.E.N.C.R.L.	Urban Systems Ltd.
CIMA+	LEA Group	Watt Consulting Group
Coencorp	LTK Engineering Services	Wendel
CSched	Morrison Hershfield Limited	WSP Canada Group Limited
Deloitte Inc.	movmi Shared Transportation Services	ZGF Architects Inc.
Dentons Canada LLP	Network Rail Consulting Inc.	
Dialog	Norda Stelo Inc.	

11. Technology Trends in the Transit Sector

Autonomous Vehicles

Many airports already use driverless, rail-based systems to move passengers between terminals. The next step is autonomous shuttle vehicles to move passengers from the terminal to parking lots. Ottawa Airport will soon be trying out this technology. Toronto has announced that it will experiment with driverless vehicles to shuttle passengers to and from transit stops. Stockholm is currently experimenting the use of autonomous buses as part of their public transit system.

Autonomous Bus in Stockholm, Sweden
https://www.roboticsbusinessreview.com/unmanned/moving-masses-autonomous-vehicles-public-transport/


TORONTO STAR

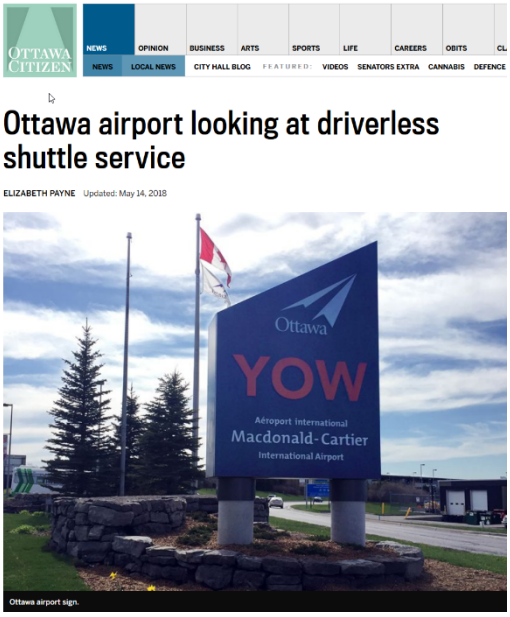
News • GTA

Toronto plans to test driverless vehicles for trips to and from transit stations

By BEN SPURR Transportation Reporter
Tues., July 3, 2018

Two years from now the bus that commuters take to their nearest TTC station may be missing a familiar feature — a driver.

The City of Toronto plans to take a step into the pioneering field of autonomous vehicles with a pilot project that would test driverless shuttles operating to and from transit stops.


OTTAWA CITIZEN

NEWS OPINION BUSINESS ARTS SPORTS LIFE CAREERS OBITS

NEWS LOCAL NEWS CITY HALL BLOG FEATURED: VIDEOS SENATORS EXTRA CANNABIS DEFENCE

Ottawa airport looking at driverless shuttle service

ELIZABETH PAYNE Updated: May 14, 2018

Ottawa airport sign.

Autonomous vehicle technology is essentially an application of advanced robotics to mobility. Engineering and technology graduates who want to work in this field will be prime candidates if they can demonstrate well-developed skills in some or all of the following fields:

- Sensor technology,
- Actuator technology,
- Artificial intelligence, and
- Big data analytics.

Although personal autonomous vehicles are getting the most media attention, transit systems are the most advanced experimenters with this technology. Autonomous vehicle technologies have the potential to reach common use as part of public bus services before personal vehicles due to financial incentives (driver salaries account for 60% of bus operators' expenditures) and fewer navigation challenges (fixed routes, limited geographical range)[4].

[4] Optibus, *Dynamic Scheduling for the Autonomous Public Transportation* Era (p. 5)

Engineering and technology graduates who are interested in the application of advanced robotics to mobility should look into the transit sector. In the transit sector, these technologies will move from the experimental stage to the application stage within the next five years.

Connectivity Technologies

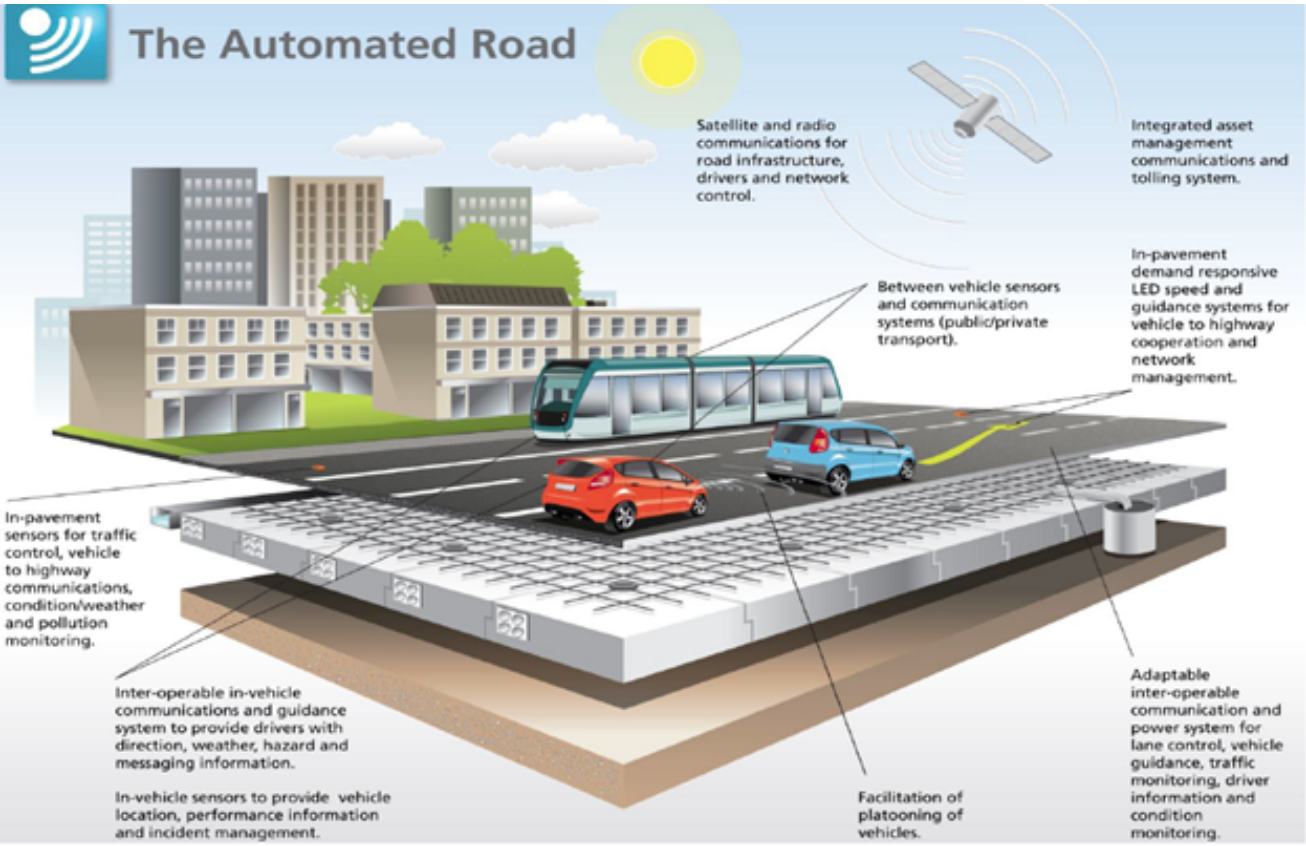
There are two types of connectivity technologies. The first type of connectivity technology links transit vehicles to current data on passenger loads so that the schedule-based allocation of vehicles can be altered to reflect surges in actual need. This technology is known as a Dynamic Scheduling System (DSS). A DSS will use real-time information to make instant changes to the transit service, for example, by adding buses so that route capacity never falls below demand levels or by adding carriages to subways.

The second type of connectivity technology links transit vehicles to the traffic management infrastructure. This technology will enable, for example, the timing of traffic lights to be adjusted to take account of transit needs. Connected buses could trigger advanced green lights (Transit Signal Priority), communicate passenger transfer information to other buses, and coordinate travel across jurisdictional boundaries.

The implementation of connectivity technologies will require engineering and technology graduates with well-developed skills in internet protocol, wireless technology, and systems integration.

Automated Road Technology

'Automated Road' technology is integral to the implementation of both autonomous vehicles and connective vehicles. Automated roads build into the road system sensors for traffic management, speed guidance and communications with both control centres and vehicles.



Source: "Automated Vehicles and Infrastructure Planning Policy" (p. 18)

Battery and Fuel Cell Propulsion Systems

As in the auto sector, three alternative propulsion systems are being trialed by transit systems across Canada:

- Hydrogen fuel cells,
- Battery-powered buses, and
- Hybrid battery/diesel buses.

> What is a Fuel Cell?
>
> A fuel cell converts hydrogen and oxygen into water and, in the process, also creates electricity. A battery stores all of its chemicals inside and then generates electricity through an electro-chemical process. A fuel cell uses oxygen, hydrogen and catalysts that are added to the fuel cell.
>
> Every fuel cell has a positive electrode (the anode) and negative electrode (the cathode). These are separated by an electrolyte barrier. Hydrogen goes to the anode side, while oxygen (or just air) goes to the cathode side. When both of these chemicals hit the electrolyte barrier, they react, splitting off their electrons and creating an electric current. A catalyst speeds up the reactions.

