29 SEPTEMBER 2022

Canadian Robotics Landscape and SWOT Analysis

Canada's Robotics Ecosystem

PREPARED FOR:

CANADIAN ROBOTICS COUNCIL
CONSEIL CANADIEN DE LA ROBOTIQUE

In late 2020, Avascent was contracted by ISED and the CSA to undertake an analysis of the current state of Canada's robotics sector

1 | *Project Background*

- Project focus was identifying domestic firms & capabilities, including regionalization, areas of differentiation, and situating Canada's domestic industry

- The project took place over a six-week period from mid-November to the end of December 2020

2 | *Objective*

- The objective of this project was to analyze the Canadian robotics industry, research/academic institutions, and government actors

- This project built upon a prior 2019 analysis conducted by Avascent for ISED on the global industrial landscape for space robotics

3 | *Analysis*

- Avascent identified hundreds of firms, academic institutions, and other organizations operating within Canada's robotics ecosystem

- Organization data was captured while capabilities were tracked and mapped into market segments, robotic classifications, and archetypes developed by Avascent

- Canadian capabilities were situated within international trends

Avascent has developed a working definition and segmentation of robotics

Definitional Challenges

Defining what constitutes a robotic system is an ongoing challenge in the industry and Avascent has focused on...

- **Broadly capturing the robotics industry**, but not so broad to reduce its analytical value

- Ensuring that **segments are clear and logical** to support a comprehensive framework

- Actively supporting the **development of actionable analysis**

Discussion

Keeping these challenges in mind, Avascent evaluated the organizations in Canada's robotics industry by:

- The **end market** that they serve (e.g., consumer, civil, etc.)

- The **programming or autonomous complexity** (e.g., pre-programmed, teleoperated, etc.) they have

- Their **position along a value chain** for manufacturers (e.g., effector, power, propulsion, etc.)

Which should act as a holistic framework to evaluate Canada's whole robotics industry, **offering insight into areas of differentiation** as well as their position both within robotics and in relation to other key Canadian industries

Avascent's Working Definition

Robotics includes the engineering and technical disciplines for the productive capacity and operating know-how necessary to **design and use physical machines that sense, think, and/or act to replace, supplement or enhance human tasks**

Sources: IEEE, Learn.g2.com, EU Robotics, Consortium on Cognitive Science Instruction, and the University of Toronto Robotics Institute

The Canadian robotics industry can be segmented into nine user markets…

Market	Definition
Consumer	• Robotics for **domestic use, transportation, education supplement, or entertainment** (e.g., autonomous vehicles, robotic vacuums, teaching assistants, or consumer drones)
Civil	• Robotics used for civil applications including **infrastructure services**, **policing services, and emergency services** (e.g., urban cleaning robots and search & rescue field robots)
Commercial	• Robotics used in commercial applications such as in **oil & gas, utilities, mining, and office automation** (e.g., traversing dangerous environments, office cleaning, etc.)
Logistics & Transport	• Used to automate the **storing and moving goods as they move through supply chains** (e.g., automated guided vehicles for warehouses and delivery robots)
Military & Security	• Commonly used in **dangerous environments** (e.g., explosives scouting) or to **augment human skills** (e.g., exoskeletons for soldiers)
Industrial & Manufacturing	• Commonly **automated, programmable robotic arms performing repetitive tasks** at high rates of speeds (e.g., welding, painting, assembling, inspecting, and testing)
Healthcare & Medical	• Robots used in environments such as **hospitals and rehabilitation centers** (e.g., robotic arms used during surgeries as well as exoskeletons for recovery or prosthetics)
Agriculture	• Robotics used for agricultural purposes, commonly used to **automate slow, repetitive, and dull tasks for farmers** (e.g., fruit picking robots and driverless crop sprayers)
Other	• Other robotic applications not captured by the preceding categories (e.g., research robots, etc.)

AVASCENT

…And classified into five different categories of autonomy or complexity

Type	Definition
Autonomous	• Operate independently of humans, the **robotic system determines environmental changes and adapts** – often used in mixed human-robotic environments • Examples: household robotic vacuum cleaners and unmanned aerial vehicles
Collaborative	• Robots that safely **work alongside humans in shared, collaborative workspaces** – designed with safety as a top priority • Example: robotic arms performing inspections alongside humans on an assembly line
Teleoperated	• **Controlled remotely by human beings**, taking commands from operators and executing tasks precisely how they are instructed • Example applications: robotics used in medical surgeries and the Canadarm3 in space
Augmenting	• Augmenting robots are those that can be **connected directly to the human body** • Commonly used to enhance user's natural skill (e.g., extend reach) and replacing skills that have been lost (e.g., robotic prosthetic arms)
Pre-Programmed	• Used in controlled environments **isolated from humans to execute programmed tasks** – incapable of changing behaviour or being guided by humans while operating • Example application: robotic arms used on automotive assembly lines

Complexity (HIGH → LOW)

Sources: IEEE, EU Robotics, Consortium on Cognitive Science Instruction, International Federation of Robotics

AVASCENT

CANADIAN ROBOTICS LANDSCAPE AND SWOT ANALYSIS | PREPARED BY AVASCENT FOR THE **CANADIAN ROBOTICS COUNCIL** 2022 SYMPOSIUM | 5

There are over 305 companies and 105 academic research labs that comprise Canada's robotics sector

*Source: Invest in Ontario
[†] Source: Regroupement des Entreprises en Automatisation Industrielle (REAI)

Western Canada

Specializes in logistics and agriculture, with **concentration on RPAS and teleoperated systems**

British Columbia

Industry is growing rapidly (e.g., 51% is under < 10 years) and **specializes in teleoperated and autonomous applications for commercial markets**

Legend

Highest # of companies	**1**	# of academic labs
Lowest # of companies	1	# of companies
		Most common market application

Quebec

Home to 7,500 robots[†] and **~22% of Canada's robotic software companies** with one-third of firms headquartered in Montreal

10
43

15
15

1
4

2
11

44
155

27
66

2
3

3
1

2
7

Ontario

Clustered in Toronto/Mississauga and Kitchener/Waterloo with the **automotive sector driving 57% of robotics demand*

Key

Commercial market
Agriculture market
Industrial market

AVASCENT

Nearly half of all Canadian robotics firms are headquartered in the Greater Toronto, Montreal, and Vancouver metropolitan areas