In 2010, Vancouver was the first municipality in Canada to test hydrogen fuel cell buses. The experiment was abandoned owing to higher maintenance costs. However, other transit systems continue to experiment with fuel cell propulsion. Hydrogen fuel cells have zero carbon emissions. **CUTRIC** recently launched the **Pan-Canadian Hydrogen Fuel Cell Vehicle Demonstration & Integration Trial.** **Ballard Power Systems** reports that a bus powered by one of its fuel cells achieved a new durability record - 25,000 hours of service - with no significant

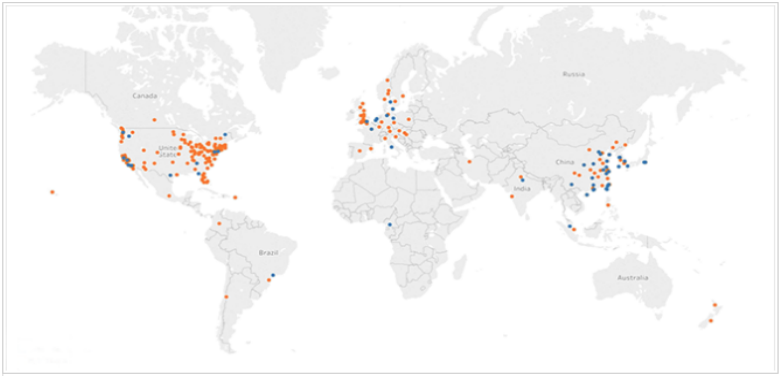
maintenance to the fuel cell. This is equivalent to operating a bus on a 14-hour daily schedule, 5-days per week for almost 7 years.

Battery-powered buses are now in experimental operations across Canada. Montreal started using electric buses in 2017. Vancouver commenced its electric bus experiment in 2018. In Ontario, various transit services are rolling out experimental use of electric buses. The **CUTRIC** electric bus trial aims to deploy 25 e-buses across transit agencies in Ontario by 2018. It will integrate at least seven transit systems across five or more electrical distribution jurisdictions. The trial will evaluate electric buses manufactured by two Canadian bus manufacturers, **New Flyer Industries** in Manitoba and **Nova Bus** from Quebec. **ABB** will supply interoperable opportunity charging systems with inverted pantograph technology, rated up to 450 kW. The company will provide a system that is open to all bus brands as well as other charger manufacturers. **Siemens Canada** will be the charging solution provider for the Pan Canadian Demonstration Project.

Hybrid buses have been widely used by transit systems across the world for more than 10 years. Currently, a majority of electric buses in service are hybrid because they cost less and offer operational flexibility. There are now several thousand hybrid buses in operation across North America. In New York, about 13% of the fleet of 6,200 buses are hybrids. In Toronto, a third of the fleet of 1,700 buses are hybrids. Los Angeles plans to transition to an emission-free bus fleet by 2030, while New York City has announced it aims to have an all-electric bus fleet by no later than 2040.

Fast-charging buses could use a charging system built into bus stations, needing only the time when people are loading on and off the bus to power up. Wireless charging systems could also be embedded in the roadway itself, as Volvo has done for a 2km stretch of road in Sweden.

Market analysts expect hybrids and battery-electric buses to account for 20-25% of global bus sales by 2027. Bloomberg New Energy Finance predicts nearly half of municipal buses on the road in 2025 will be electric. Battery prices have already fallen 90% in the past 10 years and could become sufficiently cheap by 2020-2025[5]



Distribution of battery-powered electric bus (blue) and hybrid bus fleets (orange) around the world.
Source: Xiangyi Li/WRI

Major companies in the battery-electric bus market include:

- Proterra (United States)

[5] Ibid.

- Volvo (Sweden)
- Hyundai (Korea)
- Volkswagen (Germany)
- **New Flyer (Canada)**
- **Nova Bus (Canada)**
- BYD (China), and
- Tata Motors (India)

Materials Engineering

The weight of a vehicle is a major determinant of its fuel requirements. The curb-side weight is the weight of an empty bus that is fully fueled. This is a standard industry measure. The trend has been to increase the curb-side weight. A number of factors are causing curb-side weights to increase. These include additional passenger amenities (e.g., better seating and air conditioning systems) and ramps to enable disabled access. The increase in curb-side weight has offset many of the efficiency gains achieved through improved engine design.

Reversing the vehicle weight trend is critically important to reducing greenhouse gas emissions and also to comply with government regulations. In round terms, every 15% reduction in weight translates into a 10% reduction in fuel use.

Reversing the vehicle weight trend is primarily about innovations in materials engineering. Light-weighting of transit vehicles chiefly involves: (1) reducing the current reliance on steel and aluminum with newer, light-weight alloys, magnesium and polymer composite materials, (2) reducing the weight of components, and (3) developing design strategies that require less material usage.

What is Light-Weighting?

There are two definitions:

- The replacement of steel with lighter weight materials, such as aluminum, magnesium, composites (e.g. carbon fiber reinforced polymers), biofibers or a combination of those materials (as in multi-material or hybrid structures).
- The removal of mass associated with parts/components of a vehicle (e.g. smaller, downsized engines) or the removal of entire parts/components of a vehicle.

CUTRIC, "Light-weight, electrified, automated, and cybersecure transportation innovation in Ontario" (2017)

A key challenge in light-weighting strategies in the transit sector is that the durability requirements are much greater than in the personal vehicle sector. Light-weighting strategies that are feasible in personal vehicles often fail in transit applications because they cannot withstand substantially greater levels of wear and stress. This applies to both material failure from fatigue and failure of adhesives and joining technologies to perform as required under stress. Materials strategies developed for the aerospace industry hold considerable promise.

Light-weighting strategies are in development for virtually all larger mass components of heavy-duty vehicles:[6]

- *Engines* – reducing vehicle aerodynamic load, reducing power and torque demands

[6] "Lightweighting as a means of improve Heavy Duty Vehicles's energy efficiency and overall CO2 emissions" (p. 38)

- *Transmissions and drivelines* – same as engines, plus improvements in transmission casing through Carbon Fibre Reinforced Plastics (CFRP)
- *Ladder frames, trailer draw bars* – replacing steel structures with aluminum
- *Axles, wheels, tires, brakes, springs, dampers and steering systems* – transition from cast iron construction to aluminum, increased uptake of alloy wheels & introduction of composite wheels
- *Body structures, cabins, trailer upper structures* – shift to full aluminum structures/plastic panels.

Engineering and technology graduates with skills in materials engineering and polymer composite engineering should look into the opportunities for research and design careers in the transit sector.

12. Hyperloop and Maglev

Hyperloop

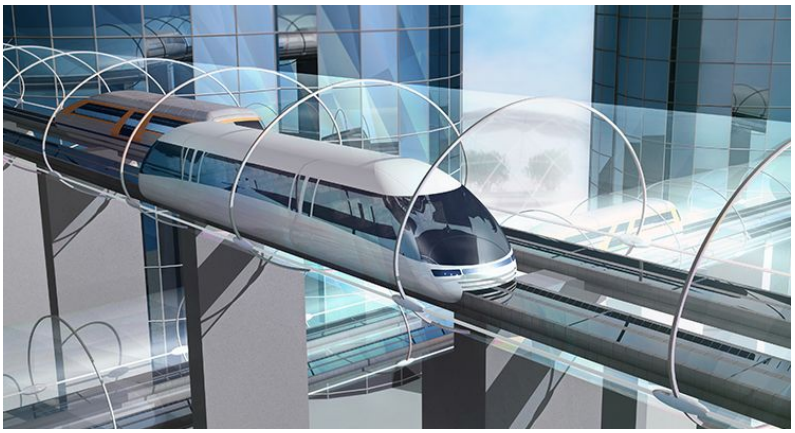
One of the technical hurdles to developing high-speed rail for transportation of goods or people is that both friction and air resistance become more serious impediments at high speeds. Vactrain technology seeks to overcome these impediments by utilizing magnetic levitation and partial vacuum tubes. This is an emerging technology. 'Hyperloop' is the term chosen by Elon Musk for his venture in this field and has now become synonymous with the technology.

Elon Musk's SpaceX is sponsoring university-based technology competitions to advance the hyperloop technology.

SpaceX Hyperloop Technology Competition

https://www.spacex.com/hyperloop

There are currently three test tracks in operation or under development: one in France and two in the Untied States. In the past two years, a spate of development agreements have been announced for feasibility studies on various proposed routes.



The first Hyperloop project by Hyperloop Transportation Technologies will enter the construction phase this year in Abu Dhabi.

There is one Canadian company currently developing hyperloop technology – Transpod Hyperlink. Transpod has commenced construction of a test track in France. The company is planning to set up a test track in Canada. You can view a YouTube video on Transpod at:

https://www.youtube.com/watch?v=rcElYsycmes&list=PLZD6DZedccj4-SOu4K0LivCYNIcPkYgK_

You can also read about Transpod's concept of a Toronto-Windsor hyperloop.

Transpod
Initial Order of Magnitude Analysis for
Transpod Hyperloop System Infrastructure
(Toronto-Windsor Corridor)

https://transpod.com//wp-content/uploads/2017/07/TransPod-infrastructure_EN_July-17-update2.pdf

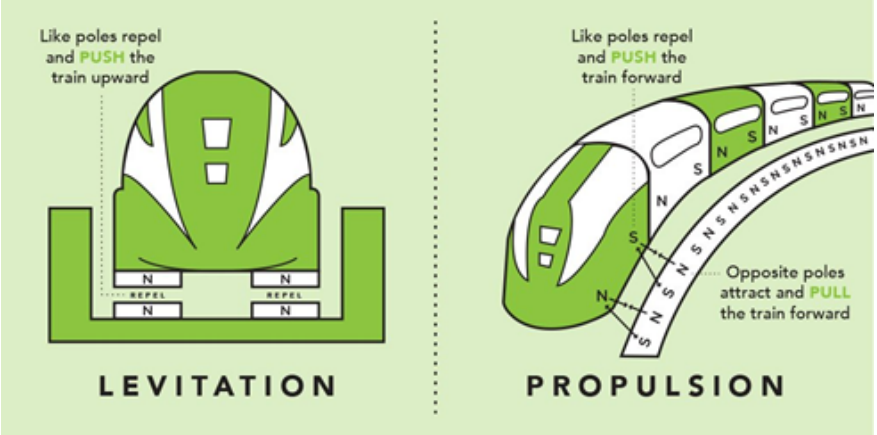
Leading companies in hyperloop technology include:

- Virgin Hyperloop One (Los Angeles, California): https://hyperloop-one.com
- Hyperloop Transportation Technologies (Culver City, California): http://www.hyperloop.global
- SpaceX: https://www.spacex.com/hyperloop
- Transpod Hyperlink (Toronto, Canada): https://transpod.com
- DGWHyperloop (Banglaore, India): https://www.dgwhyperloop.com
- Arrivo (Los Angeles, California): https://www.arrivo-loop.com
- Hardt (Delft, Netherlands): https://hardt.global
- Hyper Chariot (Santa Monica, California): https://www.hypercharIot.com

Maglev

Maglev (*magnetic levitation*) is a transportation system that utilizes one set of magnets to raise a train off the 'track' and second set of magnets to move the 'floating train' forward at a high speed, owing to the lack of friction. The maglev train moves through a guideway of magnets which control the train's stability and speed. Maglev trains are quieter and smoother than wheeled vehicles and also potentially faster. Currently, maglev systems are significantly more costly to construct than wheeled systems, although their operating and maintenance costs are much lower.