Top Cities of Canada's Robotics Sector*

*Note: Statistics Canada 2016 Census Metropolitan Areas (CMA) were used to segment robotics firms' headquarter locations.
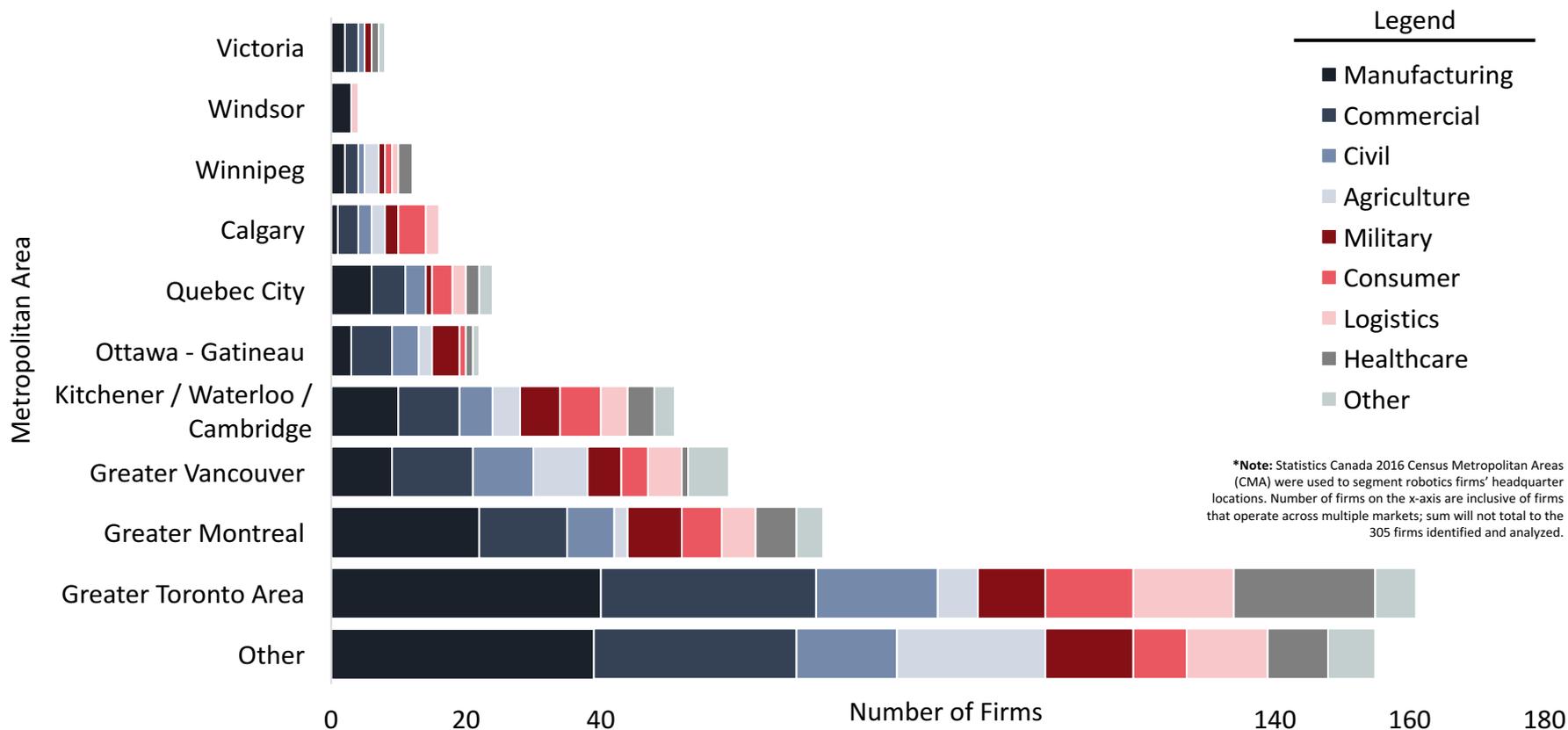
Metropolitan Area	Number of Firms
Victoria	4
Windsor	4
Winnipeg	7
Calgary	8
Quebec City	9
Ottawa - Gatineau	13
Kitchener / Waterloo / Cambridge	24
Greater Vancouver	34
Greater Montreal	43
Greater Toronto Area	74
Other	85
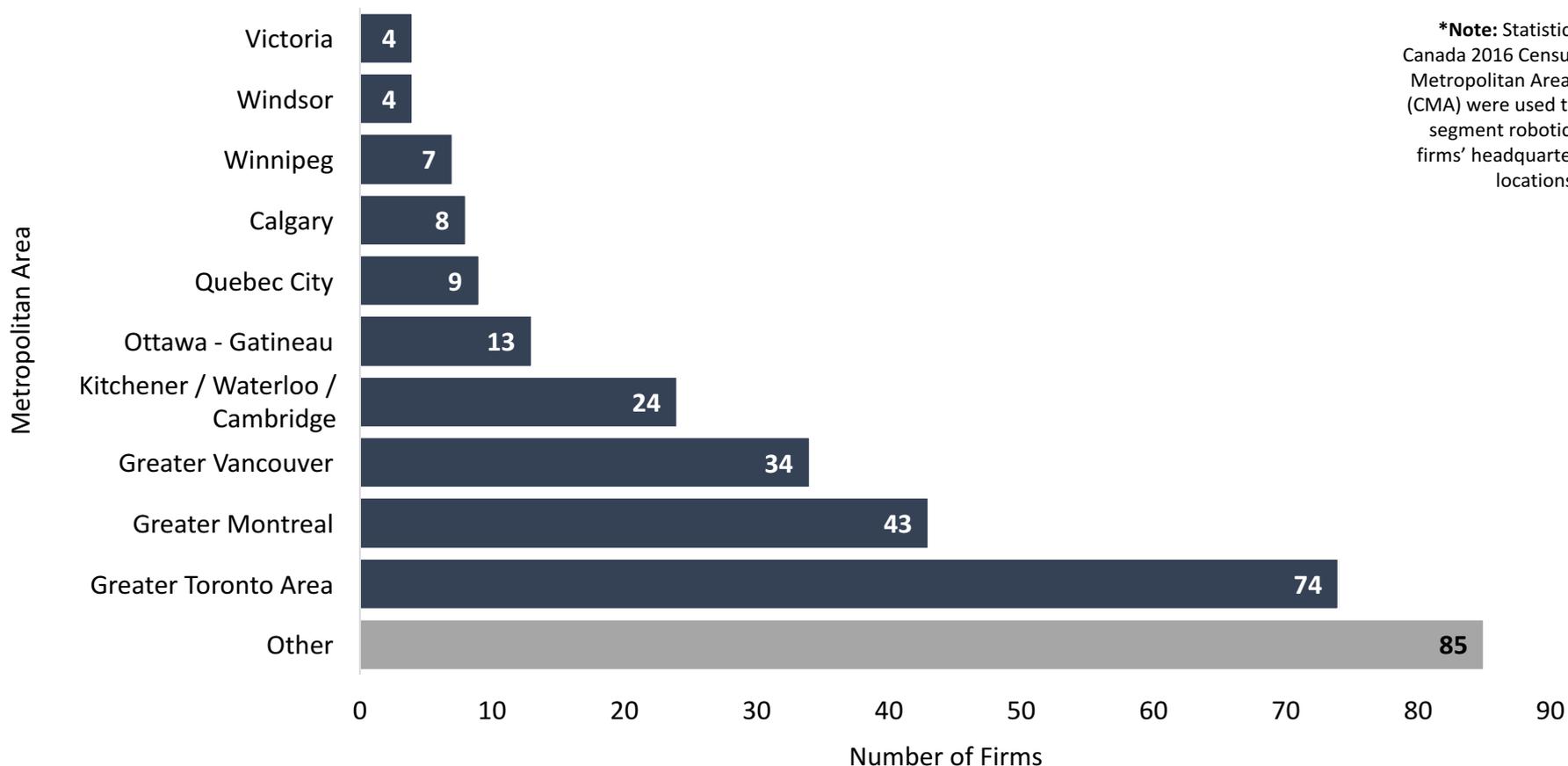
The Toronto and Kitchener / Waterloo / Cambridge areas demonstrate a high density of robotics firms which represents ~32% of Canada's total industry

On average, Canadian robotics firms serve 1.9 end markets, with the manufacturing and commercial markets representing 43% of industry focus
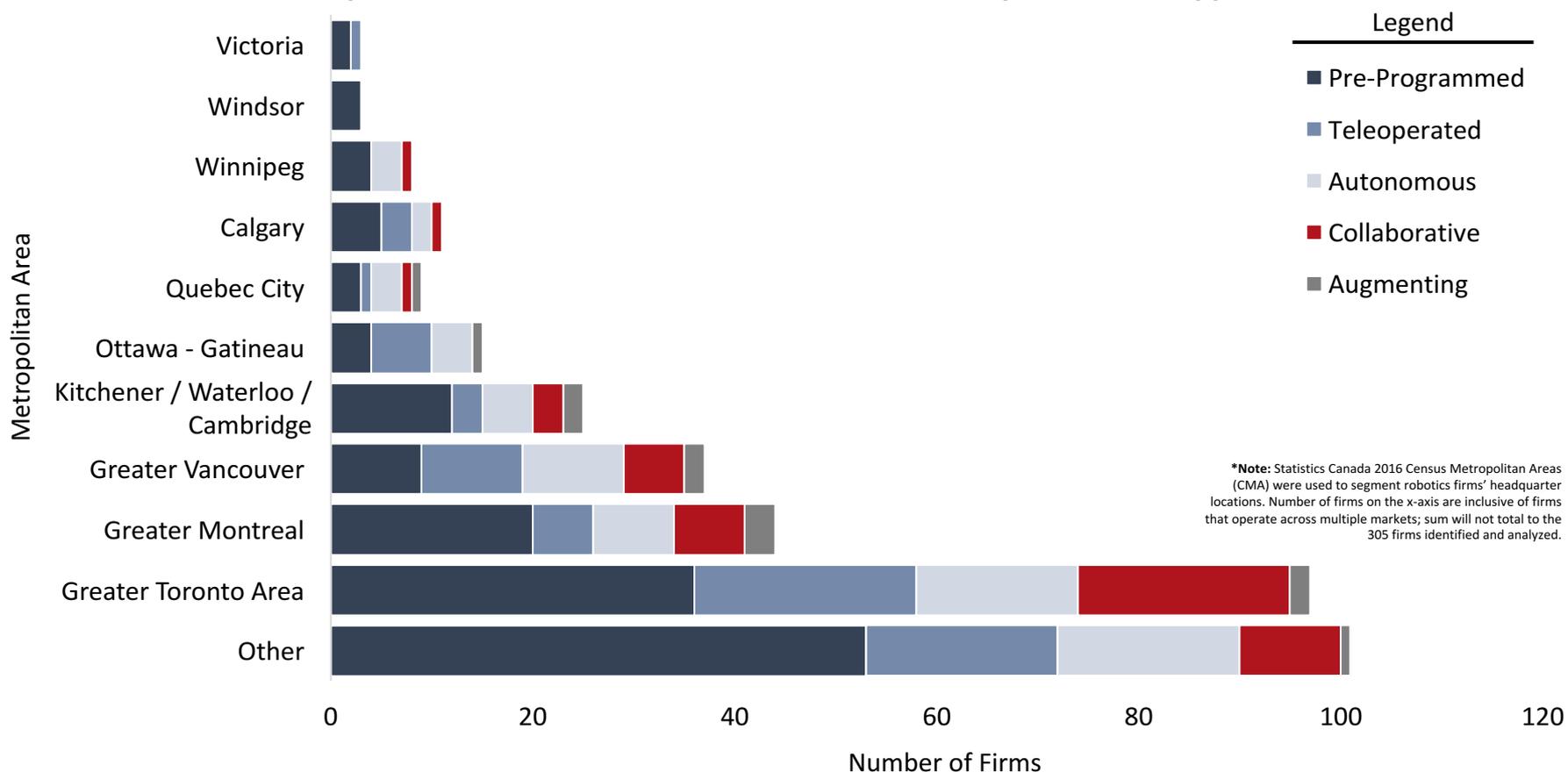
Top Cities of Canada's Robotics Sector by Robotic Market*

Legend

- ■ Manufacturing
- ■ Commercial
- ■ Civil
- ■ Agriculture
- ■ Military
- ■ Consumer
- ■ Logistics
- ■ Healthcare
- ■ Other

*Note: Statistics Canada 2016 Census Metropolitan Areas (CMA) were used to segment robotics firms' headquarter locations. Number of firms on the x-axis are inclusive of firms that operate across multiple markets; sum will not total to the 305 firms identified and analyzed.

Firms located in robotic clusters (e.g., Toronto, Kitchener / Waterloo / Cambridge) demonstrate above average capabilities in terms of their number of markets served

AVASCENT

About a dozen Canadian firms offer three or more types of robots to their customers, while the industry averages 1.2 robot types offered per firm
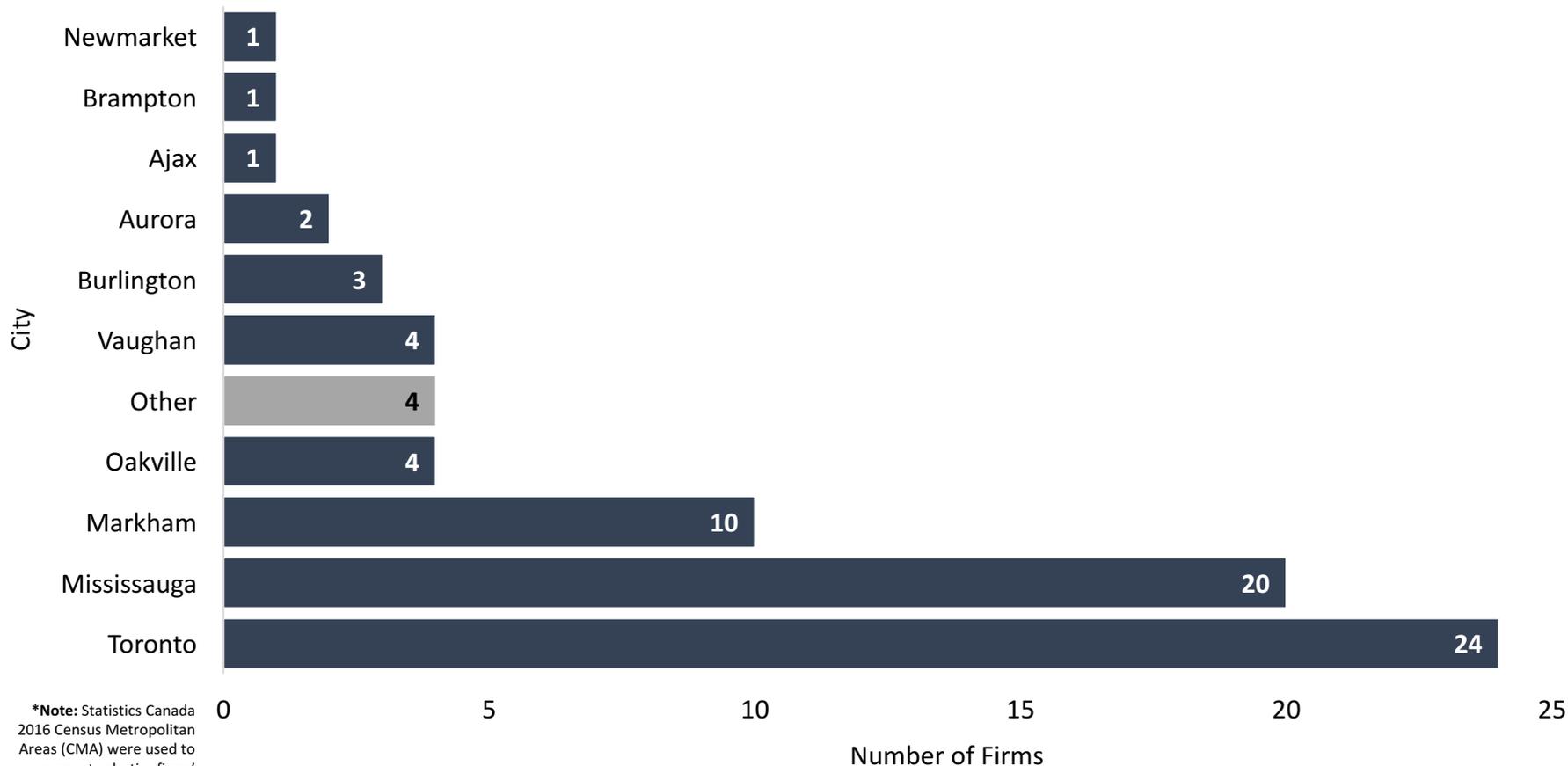
Top Cities of Canada's Robotics Sector by Robotic Type*