Maglev systems currently operate in China, Japan and Korea. Developments are currently under way in Israel and in the United States.



There is one Canadian company supplying and developing maglev technology – Magnovate, which is headquartered in Edmonton. The Toronto Zoo has invited Magnovate to develop a system that will operate with the zoo's grounds.

Magnovate
http://www.magnovate.com/
https://www.youtube.com/watch?v=pdDoiTjukZw

13. Snapshots of Companies in the Transit Sector

AECOM

AECOM is a global provider of technical and management services in transportation and other sectors. In Canada, its 4,300 employees in over 40 locations have played major roles in many bus rapid transit, light rail transit and heavy rail projects including those in Vancouver, Edmonton, Calgary, Waterloo, Hamilton, Toronto, Ottawa and Montreal.

Among its other endeavours, AECOM has developed a handheld computer-based transit facilities information management system. The integrated GPS capabilities of this customizable mobile solution allow users to gather information on the physical location and condition of assets at transit stops.

AXION Technologies

AXION supplies software and hardware for audio and visual communication systems in the bus and subway industries. The firm has offices in St. Nicolas and La Pocatière, Quebec with about 200 employees, and other locations in New York State and Denmark.

AXION's products are used by about 35 major transit systems in Canada, 50 in the United States and 30 in Europe. AXION's exports make up 80 to 90% of its annual sales, and the firm's communication systems were recently selected for over 1,400 new London Underground subway cars, based on the performance of their ethernet IP technology.

Bombardier

From its roots and corporate headquarters in Canada, Bombardier has become a global leader in rail transit. With 45 production sites in 22 countries, the company has more than 2,500 employees in Quebec and Ontario.

Bombardier Transportation offers a broad product portfolio including rail vehicles and propulsion systems, control and security solutions, and modernization and maintenance services. It has over 100,000 vehicles in operation around the world. In Canada, Bombardier Transportation is major vehicle supplier to subway and commuter rail services in the metropolitan areas of Montreal, Toronto and Vancouver.

Enseicom

Located in Montreal, Quebec, Enseicom manufactures electric signs, advertising structures and sheet furniture for transit systems across Canada and the United States. The company recently added solar-powered shelters to its product lineup, and has delivered them to communities such as Toronto, Mississauga, Montreal, Winnipeg and San Francisco. The use of solar power reduces emissions and energy consumption, eliminates the need to connect to the grid, and lets transit systems relocate shelters as needed. Enseicom currently has 55 full-time employees.

Eurovac (Clean Air Technologies)

Clean Air Technologies supplies transit systems with Eurovac bus wash systems and vacuum systems for cleaning buses, extracting dust from brake lathes and for dust extraction with source capture sanders and grinders. From Concord, Ontario it has supplied products to transit systems in seven Canadian communities including Toronto, Calgary and Vancouver, and over 50 in the United States including New York, Los Angeles, Chicago and Boston. The firm has about $4.5 million in annual exports.

GIRO

GIRO's flagship HASTUS software is used by public transit systems for planning, scheduling, operations and analysis. Advanced technology software modules for HASTUS include the HASTINFO web-based trip planning tool and BidWeb, a tool for online work selection by transit vehicle operators.

The Montreal-based company has 212 employees. Its clients include 21 Canadian transit systems (including those in Montreal, Winnipeg, Edmonton, Quebec City, Ottawa, Calgary, and Halifax), 47 in the United States, 83 in France and 113 in Spain, Germany, Austria and Australia and elsewhere. GIRO's annual exports are valued at more than $26 million, two-thirds of which are destined to Europe.

Imagi

Le Groupe Imagi produces transit advertising media including bus boards (exterior and interior), bus wraps and transit shelters. It also produces frames for different kinds of displays. The company's turnkey services include computer graphics, printing and installation. With 30 employees in its Montreal headquarters and offices in Gatineau and Saguenay, Imagi counts over 30 transit systems across Quebec among its clients.

LED Smart

LED Smart is located in Edmonton, Alberta and Surrey, British Columbia. The firm's LED lighting systems are designed and made in Canada, and are suitable for both new and retrofit installations in buses and trains. LED lamps are brighter and more reliable than mercury-containing fluorescent lamps, thereby increasing passenger comfort and safety and virtually eliminating maintenance needs. LED Smart products have been used to retrofit 72 of Calgary's CTrain cars, and are being tested by transit systems in Winnipeg, Edmonton, Montreal and Vancouver, as well in several major American cities.

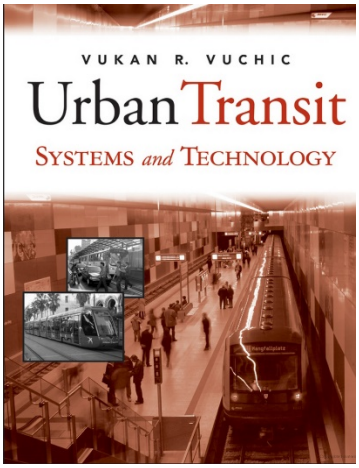
New Flyer Industries

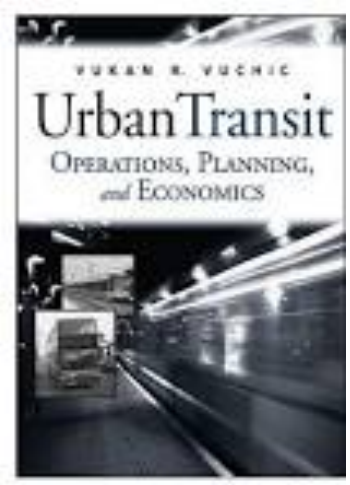
New Flyer is the largest manufacturer of heavy-duty transit buses in Canada and the United States. Its broad product line offers a variety of bus models, lengths and propulsion systems. The firm maintains corporate headquarters and manufacturing facilities in Winnipeg, and employs 1,400 workers in Canada and 1,000 others across North America.

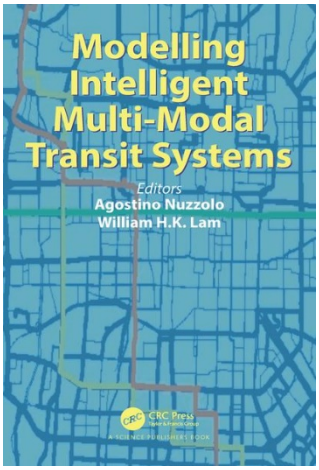
New Flyer buses are in use at 250 transit systems throughout North America. Recent high-profile projects have included bus rapid transit systems in Ohio and Oregon, electric trolley bus contracts in Philadelphia and Vancouver, and the provision of fuel cell buses to BC Transit for the 2010 Olympic Winter Games.

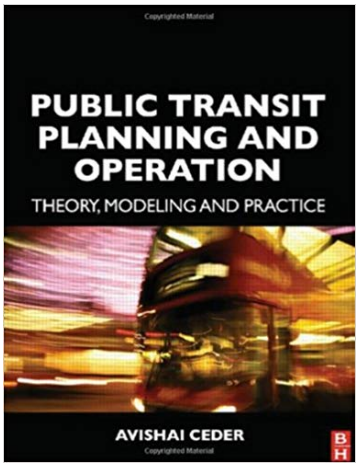
14. Other Resources about the Transit Sector

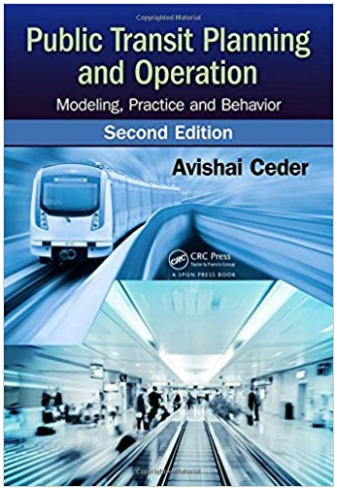
Books

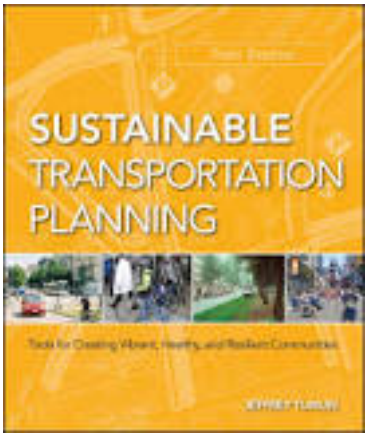












Web Sites

Canadian Urban Transit Research and Innovation Consortium (CUTRIC)
http://cutric-crituc.org/home

Canadian Urban Transit Association
http://cutaactu.ca/

Ontario Pubic Transit Association
http://www.ontariopublictransit.ca/

Transportation Association of Canada
www.tac-atc.ca

Intelligent Transportation Systems Society of Canada
www.itscanada.ca

Canadian Institute of Transportation Engineers
https://www.cite7.org/

Courses

MIT Open Courseware
An Introduction to Intelligent Transportation Systems
https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-212j-an-introduction-to-intelligent-transportation-systems-spring-2005/index.htm?utm_source=OCWCourseList&utm_medium=CarouselSm&utm_campaign=FeaturedCourse

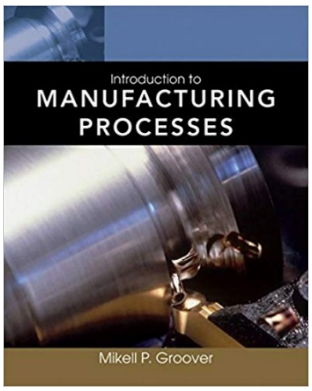
15. Skills that will give You an Edge

1. Understanding Manufacturing Processes

It is important to understand the basic manufacturing processes. If you studied mechanical or manufacturing engineering, you already have the necessary background. But if you are coming to the manufacturing sector from a different background – say chemical engineering or computer engineering – you will need to pick up some additional some additional knowledge.