Legend

- Pre-Programmed
- Teleoperated
- Autonomous
- Collaborative
- Augmenting

*Note: Statistics Canada 2016 Census Metropolitan Areas (CMA) were used to segment robotics firms' headquarter locations. Number of firms on the x-axis are inclusive of firms that operate across multiple markets; sum will not total to the 305 firms identified and analyzed.

Pre-programmed robotic solutions comprise 43% of industry offerings and are often serving industrial and manufacturing customers in Ontario and Quebec
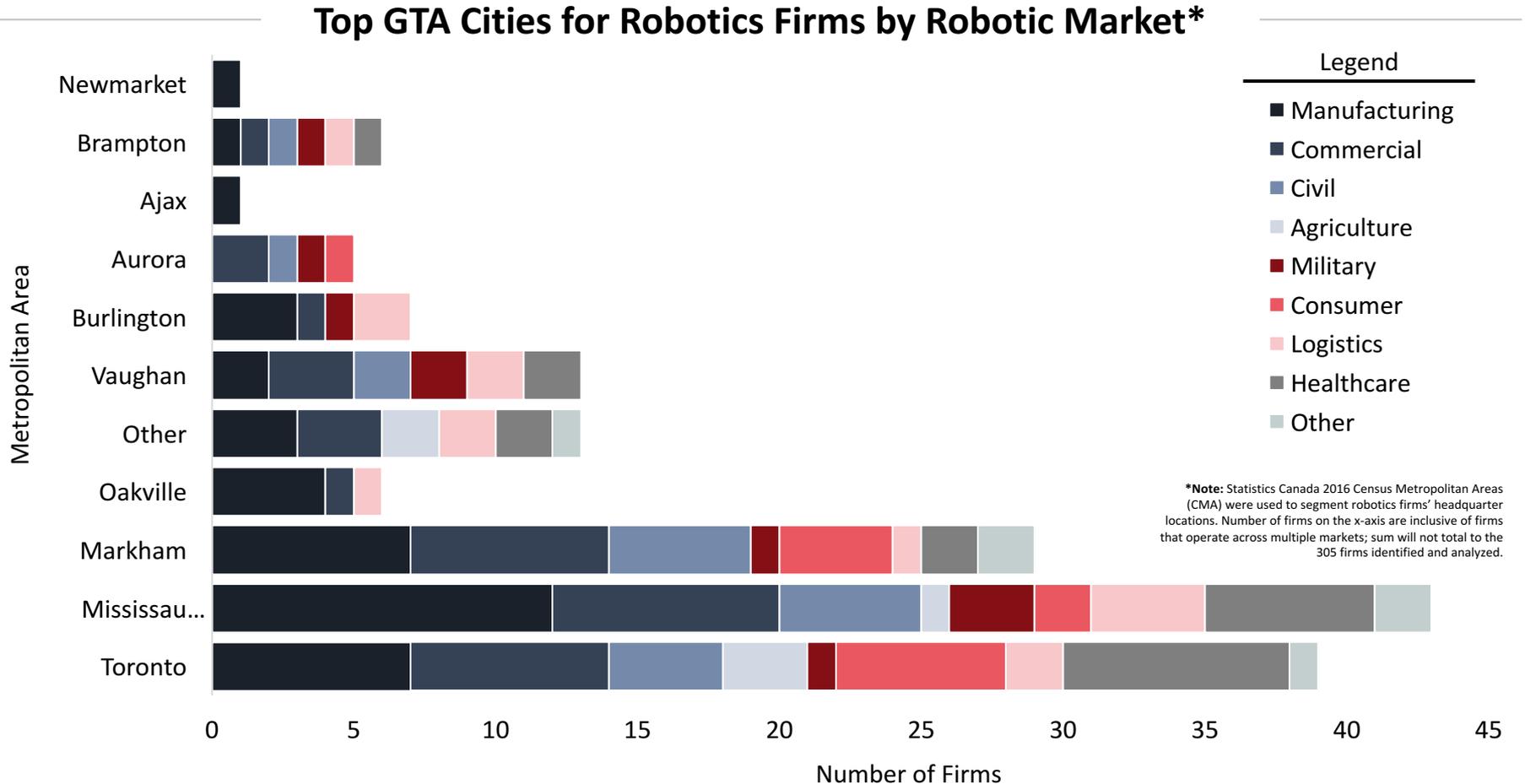
AVASCENT

Within the Greater Toronto Area (GTA), over 59% of robotics firms are located in the City of Toronto and Mississauga

Top GTA Cities for Robotics Firms*

*Note: Statistics Canada 2016 Census Metropolitan Areas (CMA) were used to segment robotics firms' headquarter locations.

On a robotics company per capita basis, Aurora and Markham demonstrate a high density of firms (~2.4x multiple) compared to the industry average within the GTA
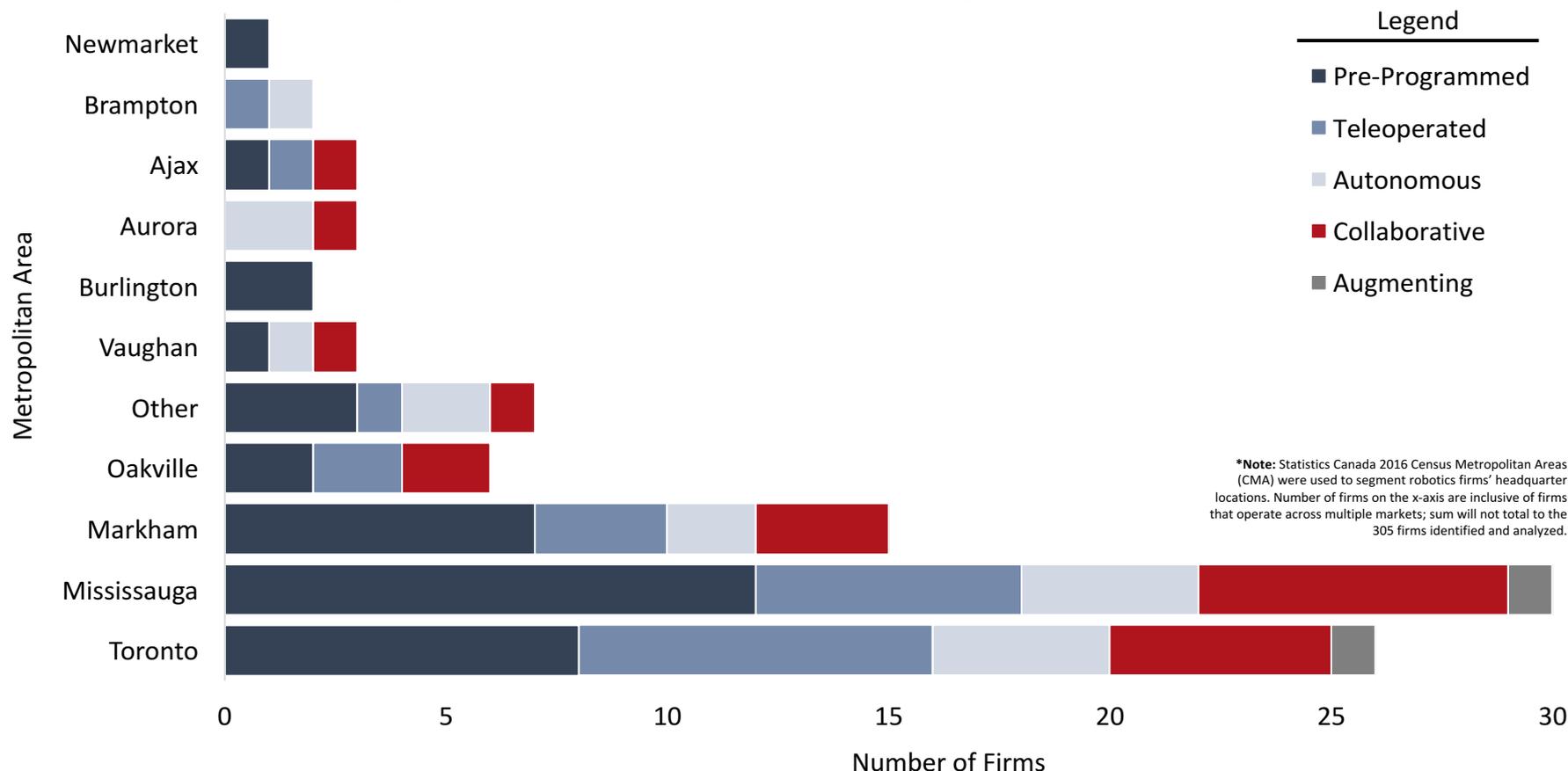
GTA firms serve more markets than the average Canadian firm which may be attributed to their closer proximity to more customers, suppliers, & skilled labour

Top GTA Cities for Robotics Firms by Robotic Market*

Legend
- Manufacturing
- Commercial
- Civil
- Agriculture
- Military
- Consumer
- Logistics
- Healthcare
- Other

*Note: Statistics Canada 2016 Census Metropolitan Areas (CMA) were used to segment robotics firms' headquarter locations. Number of firms on the x-axis are inclusive of firms that operate across multiple markets; sum will not total to the 305 firms identified and analyzed.

Nearly 45% of Canadian firms offering robots for healthcare and medical applications operate out of the GTA, with large concentrations in Toronto and Mississauga

Companies in the GTA demonstrate strong product and service offerings across all robotic types, with the exception of augmenting solutions
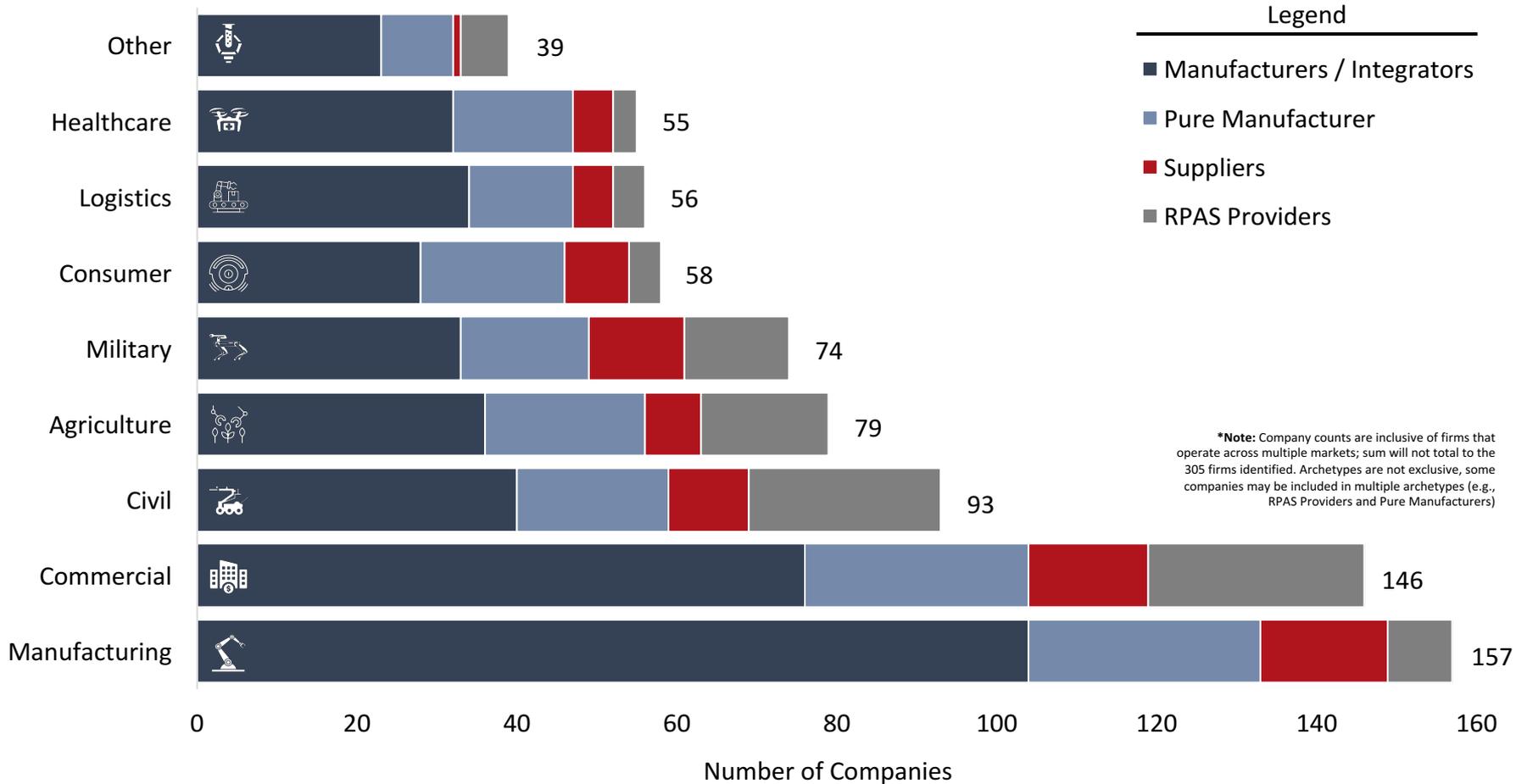
Top GTA Cities for Robotics Firms by Robotic Type*