The basic manufacturing processes are:

- Casting
- Forging
- Moulding
- Forming
- Machining
- Joining
- Imaging and Coating
- Assembling



E-learning Courses:

EdEx
Mass Institute of Technology (MIT)
Fundamentals of Manufacturing Processes
https://www.edx.org/course/fundamentals-manufacturing-processes-mitx-2-008x-0

Alison
Introduction to Manufacturing Processes
https://alison.com/course/introduction-to-manufacturing-processes

MOOC List of Courses on Manufacturing
https://www.mooc-list.com/tags/manufacturing-processes

Open University (UK)
Manufacturing (no charge)
http://www.open.edu/openlearn/science-maths-technology/engineering-and-technology/design-and-innovation/design/manufacturing/content-section-0?active-tab=description-tab

2. Understanding Robotics

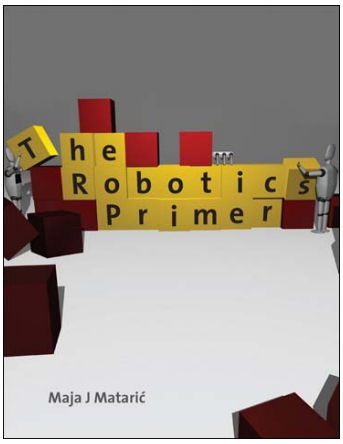
Robotic technology is central to manufacturing. Understanding the principles of robotics is critical. Again, if you have mechanical or manufacturing engineering background, you already understand these principles. But if you majored in another engineering field, you may need to upgrade your knowledge base.

Robots are used for:

- Moving materials and components
- Shaping components (cutting, bending, etc.)
- Joining components (welding, applying adhesives, bolting)
- Assembling components
- Coating components
- Inspecting

The elements of a robot are:

- Sensors
- Actuators
- Controller
- Manipulator
- Locomotion (if the robot is not stationary)



Stanford University Everywhere
Introduction to Robotics (E-Course)
https://see.stanford.edu/course/cs223a

Northwestern University
Modern Robotics, Course I – Foundations of Robot Motion (E-Course)
https://www.coursera.org/learn/modernrobotics-course1

MIT Open Courseware
Introduction to Robotics
https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/

3. Understanding Quality Control Systems.

Industry engineers report that the single greatest skill shortage of recent engineering graduates is their lack of understanding and experience with quality control systems. Even a basic knowledge of quality control systems will differentiate you.

There are two dimensions to quality control systems. The first is technical. This is chiefly understanding the principles of **statistical process control**. The most famous of the applications of statistical process control is 'six sigma' which was applied throughout General Electric.

Quality control is integral to every manufacturing process. The auto industry recently adopted a common standard known as ISO 16949. Having some familiarity with ISO 16949 is a major asset when seeking an engineering job in the auto industry.

Fee-based Courses:

- https://bsi.learncentral.com/shop/Course.aspx?id=24532&name=IATF+16949:2016+Autoflicks:+An+introduction+to+the+revised+automotive+standard
- https://www.sgs.com/en/campaigns/iatf-16949-2016-automotive-qms-introduction-elearning
- https://www.tuv-sud-psb.sg/sg-en/activity/training-services/automotive-quality-management-system-1/iso-9001-2015-and-iatf-16949-2016-awareness
- http://www.aiag.org/quality/iatf16949

Guides to ISO 16949:

- https://www.nqa.com/en-ca/resources/blog/june-2017/guide-to-iatf-16949 (free download)
- *The Automotive IATF 16949:2016 Memory Jogger*, Jeremy Hazel

Kaoru Ishikawa's *Introduction to Quality Control* is considered by many to be the authority for quality control. Originally written in Japanese, it is now available in English. It is a heavy read.

4. Programming Skills

AutoCAD and SolidWorks are industry standards for 3-D design. 3-D printing works directly from CAD files. The programming of robots requires knowledge of CAD.

Most manufacturers of robots use proprietary software to program the equipment, although knowledge of Python or C/C++ provides a good base.

Manufacturer	Language
ABB	RAPID
Comau	PDL2
Fanuc	Karel
Kawasaki	AS
Kuka	KRL
Stäubli	VAL3
Yaskawa	Inform

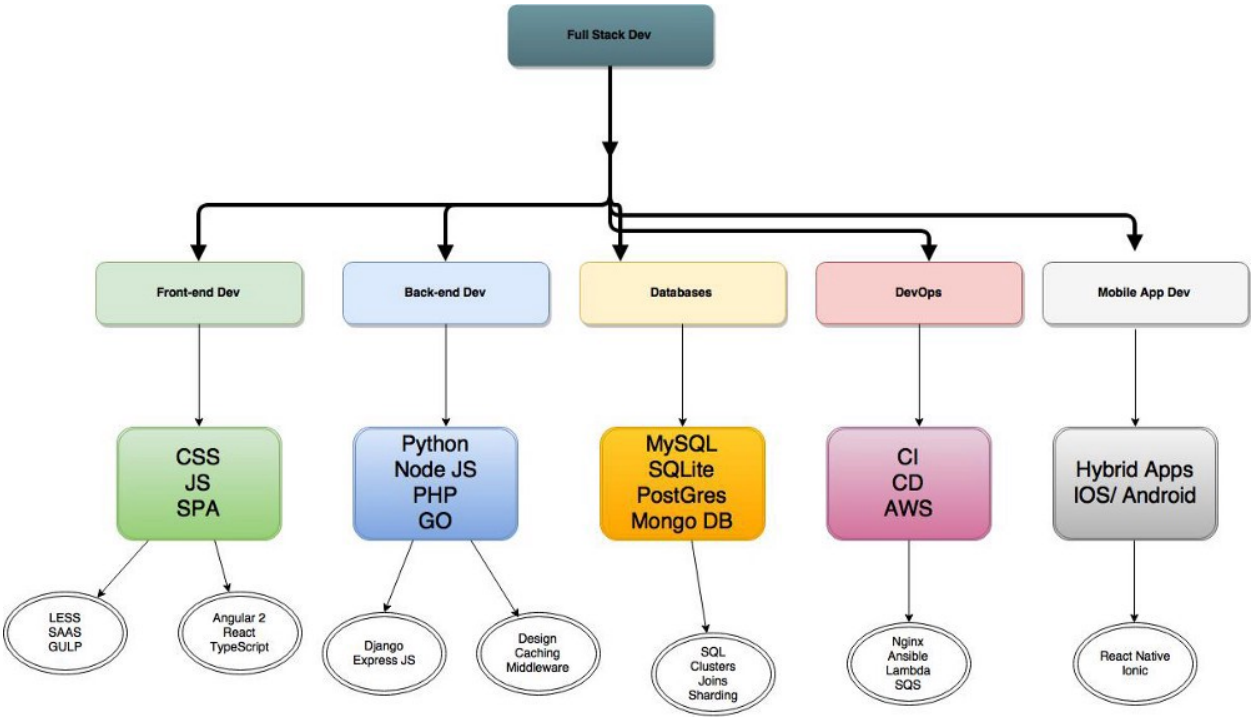
For a more detailed exploration of the role of CAD in manufacturing, check out:

Autodesk
CAD and Digital Manufacturing Specialization
Coursera – Five Courses
https://www.coursera.org/specializations/cad-design-digital-manufacturing

Given the importance of hydraulic equipment, knowledge of fluid mechanics is important.

University of Minnesota
Coursera
Fundamentals of Fluid Power
https://www.coursera.org/learn/fluid-power

"Full stack" refers to the collection of technologies needed to complete a project. A "stack" refers to a collection of sub-modules. A full stack developer is an engineer who is knowledgeable about all of the work of database design and management, including hardware requirements, network requirements, user needs, etc. The following graphic illustrates the components of a major design project and the related programming languages. The front-end of a design project is everything that the user interacts with directly. The back end is the database engine and connectivity systems that drive the application.



One major firm describes four levels of software engineering:

1) **Full Stack Developers** work on Application Program Interface (API) as well as the back end of the application. Full Stack Developers are responsible for the overall architecture of the application

and the integration of its components as well as its integration with hardware and network systems. Key programming platforms include:

- Java
- Scala
- Angular JS
- Rub on Rails
- SQL

2) **Firmware Developers** write low-level or embedded code for IoT (internet of things) applications. The key platforms are: C or C++.

3) **Data Science Engineers** develop and refine algorithms for machine learning (artificial intelligence) and manage neural networks. They require both knowledge of software platforms and statistical theory. Key software platforms include:
   - Python
   - R (for statistics)
   - C++

4) **DevOps** is a set of practices designed to overcome the problems of developing an application in silos. DevOps engineers work with all segments of a project team to ensure successful integration of components. Some companies view DevOps as a workplace culture. Other companies see DevOps as a specific set of skills.

5. Cross-Disciplinary Complementary Technical Skills

Employers report that they attach particular importance to engineering graduates who have complementary engineering skills. The reason for this is that many technologies cut across discipline boundaries. Employers are often seeking engineering graduates who are not tied to their particular field. Mechatronics, for example, combines electronics engineering and mechanical engineering. A combination of electrical engineering and chemical engineering skills is important in battery technology.

Programming skills are universally required in industry. They complement every engineering skill.

6. Working with Trades and Technicians

In every manufacturing process, there is a need for skilled tradespersons and technicians to maintain and trouble-shoot equipment. Manufacturing companies look for engineers who can communicate easily with skilled tradespersons and technicians and who respect the skills that these workers bring to the job. Any experience that you have in working with skilled tradespersons and technicians, regardless of the context, is a valuable asset.

Trades that you are most likely to work with include:

- General Machinist
- Industrial Electrician

- Industrial Mechanic Millwright
- Instrumentation Control Technician
- Metal Fabricator
- Tool and Die Maker
- Welder
- Sheet Metal Worker
- Steamfitter

Most trades receive around 1,200 hours of in-school training and 4,000 to 6,000 hours of on-the-job training.

A good resource to learn about trades is:

Trades in Ontario
http://www.collegeoftrades.ca/trades-in-ontario

7. Communications Skills - Emails

Learn how to write emails that are clear and concise. When you are on the job, you may receive 40-60 emails per day from colleagues or suppliers. Many emails (perhaps most) are badly written. As a result, people often do not open them and, if they do, they just scan them. This can cause serious communications problems

If you want your emails to be read, you have to write emails that are necessary, clear and concise.

A useful tool to help you write in clear and simple English is the Hemmingway App. This app will review your text and highlight areas where it could be improved and shortened for easier reading. You should test yourself to see if your email writing style is really as clear and concise as you may think it is.

Hemmingway App
http://www.hemingwayapp.com/desktop.html

Some useful web sites:

- https://www.leandna.com/blog/5-ways-strengthen-supplier-communication
- https://www.cips.org/supply-management/opinion/2015/may/four-top-tips-to-improve-supplier-relationships/
- https://www.youtube.com/watch?v=amJZXjxnhTI
- https://www.youtube.com/watch?v=8oQeYeley1I
- https://www.youtube.com/watch?v=y50xhHQ8Qf0

8. Communications Skills – Verbal Communications

Verbal communications, whether in a team or one-on-one, is a key part of every-day engineering. Companies want good communicators. Some companies test for communications skills. Other companies assess your communications skills during the interview.

We all think that we are good communicators. That's not always the case. The important thing to remember is that communications skills can be learned and improved. Weak communications skills don't need to be a barrier. But you have to start by recognizing whether those skills need strengthening. Want to see if your verbal communications skills need improvement? Here are a few tests:

- https://www.mindtools.com/pages/article/newCS_99.htm
- https://www.activia.co.uk/communication-skills-test
- http://wittcom.com/communication-skills-quiz/
- https://www.psychologytoday.com/ca/tests/relationships/interpersonal-communications-skills-test (Free summary; full report charged.)
- https://www.highspeedtraining.co.uk/hub/communication-skills-quiz/

More comprehensive skills upgrading is available through continuing education programs:

McMaster University
Communication Essentials Courses
https://mcmastercce.ca/communication-essentials-courses

There are some longer e-courses that you could explore:

Rice University
Coursera
Communications Skills for Engineers
https://www.coursera.org/specializations/leadership-communication-engineers

University of California
Coursera
Communication I the 21st Century Workplace
https://www.coursera.org/learn/communication-in-the-workplace

There are also some helpful tips to use when being interviewed:

- https://www.thebalancecareers.com/communication-interview-questions-and-best-answers-2061251

9. Teamwork

The team is the basic unit or organization in the private sector. Companies place huge importance on their teams. Employers look to hire engineers who can work in a team environment. To be

competitive, your résumé should include examples of team working.

When interviewing, you should anticipate being asked questions about how you handle issues within a team. Examples might include how you deal with conflict on a team, someone not carrying their weight or someone not meeting their commitments to the team. Your responses to these questions should be strong, including clear examples. Often, they aren't… even when we have the relevant team experience and know that we will be asked about it.

The University of Kent offers a free, self-administered test that will assist you in deciding whether your team working skills need to be strengthened.

University of Kent
Team Working Skills
https://www.kent.ac.uk/careers/sk/teamwork.htm

Here is a good podcast from the University of Waterloo that discusses teamwork in a serious way.

University of Waterloo
Centre for Teaching Excellence
Teamwork Skills: Being an Effective Group Member (podcast)
https://uwaterloo.ca/centre-for-teaching-excellence/sites/ca.centre-for-teaching-excellence/files/uploads/files/Teamwork-Skills-Being-an-Effective-Group-Member.mp3

Here is a Coursera course on team working skills from the University of Colorado. It is definitely worth checking out.

University of Colorado at Boulder
Coursera
Teamwork Skills: Communicating Effectively in Groups
https://www.coursera.org/learn/teamwork-skills-effective-communication

Other resources:

- https://www.thebalancecareers.com/list-of-teamwork-skills-2063773
- https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/tips-students/being-part-team/teamwork-skills-being-effective-group-member
- https://www.skillsyouneed.com/

10. Project Management

Project management skills are in demand in every industry. Project management qualifications open career doors and accelerate career advancement.

The premier qualification is certification from the Project Management Institute.

https://www.pmi.org/

You can find courses on project management at most colleges:

https://www.ontariocolleges.ca/en/programs/business-finance-and-administration/project-management

There are also some good e-courses available:

University of California
Coursera
Project Management: The Basics for Success
https://www.coursera.org/learn/project-management-basics

Wharton Business School, University of Pennsylvania
Coursera
Improving Communications Skills
https://www.coursera.org/learn/wharton-communication-skills

You can also find courses on project management through the continuing education programs offered by many universities. Here is a partial list:

- University of Toronto School of Continuing Studies
  https://www.ontariocolleges.ca/en/programs/business-finance-and-administration/project-management

- McMaster University, Centre for Continuing Education
  https://www.mcmastercce.ca/project-management

- Ryerson University – Chang School for Continuing Education
  https://ce-online.ryerson.ca/ce/default.aspx?id=2514

- Western University – Continuing Studies
  https://wcs.uwo.ca/public/category/courseCategoryCertificateProfile.do?method=load&certificateId=22431

- Carleton University - Sprott School of Business
  https://ppd.carleton.ca/project-management-professional-certificate-ottawa

11. Presentation Skills

At some point, you will have to present an engineering concept to a non-technical audience. If your audience doesn't understand your presentation, they will blame you or conclude that you don't really know your subject. If you have good presentation skills, your team will want you to be the presentation leader. Good presentation skills will accelerate your advancement. Poor presentation skills can hold back a career.

Presenting to your classmates in college or university is good experience. But, workplaces have much higher standards. Unless you've had previous training in presentation skills, it's best to assume that your presentation skills are not sufficient as-is and need to be upgraded.

University of California
Coursera
Presentations: Speaking So that People Listen
https://www.coursera.org/learn/presentations-speaking-so-that-people-listen

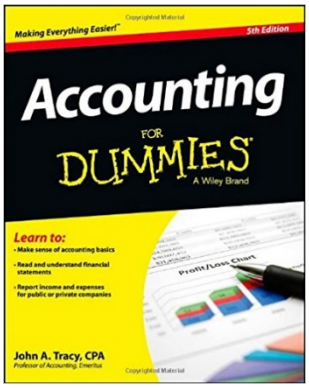
PWC
Coursera
Effective Business Presentations with Powerpoint
https://www.coursera.org/learn/powerpoint-presentations

University of Colorado at Boulder
Coursera
Successful Presentation
https://www.coursera.org/learn/presentation-skills

Open University (UK)
Talk the Talk: How to Give a Great Presentation
https://www.class-central.com/course/futurelearn-talk-the-talk-how-to-give-a-great-presentation-2120

12. Basic Accounting and Finance

Accounting is the "language of business". There are three types of accounting and financial analysis:



- **Financial accounting** consists of the reports that managers generate to provide external parties with a summary of the firm's financial position and operations. When the term 'accounting' is used, it usually means financial accounting.

- **Managerial accounting** (sometimes called 'cost accounting') focuses on the information and the analytical tools that help managers and employees make the right business decisions.

- **Feasibility analysis** does a cost-benefit of an operation or a payback analysis of a proposed investment.

Introduction to Accounting and Feasibility Analysis:

This YouTube series of short videos provides a good introduction to the basis of financial accounting:

Introduction to GAAP (Generally Accepted Accounting Principles)
Ed Spira

https://www.youtube.com/watch?v=nqkk9omr3sc&list=PL_KGEFWqEaTCDEzqFn0imjpyIRDy4p63s

A second set of videos covers managerial accounting:

Introduction to Managerial Accounting
Ed Spira

https://www.youtube.com/watch?v=KCyg8-zM9bA&list=PL_KGEFWqEaTAswdGBQr2YwKDQoKz84iox

Key concepts in feasibility analysis are net present value (NPV) and internal rate of return (IRR). Both of these can be computed in Excel. It's important to understand these measures and how to develop them.

Capital Budgeting in Excel
https://www.youtube.com/watch?v=19n-4yf9jlE

Net Present Value
Ed Spira
https://www.youtube.com/watch?v=19n-4yf9jlE

Internal Rate of Return
Ed Spira
https://www.youtube.com/watch?v=OSDDrZZaV8E

NPV vs IRR
Ed Spira
https://www.youtube.com/watch?v=6RztxNwerOA

A Feasibility Study: Step by Step
https://www.youtube.com/watch?v=cQAMQdZRGR4

More Advanced Courses:

Rice University
Courera
Finance for Non-Financial Professionals
https://www.coursera.org/learn/finance-for-non-finance

University of Pennsylvania
Introduction to Financial Accounting
Coursera
https://www.coursera.org/learn/wharton-accounting

University of Virginia
Coursera
Managerial Accounting Fundamentals
https://www.coursera.org/learn/uva-darden-managerial-accounting

16. 25 Tips on Getting the Job You Want

Advice from Randstad

Randstad is one of the largest international employee search companies ('head hunter') in the engineering sector. They operate in more than 30 countries. They have more than 20 offices in Canada. Randstad knows what employers are looking for. They offer advice at:

https://www.randstad.ca/job-seeker/job-tips/archives/tips-for-finding-your-first-engineering-job_563/

Tip No. 1:
Read the job posting carefully and decode it.