Legend
- Pre-Programmed
- Teleoperated
- Autonomous
- Collaborative
- Augmenting

(Vertical axis label: Metropolitan Area. Cities from top to bottom: Newmarket, Brampton, Ajax, Aurora, Burlington, Vaughan, Other, Oakville, Markham, Mississauga, Toronto. Horizontal axis: Number of Firms, 0 to 30.)

*Note: Statistics Canada 2016 Census Metropolitan Areas (CMA) were used to segment robotics firms' headquarter locations. Number of firms on the x-axis are inclusive of firms that operate across multiple markets; sum will not total to the 305 firms identified and analyzed.

Many (42%) of the firms that provide collaborative robots are headquartered in the GTA, applications range from manufacturing, commercial, healthcare, and civil use cases

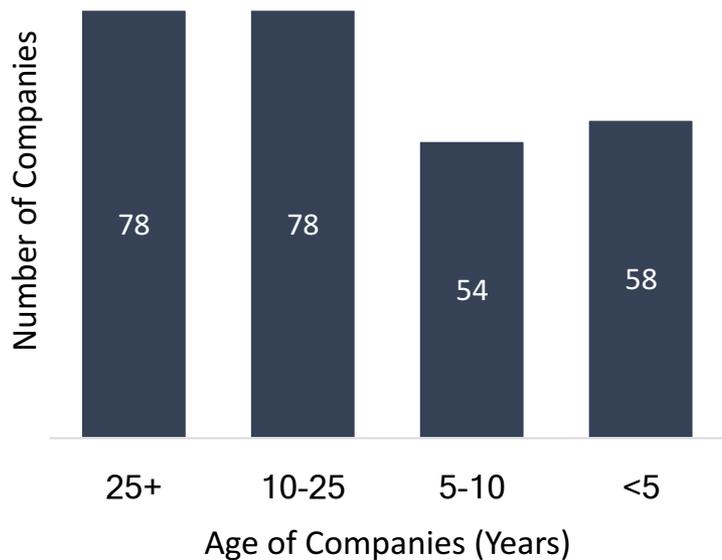# Robotic manufacturers / integrators are the largest (identifiable) segment of firms across all major markets
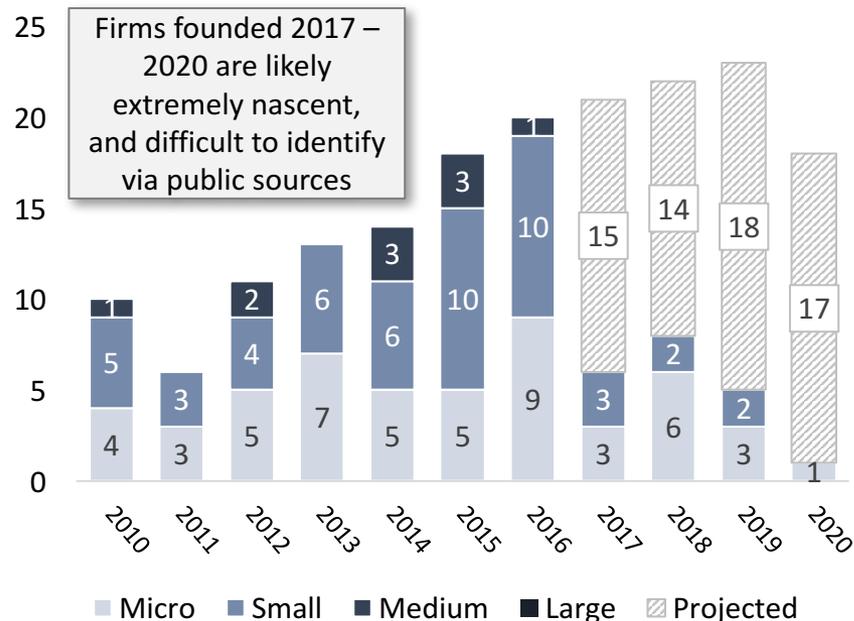
Robotics Archetypes by Market*

Legend
- Manufacturers / Integrators
- Pure Manufacturer
- Suppliers
- RPAS Providers

Market	Number of Companies
Other	39
Healthcare	55
Logistics	56
Consumer	58
Military	74
Agriculture	79
Civil	93
Commercial	146
Manufacturing	157

Number of Companies

*Note: Company counts are inclusive of firms that operate across multiple markets; sum will not total to the 305 firms identified. Archetypes are not exclusive, some companies may be included in multiple archetypes (e.g., RPAS Providers and Pure Manufacturers)

Canada's manufacturers and integrators may be threatened by supply chain challenges, the commoditization of robotics, and slow domestic industry adoption rates