Companies spend a lot of time developing job postings. Every word or phrase in the job posting matters to someone who was part of the process of developing the job posting. Your application will be assessed against the skills and experience requirements that are described in the job posting. Go through the job posting carefully. Identify both the technical skills and the non-technical skills that the employer is seeking. Identify the experience that the employer wants.

The following are three actual examples of job postings for junior engineering jobs. Read these examples to learn how to decode a job posting and customize your application.

Transportation Engineering Analyst (EIT)
(Company Identity Suppressed)

You want to be part of a team that plans and designs the transportation network you'll be driving for years to come. You want to learn more about the engineering process and how a team works together to get projects done. You're not afraid to ask questions. You make- and own-your decisions. XXXXXX is looking for a Transportation Engineering Analyst (EIT) to join our Traffic Services Division, which provides traffic engineering services for land development traffic studies, transportation planning studies, traffic operational reviews and traffic management studies. Our recent projects include… This position is in our XXXX office, located near XXXX. You will work with experienced Project Managers and Professional Engineers on a variety of transportation projects. You will conduct traffic analysis, undertake transportation planning studies, prepare transportation models, perform field visits, assist with proposal preparation and communicate with various parties on projects. **YOUR ROLE:** • Completing Traffic Engineering analysis and Transportation Planning with respect to mobility and safety • Performing field visits and intersection turning movement count • Performing transportation planning and traffic engineering work under the direction of Professional Engineers • Preparing design drawings using AutoCAD or Civil 3D • Preparing technical reports to summarize analysis methodology and findings	Teamwork is the first thing mentioned in this posting. That means it is important. Be sure to show that you have team working experience. Wanting to learn is the second thing mentioned. Show your passion for learning through an example in your résumé. This employer expects you to be proud of your profession and to be registered as an EIT. Use the key words highlighted when describing your experience, but don't exaggerate.

• Maintaining complete traffic engineering and quality assurance records • Ensuring quality control procedures are completed as per XXXXXX's Organizational Quality Management (OQM) Policy • Ensuring that all designs and calculations adhere to legal standards through consultation with the project's Engineer of Record **WHAT YOU BRING:** • Previous work experience in a transportation engineering environment (e.g. work terms while in school or co-op experience) • Completed Degree in Civil engineering preferably with enrollment in transportation engineering and planning courses • Registration as an EIT… (or eligible for immediate registration) • Valid XXXX Driver's License and personal vehicle preferred • Previous exposure to AutoCAD or Civil 3D Interested in this job? Let us know why you want to work at XXXXX, and why you would be a fit as our next Transportation Engineer (EIT).	Without exaggerating, customize your résumé to meet as many of these qualifications as you can. This employer wants to know why you think you would be a good fit. Answer this question in a few sentences in your cover letter and in the caption of your résumé. Remember, they are looking for someone who wants to work in a team, is passionate about learning, proud of becoming an engineer and has some relevant experience.

Junior Design Engineering Specialist
(Company Identity Suppressed)

Company XYZ is a tier 1 automotive supplier, located in XXXXX. We're currently looking for a JR. Desirn Engineering Specialist to join our team. If you are interested in working for a company that promotes professional development and work/life balance, we'd love to hear from you! We are a non-unionized environment that promotes internal growth; we believe in the development of our team members in order to succeed as an organization. If you are looking for an opportunity to grow with a company, look no further! **Job Summary** The Jr. Design Engineering Specialist is responsible for designing and/or modifying automotive parts in collaboration with the company's OEM customers. The team member is also responsible for creating and maintaining part and assembly documentation associated with customer projects. **This role may involve being relocated to one of the overseas plants or a Customer Engineering Centre. Countries may include USA, Mexico, Brazil, Argentina or Japan.* Duties & Responsibilities • Support senior design engineer and other engineering team members with general tasks • Continual training in design softwares (Catia, NX Unigraphics) in preparation of customer awarding design-responsible business to company • Liaison to our manufacturing facilities and customer design/engineering departments	The qualities that this company values most highly are stated up front: team orientation, professional development and employees who want to grow. Design and design documentation are key aspects of the job. Make clear your willingness to travel. Note that teamwork is stated first. Training is number two. This employer expects you to show your keenness for training. You have to know what DFMEA means. That's why they didn't spell

• Provide insight into manufacturability of products based on drawing or design • Lead and or participate in the creation of the DFMEA and incorporate necessary actions into design • Attend or lead project meetings • Manage both internal and customer open issues list for product design issues, support issue resolution to the customer timeline • Lead development projects through: creation of CAD designs, finite element analysis, 3D printing, testing of products, creation of slideshows, and presenting the findings to senior managers • Aid in activity relating to prototyping which includes understanding and running equipment in a safe and efficient manner. • Create and maintain documentation such as engineering drawings and bill of materials for customer projects • Benchmark competitor parts and assemblies through reverse engineering by purchase, disassembly, and analysis of competitor products Job Qualifications *Education* • Successful completion of a minimum 2-4 year post-secondary program; both mechanical and design engineering considered relevant • Successful completion of a bachelor of mechanical engineering/design engineering is considered an asset *Experience* • 1 – 2 years of experience using CAD design software's (Catia, NX Unigraphics) • Knowledge of the automotive industry is considered an asset *Skills and Abilities* • Maintain a high level of accuracy and attention to detail when producing CAD drawings • High level of attentiveness to analytical details and abilities when creating a drawing • Sense of creativity when working on cost/mass reducing development projects • Actively listening to team members when developing designs, and while going through training exercises with the senior design engineer • Time management skills in order to complete tasks by the required deadlines • Organizational skills; ability to manage tasks efficiently while working on several different projects • Ability to show versatility and resourcefulness when problem solving *Other* • Must have a valid driver's licence • Must be able to travel Equity, Diversity and Inclusion: Company XYZ is committed to fostering an inclusive, accessible environment where all employees and members of the public feel valued respected and supported. We are dedicated to building a workforce that reflects the diversity of the public and the communities in which we live and serve.	it out. (It means Design for Manufacture and Assembly). In your résumé describe your experience using, where possible, the highlighted words and phrases in the posting. The technical qualifications that are stated are fairly basic. Many applicants will meet the minimum technical requirements. The successful applicant will be chosen based on his or her attitudes and soft skills. When you read the 'Skills and Abilities' section carefully, you will see that almost all of the skills the company is seeking are 'soft skills' even though this is an engineering job. Your résumé has to communicate clearly that you have those skills.

Junior DevOps Engineering Specialist
(Company Identity Suppressed)

Job Overview:
As a Junior DevOps Engineering Specialist, you will work with the DevOps lead to learn how to manage the IT infrastructure that's needed to support software code in dedicated, multi-tenant or hybrid cloud environments. You may be required to provision required resources, select an appropriate deployment model, direct the testing protocol to validate release and monitor performance after release. Tasks may include preparing test data, analyzing results, troubleshooting problems and communicating issues back to development.

Your research will show that this is a mid-sized company (around 100 employees). They are looking for a broad skill-set that combines technical and non-technical skills and a high degree of versatility.

Responsibilities:

- Help develop and deploy systems within defined long-term principles and vision
- Evaluate technologies and tools for suitability to business goals and delivery capabilities
- Work closely with the lead developers and architects to learn and understand overall architectural vision and principles
- Help design and deploy systems that can scale to support exponential growth with no loss of system responsiveness or capacity
- Design and/or deliver processes to measure end-to-end system performance, and be able to act on performance issues
- Define and work towards timetables for researching, developing, and deploying systems and services
- Define development and release processes and standards (including unit, functional, and client acceptance testing)
- Work effectively as a technical team member
- Detect, report, and resolve any issues or failures
- Establish a good working relationship with team members and management to ensure that issues are escalated in a timely and appropriate manner

You need to understand the company's business goals.

Proprietary technology is the foundation of this company.

Time management skills are important. You need to show this in your résumé.

Teamwork skills are essential. You need to show this in your résumé.

Qualifications:

- A Computer Engineering or Computer Science degree or similar technical field or relevant diploma/certificate
- Ability to code and script
- Demonstrated ability to work well within technical and marketing teams as well as independently
- Strong communication, collaboration, and interpersonal skills; verbal and written
- Innovation top of mind, always
- Ability to quickly learn and master new technologies and frameworks
- Thrive in an agile, fast-paced environment

Communication skills are key in this job. You need to bridge between marketing staff and development staff. Your résumé has to show that you have good communications skills.

Innovation – they are looking for a self-starter who is creative. You need to give examples in your résumé.

Skills (not required, but would be an asset):

- Knowledge of Chef, Jenkins, Vault, Docker, Kubernetes
- Knowledge of Cloud Infrastructure: AWS, MS Azure
- MySQL or other relational database management systems
- MongoDB or other document-oriented database programs
- Ability to use a wide variety of open source technologies and tools

We are an automotive /AI/ company that helps dealers sell more cars faster.

You need to research this company and show that you understand their products.

Tip No. 2:
Learn about résumés that work.

Your résumé is the key that opens career opportunities. It is your single most important investment when you are seeking an engineering job. Learning from the experts about how to write résumés that work can be very useful.

Résumé Writing for Recent College Graduates
Presented by
The Job Network and Top Résumé
https://www.youtube.com/watch?v=X-QmJbA5C3w&feature=youtu.be
(1 hour)

How to Write an Entry Level Résumé
Dr. Christina Fisanick of California University of Pennsylvania
https://www.youtube.com/watch?v=BLSYMmB7gH4
(25 minutes)

Résumé Examples
http://www.resumeworld.ca/resume-samples/entry-level-resumes-samples/new-grad-resume.html

Check out the example on the following page.