AVASCENT

42% of Canada's robotics industry was founded within the last 10 years, indicating potential momentum for future growth
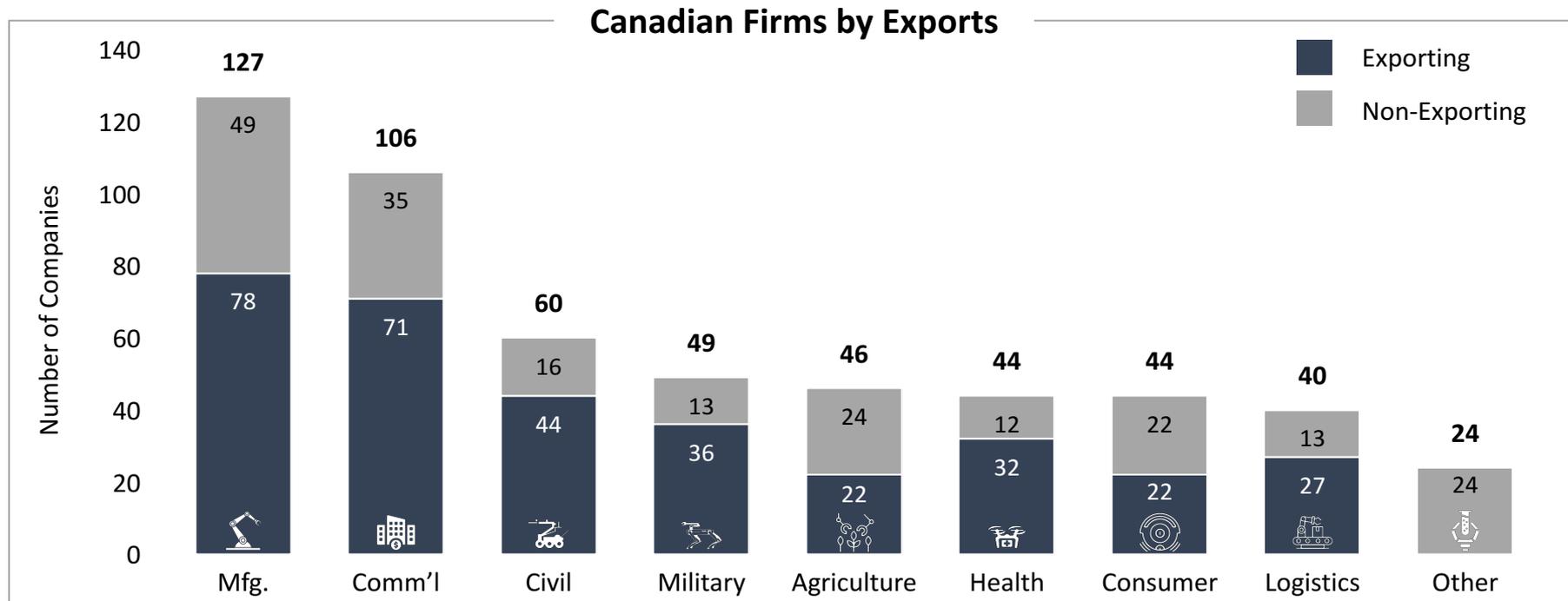
Age of Canadian Robotics Firms (in 2020)

Number of Companies

| 78 | 78 | 54 | 58 |

Age of Companies (Years): 25+, 10-25, 5-10, <5

Canadian Robotics Snapshot, 2010 – 2020*

Firms founded 2017 – 2020 are likely extremely nascent, and difficult to identify via public sources

Legend: Micro, Small, Medium, Large, Projected

Discussion

- **88% of the 305 firms from Canada's robotics sector** are domestically owned

- There were **44% more firms founded between 2010 and 2020 than in the 15 years prior**

- However, **fewer startups are scaling** to medium-size or above; those that do are growing slower than firms in previous decades

AVASCENT

The robotics sector is a clear champion of Canadian ingenuity, with more than 58% of firms having exported abroad
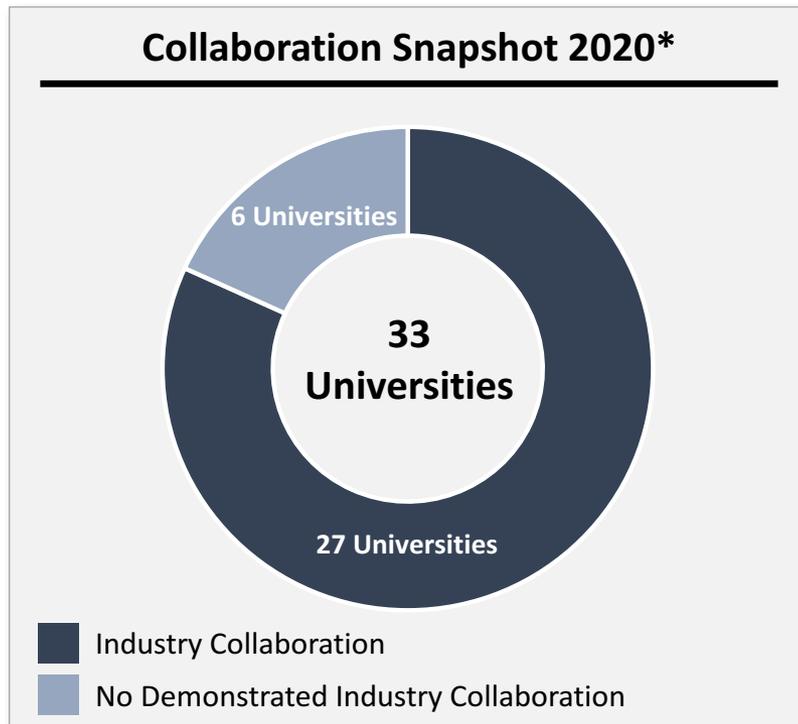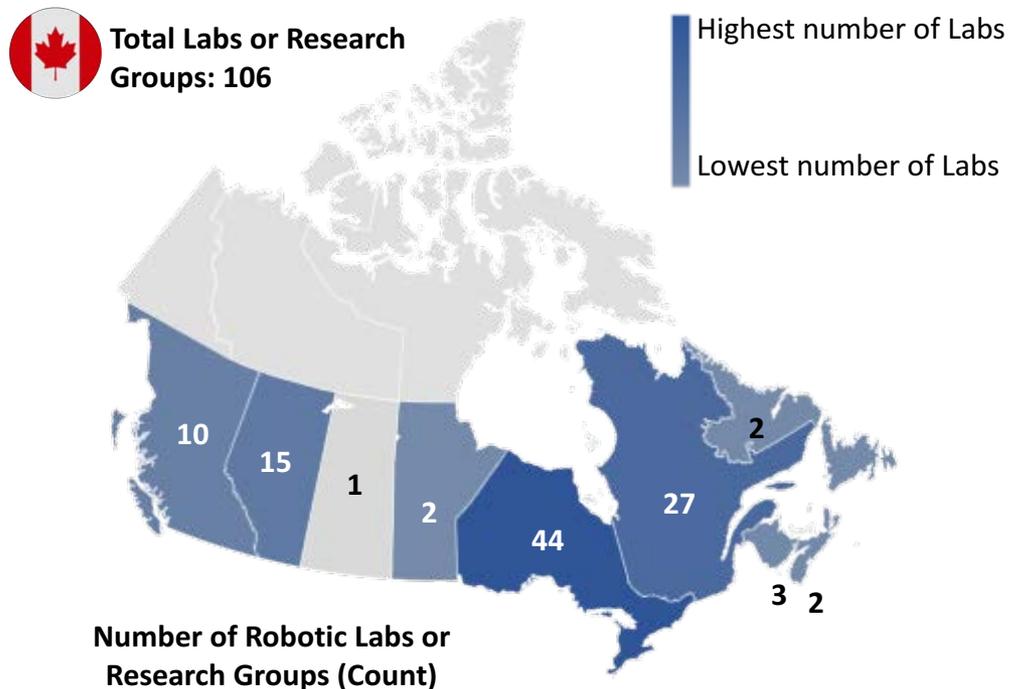
Canadian Firms by Exports

Legend:
- Exporting (dark)
- Non-Exporting (grey)

Y-axis: Number of Companies (0 to 140)

Category	Exporting	Non-Exporting	Total
Mfg.	78	49	127
Comm'l	71	35	106
Civil	44	16	60
Military	36	13	49
Agriculture	22	24	46
Health	32	12	44
Consumer	22	22	44
Logistics	27	13	40
Other	—	24	24

*Source: 2018 data from Statistics Canada   †Source: International Federation of Robotics, World Robotics 2020 Report