① Mark Anderson

email address • telephone number • Toronto, ON ②
linkedin URL ③

Entry-Level Design Engineering Specialist ④

Recent mechanical engineering graduate with industry experience supporting senior engineers and working with technicians to test systems and trouble-shoot production problems. Understanding of quality control principles and translating specifications into design strategies. Experience working with AutoCad, Catia SolidWorks, statistical software and MySQL. Strong time management skills. Keen to acquire new skills. Registered Engineering Intern (EIT) with PEO. ⑤

Education ⑥

Bachelor of Applied Science (2018) (GPA 3.65/4) ⑦
XXX University
Capstone Project: our team designed a robot to inspect and service the interior of 8" to 12" pipes. ⑧

Relevant Experience

Engineering Intern — June to August, 2017
Company XYZ, Mississauga, ON
Manufacturer of components for aerospace and auto industry. ⑨

- Reviewed specifications and technical drawings. ⑩
- Checked machinery settings and calibrations.
- Worked with machine operators to reduce the number of non-forming parts. ⑪
- Administered process and quality control check lists.
- Liaised with suppliers' technical staff.

Engineering Intern — June to August, 2016
Company XYZ, Brampton, ON
Auto parts manufacturer.

- Supported design engineers in stress-testing weld joints and writing up results. ⑫
- Compared stress test results to customer specifications. ⑬
- Supported Failure Mode and Effects Analysis (FMEA) in welding processes.
- Tested and calibrated robotic welding equipment.
- Worked with technical staff to maintain machinery and trouble-shoot production problems.

Engineering Intern — June to August, 2015
Company XYZ, Markham ON
Metal parts fabricator.

- Worked in a cross-functional, multi-disciplinary team to optimize production process. ⑫
- Documented manufacturing processes.
- Performed statistical analysis.
- Contributed to evaluation of alternative machinery.

Honours ⑭

- Undergraduate Scholarships
- Engineering Society Award

Additional Experience

- Intra-mural sports, camping ⑮ ⑯

① No photo. No fancy fonts. No colour.

② Professional standard email address. One phone number.

③ URL to Linked-In profile enables recruiter to obtain more information than you can provide on a one-page resume.

④ Short precis of experience and skills. This section is always customized for each job. Important to use words and phrases from the job posting, but they must relate to the experience you subsequently describe. This example highlights: teamworking, testing, trouble-shooting and quality control experience because those were identified in the job posting. Keenness to learn new skills is important in an entry-level job.

⑤ Registering as an Engineering Intern with PEO shows commitment to the profession.

⑥ Education is usually after experience. However, for a recent grad applying for an entry-level job, you can move it up. Omit your high school.

⑦ Include GPA if it is above average and you are a recent grad. Omit if you are more than two years out of university.

⑧ For recent grads with limited experience, your capstone project is important. Limit the description to one sentence. If you are interviewed, you will likely be asked about your capstone project. You can add a URL to a description of your capstone project in your Linked-In profile. Note the reference to 'team' in the project description. This is important.

⑨ Provide a short description of what the company does, unless the companies you worked for are well known.

⑩ Always start description of what you did with an action verb.

⑪ Don't overstate your role. Experienced recruiters are turned off by resumes that exaggerate.

⑫ Demonstrate in the experience that you worked with others.

⑬ Be as concrete as possible in describing what you did.

⑭ Include relevant honours. Otherwise omit this section.

⑮ Do not include references. There is no need to indicate that you will provide references when requested. It is assumed that you will do so.

⑯ One page is best. One-and-half in length is the maximum.

Tip No. 3:
Always customize your résumé to respond to the job posting.

It is essential that your résumé (and cover letter) includes the words and phrases that are used in the job description. Often, employers use software-based systems to screen out applications that do not align with the job posting. These systems are programmed to scan your application for the key words and phrases included in the job posting. If those words and phrases do not appear in your application, you will be screened out.

Employers may receive up to 50 applications for each job posting, sometimes more. Experienced HR staff can tell the difference between someone who has taken the time to customize their application and someone who is using a boiler-plate résumé. Aligning your résumé to the job posting improves the chance of a second look.

Tip No. 4
Describe what you did.

Engineering is an applied science. Employers want to know what you did. Put the emphasis on your experience. Some companies are so fed up with résumés that do not describe what you actually did that they have replaced résumé applications with electronic forms on their web site that force you to describe what you did. Employers know that there has been a great deal of 'title inflation' , i.e., job titles that exaggerate a person's actual role. As a result, many employers no longer trust job titles. It is essential that you describe what you actually did on a project or in a job.

Tip No. 5
Don't over-sell your experience.

An engineering employer can tell almost immediately when a résumé is exaggerating a person's experience or their role in a project. Describe your experience, but describe it honestly. Employers report that over-selling is a common mistake. It often leads to a qualified candidate being screened out.

Tip No. 6
Don't under-sell your experience.

Sometimes engineering graduates under-sell their experience. Under-selling is just as serious a mistake as over-selling. Think about your experience and ask yourself what aspect of that experience would be valuable to this employer. Maybe it was meeting deadlines. Maybe it was working with tradespersons or production staff. Maybe it was supporting someone else. All experience is useful. All experience has value.

Tip No. 7:
Describe your non-technical skills.

It is a common mistake for engineering graduates to under-value or even ignore non-technical skills. Every job posting describes the non-technical skills that the company values when hiring engineering graduates. They put those non-technical skills in the job posting for a reason.

You should assume that, in addition to you, the company will receive several other applications from candidates whose technical skills are equal to yours. Quite often, the selection of a successful applicant is based on perceived differences in their non-technical skills. Employers regularly report that 'A' and 'B' could both do the job, but 'A' will 'fit in' better because he or she seems like a better team worker or demonstrated a greater keenness to learn.

Re-read the job posting to identify the non-technical skills. Include a concise description of the non-technical side when you describe your work experience.

Tip No. 8:
Describe your capstone project in a way that relates to the job posting.

Employers are interested in your capstone project, i.e., your major final year project. It tells them what you are passionate about. If you are a recent graduate, you will almost always be asked about your capstone project in your interview. If your capstone project relates in any way to the skills in the job posting, be sure to include a short description of the project and why you chose it.

Tip No. 9:
Become an Engineering Intern (EIT)

Employers look for engineering graduates who are keen to be professional engineers. One way to demonstrate your commitment is to become an Engineering Intern (EIT). Other things being equal, many employers will choose a recent graduate who has registered as an EIT over one who has not.

http://www.peo.on.ca/index.php?ci_id=2064&la_id=1

Tip No. 10:
Join the Ontario Society of Professional Engineers (OSPE).

Joining the Ontario Society of Professional Engineers tells employers that you are committed to an engineering career. There are also other important benefits: networking opportunities with other engineers, discounts on professional development courses and access to OSPE's proprietary salary survey.

https://www.ospe.on.ca/join

Tip No. 11
Join a Technical Association

Joining an engineering technical association tells employers that you are keen to learn and that you are committed to your engineering career. The conferences and seminars that are run by the technical associations can also be useful networking opportunities.

Canadian Geotechnical Society http://www.cgs.ca/	
Canadian Medical and Biological Engineering Society https://www.cmbes.ca/	
Canadian Nuclear Society https://www.cns-snc.ca/home	
Canadian Society for Bioengineering https://www.csbe-scgab.ca/	
Canadian Society for Civil Engineering https://csce.ca/	
Canadian Society for Chemical Engineering https://www.cheminst.ca/	
Canadian Society for Engineering Management http://www.csem-scgi.org/	
Canadian Society for Mechanical Engineering http://www.csme-scgm.ca/	
Institute of Electrical and Electronics Engineers – Canada	

https://www.ieee.ca/en/

Institute of Industrial and Systems Engineers – Canada
http://www.iise.org/Details.aspx?id=13558

Tip No. 12
Demonstrate your keenness to learn.

Employers do not expect a recent engineering graduate to have fully developed technical skills. Employers report that they are often looking for recent engineering graduates who are keen to learn and who are passionate about engineering. This is especially true for large employers. They are looking for evidence of this keenness to learn in your résumé. You can demonstrate that by commenting on what your learned in each job or assignment. Joining engineering technical associations and taking courses demonstrates a keenness to learn. In this resource, we have listed a number of courses that you might consider. Employers are especially positive about candidates who demonstrate that they are learning about subjects outside their specialization.

Tip No. 13
Learn about the company.

Employers expect you to have learned at least the basics about their company and to reflect some of that knowledge in your job application. No employer is interested in an applicant who has not taken the time to investigate the company and its technologies. The place to show that you have investigated the company is in your cover letter.

Tip No. 14
Small companies are good experience. They also have different skill needs.

For recent graduates, the advantage of a small company is that you will get a broad range of experience that will support you as you advance in your career. You will also likely have more responsibility for assignments and projects than in a large company. However, it is important to recognize that small companies are different. They often look to hire a different type of person:

- Small companies need people who are quick learners. If you can demonstrate that in your résumé, you will be a strong candidate.
- Small companies need people who can multi-task and who are multi-skilled. If you can demonstrate adaptability in your résumé, you will be a strong candidate.
- Small companies value an entrepreneurial attitude. They usually assign a high value to any type of business experience that is entrepreneurial.
- Most small companies weed out candidates who have not taken the time to do any research on the company.

- When the job posting lists a required technical skill or type of experience, that is non-negotiable. If you do not have that skill or experience, the company will not follow up on your application.
- Experience of any kind in the same industry ("domain experience") is an extremely strong advantage.

Tip No. 15
Include extracurricular experience that you can relate to the "soft skills" the company is seeking.

Your extracurricular experience is relevant only if it illustrates the soft skills that the company is seeking, e.g., team working ability, leadership, problem-solving, ability to relate to customers, *etc.* Only include extracurricular activities that relate to the soft skills identified in the job posting.

Tip No. 16
Keep your résumé short: 1 to 2 pages.

A one-page résumé is ideal, but it is often difficult to get all of the information on one page. However, more than two pages is too long. Résumés that are longer than two pages have a high failure rate.

Tip No. 17
Create an On-Line Portfolio

Creating a portfolio has four benefits. First, it helps you focus on the aspects of your qualifications and experience that are most relevant to employers. Second, it makes you stand out from the crowd. Not everyone has an on-line portfolio. Third, it enables employers and search firms to find you. And fourth, when you go to an interview, you can give the company a hard copy of your portfolio. A good portfolio typically includes:

- A bio page, which summarizes your strengths, education, professional and technical association memberships and recognitions.
- Your résumé.
- Concise information about your coursework, internships, volunteer work, language proficiency, hobbies, and other things that set you apart from the crowd.
- A short description of your capstone project.
- Examples of work-related and other projects you've worked on.
- Evidence of your non-technical skills. This applies to personal accomplishments too. For example, instead of just stating that you ran a marathon, discuss the self-discipline and hard work needed to train for the event.

Your portfolio should be hosted online, so you can include it on your résumé and LinkedIn profile or any other materials you're submitting with your application.

Tip No. 18
No mistakes in the résumé or cover letter.

Some employers pay no attention to a typo. Others interpret typos in a résumé as evidence that your are careless.

Tip No. 19
Learn good interviewing techniques.

Most YouTube videos on interview techniques are promotion pieces for consultants. They are of little value. Consider taking an online course:

Successful Interviewing
University of Maryland
Coursera
https://www.coursera.org/learn/successful-interviewing
(5 classes)

Advanced Interviewing Techniques
University of Maryland
Coursera
https://www.coursera.org/learn/interview-techniques
(5 classes)

How to Succeed at Interviews
University of Sheffield (UK)
(Fee-based Upgrade Available)
https://www.futurelearn.com/courses/interviews
(3 weeks / 3 hours per week)

Tip No. 20
Prepare for situational or behavioural questions.

Many companies use situational or behavioural questions in their interviews. They do this to identify personality traits or attitudes which are important to the company. Many job applicants handle these questions poorly because they have not prepared for them. Here are some typical situational or behavioural questions:

- Give an example of an occasion when you used logic to solve a problem.
- Give an example of a goal you reached and tell us how you achieved it.
- Give an example of a goal you didn't meet and why.
- Describe a stressful situation at work or in your university studies and how you handled it.

- Tell us about how you work when you are under pressure.
- Have you been in a situation where you didn't have enough work to do? What did you do?
- Have you ever made a mistake? How did you handle it?
- Describe a decision you made that was unpopular and how you handled implementing it.
- Have you gone above and beyond the call of duty? If so, how?
- When you worked on multiple projects how did you prioritize?
- How did you handle meeting a tight deadline?
- Give an example of how you set goals and achieve them.
- What do you do when your schedule is interrupted? Give an example of how you handle it.
- Have you had to convince a team to work on a project they weren't thrilled about? How did you do it?
- Give an example of how you've worked on a team.
- Have you handled a difficult situation with a co-worker or fellow student? How?
- Give an example of what you did when you disagreed with a co-worker or with a fellow student on a project?
- Do you listen? Give an example of when you did or when you didn't listen.
- Have you handled a difficult situation with a supervisor? How?

Notice, that these questions almost always ask for an example.

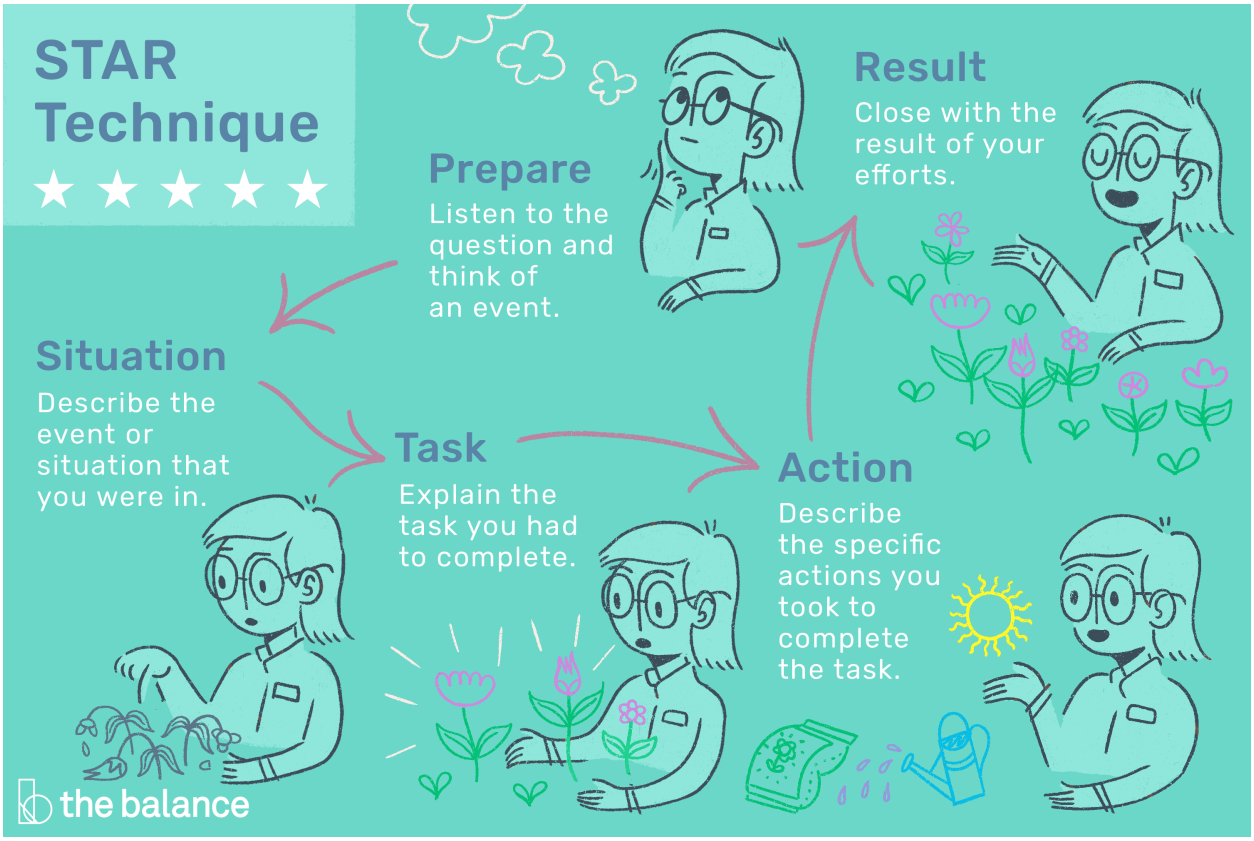
Many interviews use what is called the STAR method:

S=Situation:
Describe the situation that you were in or the task that you needed to accomplish. You must describe a specific event or situation, not a generalized description of what you have done in the past. Be sure to give enough detail for the interviewer to understand. This situation can be from a previous job, from a volunteer experience, or any relevant event.

T=Task:
What goal were you working toward?

A=Action:
Describe the actions you took to address the situation with an appropriate amount of detail and keep the focus on what you did. What specific steps did you take and what was your particular contribution? Be careful that you don't describe what the team or group did when talking about a project, but what you actually did. Use the word "I," not "we" when describing actions.

R=Result:
Describe the outcome of your actions and don't be shy about taking credit for your behaviour. What happened? How did the event end? What did you accomplish? What did you learn? Make sure your answer contains multiple positive results.



https://www.thebalancecareers.com/behavioral-job-interview-questions-2059620

Interview Techniques – The STAR Method
https://www.youtube.com/watch?v=0nN7Q7DrI6Q

Tip No. 21
Prepare some questions that you want to ask.

At the end of an interview, you will usually be invited to ask the interviewers some questions. Not asking any questions implies a lack of interest in the job or the company. Consider asking these questions:

- What would my first priority be in this job?
- How will success be measured?
- What can you tell me about the team I will be working with?
- What do you think are the most important qualities for someone to excel in this role?
- What are the next steps in the interview process?

Tip No. 22
Write a cover letter.

Some employers do not read cover letters. Other employers expect a cover letter. Your cover letter should be short – about half a page or 300 words is ideal.

A cover letter is your opportunity to communicate your strongest qualification for the job you are seeking.

1. Express interest in a specific position (maximum one sentence each):
    - List the title of the position to which you are applying.
    - Explain how you learned of the position.
    - State (briefly) how you believe your skills will fit well with the job.
2. Provide details regarding your relevant experience, applicable to the job:
    - Summarize your relevant professional background and years of experience.
    - Describe key responsibilities in your current or past position.
    - List skills that directly apply to requirements pulled out of the job listing.
    - Include soft skills such as management or teamwork that may be applicable to the role.
3. Encourage further communication (maximum one sentence each):
    - Express excitement in the position and that you're interested in learning about the next steps in the hiring process.
    - Mention that your résumé is enclosed and that you are happy to provide additional information.
    - Thank them for their consideration.

Tip No. 23
Write a follow-up letter – usually a short email.

Who doesn't like appreciation? This is your opportunity to thank the employer for taking the time and opportunity to discuss the role with you. You can do it with a short email, about 150 words or less, including:

- A specific item of interest they brought up during the interview, to indicate your commitment.
- How a specific aspect of your experience (perhaps the one the interviewers spent the most time discussing) aligns with this job.
- Any follow-up, e.g. if the interviewer asked you for further information.
- Your desire to hear from them at the next stage of the timeline, as determined during interview.

Tip No. 24
Check your electronic footprint. Clean it up, if necessary.

Many employers will do a web search to learn about who you are. It is important that you check your electronic footprint and clean up anything that might suggest a lack of maturity.

Tip No. 25
Join an Engineering Society at your University

A good way to show that you have the leadership skills and the commitment to engineering that many employers prize is to participate in your university's engineering society. ESSCO is the federation of Ontario student engineering societies. Check out their website.

ESSCO: http://www.essco.ca/

Appendix: Companies and Organizations Interviewed

- Accelerated Systems Inc.
- ArcelorMittal Dofasco
- Automotive Fuel Cell Corporation (AFCC)
- BorgWarner
- Canadian Hydrogen Fuel Cell Association (CHFCA)
- Canadian Urban Transit Research and Innovation Consortium (CUTRIC)
- eCAMION Inc.
- General Motors Canada
- Honda Canada Manufacturing (HCM)
- Magna International
- Miovision Technologies Inc
- Overdrive Fuel Cell Engineering Inc.
- Textron

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