Discussion

- Canadian robotics companies are globally competitive, **176 firms demonstrated export sales**, well above the Canadian average of 0.7%*

- **Canadian firms are reliant on exports for success**, due to nascent state of domestic customer base for robotics (e.g., more than 101 micro/small firms in Canada show evidence of export activity)

- Canada's **peers are adopting robotics at an accelerated rate** (e.g., Canada ranked 12th of 15 for annual robotic installations in 2019, ahead of only Thailand, Poland, and Czech Republic†)

Industry momentum comes from a robust academic sector, which spans over 105 research labs and groups, at 33 universities in 9 provinces

Total Labs or Research Groups: 106

Highest number of Labs

Lowest number of Labs

10
15
1
2
44
27
2
3 2

Number of Robotic Labs or Research Groups (Count)

Collaboration Snapshot 2020*

6 Universities

33 Universities

27 Universities

- Industry Collaboration
- No Demonstrated Industry Collaboration

Discussion

- Ontario and Quebec are home to multi-disciplinary robotic institutes which **facilitate collaborative R&D** at leading universities (e.g., University of Toronto, Waterloo, McGill University)

- Robotics researchers based in **Toronto, Montreal, and Edmonton benefit from their proximity to Canada's three national AI institutes;** and many leading firms originated from academic institutions (e.g., Clearpath Robotics, Mecademic)

Strong Opportunities and Strong Challenges

STRENGTHS

- Strong academia-industry collaboration has created a **robust start-up community and talent pipeline**

- Canada is well positioned in Agriculture and Healthcare segments via differentiated capabilities or early adopters who could become market leaders

- Recently founded firms (2010 - 2020) are **strongly aligned with future trends** (e.g., prioritizing collaborative or autonomous applications)

WEAKNESSES

- **Lack of domestic robotics customer base** (i.e., Canada ranked 18th of the top 20 economies for adoption) adds barriers for robotics growth

- Lack of large businesses bottlenecks professionals with combined business/robotics experience

  - Critical **connections between robotics and other sectors remain unexplored** or underpenetrated (mining, healthcare, agriculture, etc.)

OPPORTUNITIES

- Robust start-up community offers opportunity to reshape industry landscape

- Growing opportunity for **robotics within the logistsics and transportation industry** to relieve pain points created from supply chain disruptions

- Wider adoption of robotics is expected as recent **workforce challenges (e.g., COVID-19, labour shortages) is driving automation in new industries**

THREATS

- 105 of Canada's firms are likely to see **competitiveness decline due to pricing pressures/commoditization from China**

- Proximity to the US, and lack of dedicated 'scale up' capital reduces industry scaling, as **foreign acquisition capture domestic differentiated firms**

- **Public perception of robotics remain stuck in a 'fear-mongering' posture** (e.g., high costs, job outsourcing), significantly reducing uptake rate
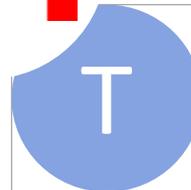
The Canadian robotics sector will need to grapple with both emerging and longstanding shortcomings

Key Industry Challenges

Small Domestic Market	Reduced uptick on automation stifles industry; Canada's high proportion of small manufacturers have limited desire or R&D funds to automate their operations **Canada ranks 18th out of the top 20 countries for robot density in manufacturing with 165 robots installed per 10k employees***
Difficulty in Scaling Up	With very few large Canadian robot manufacturers, the industry is highly fragmented and lacks the leadership and the expertise needed to scale startups **Only 5% of Canadian owned robotics firms are large businesses, and 72% of the industry is comprised of micro and small businesses**
Problems Connecting with Domestic Networks	Canada lacks a cohesive industry network to connects robotics firms, which inhibits collaboration and customers discovery, reducing overall industry maturity **Some organizations connect firms provincially (e.g., QC's REAI), but most firms rely on US networks (e.g., Robotic Industries Association)**

***Source**: International Federation of Robotics, World Robotics 2020 Report

The growth of Canadian robotics is stifled by the lack of domestic adoption, but new technology presents a strong opportunity for growth

AVASCENT

Canada's industry is well positioned to capitalize on key trends in the global robotics sector

Trend	Analysis	Top Markets

Estimated Canadian Impact (Higher → Lower)

Robotics Digitization
→ **Enabling technologies used to enhance the robotic capabilities** (e.g., AI for autonomy, LiDAR for vision, cloud for robotic network integration)
Top Markets: Healthcare, Agriculture

'Cobots' & New Applications
→ Acceptance of **collaborative 'cobots' will drive differentiation** and adoption for new applications, with significant workforce implications
Top Markets: Healthcare, Commercial

Manufacturing Commoditization
→ High demand in China and US likely **to accelerate the commoditization of robotic components, and pre-programmed manufacturing systems**
Top Markets: Manufacturing, Logistics

Regulatory Uncertainty
→ **Codifying the relationships between humans, robotics systems**, and other technologies for use in environments (e.g., RPAS for same-day delivery)
Top Markets: Consumer, Commercial, Healthcare

COVID-19 Impact
→ Covid expected to i**ncrease the pace of automation via accelerated adoption** including acting as catalyst for new sector adoption (e.g., electronics mfg.)
Top Markets: Manufacturing, Logistics

Concentrated efforts will be needed to overcome roadblocks that threaten long-term growth in Canada's robotics sector

Emerging Threats

Global Competitors	A handful of nations dominate the global robotics export market and leading countries with low manufacturing labour rates (e.g., China) threaten Canadian firms' ability to compete internationally **Over 62% of industrial robotics exports are concentrated within five countries (e.g., Japan, Germany, Italy, China, and the US)***
Acquisition Risk	Canada's proximity to the US can help support startup growth, but many firms struggle to scale independently and have been acquired by US or foreign firms **Of the 16 large Canadian robotics firms analyzed, 31% had taken some level of foreign investment compared to 9% of small & medium sized firms**
Robotics Perception	Many Canadian firms perceive that robotics implementation will demand high capital expenditure, large training efforts, require significant time investments, and will lead to job loss which slows robotics adoption **In an analysis of actual robot adoption rates as a share of expected adoption rate, Canada ranks 14th globally – 44% below expected adoption rates†**

***Source**: World's Top Exports, Top Industrial Robots Exporters | †Information technology & Innovation Foundation, Robotics and the Future of Production and Work

There are both global threats (i.e., increasingly competitive international markets) and uniquely Canadian threats facing the robotics sector

WASHINGTON D.C.

+1 (202) 452 6990

1615 L Street, NW
Suite 1200
Washington, D.C. 20036

PARIS

+33 (0) 87 39 21 13

7 rue Rouget de Lisle
75001 Paris

OTTAWA

+1 (613) 564 8303

66 Queen Street,
3rd Floor
Ottawa, ON K1P 5C6

LONDON

+44 20 3934 9100

132 Buckingham Palace Road
London SW1W 9SA

TOKYO

+81 (3) 6870 3450

East Tower, 4th Floor,
Otemachi First Square
5-1, Otemachi 1-chome,
Chiyoda-ku Tokyo
100-0004 Japan

AVASCENT | avascent.com