

SPANNING THE VIRTUAL FRONTIER

CANADA'S IMMERSIVE TECHNOLOGY ECOSYSTEM



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PREFACE

ICTC is a national centre of expertise for the digital economy. With over 25 years of experience in research and program development related to technology, ICTC has the vision of strengthening Canada's digital advantage in the global economy. Through forward-looking research, evidence-based policy advice, and creative capacity building programs, ICTC fosters innovative and globally competitive Canadian industries, empowered by a talented and diverse workforce.

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GLOSSARY OF TERMS

Augmented Reality (AR) AR overlays digital information onto the user's real-world environment in the form of words, images, video, and audio. Digital information is displayed using tablets, mobile phones, smart watches, and other wearables. Headsets that produce an AR experience, such as the Microsoft's HoloLens, are sometimes classified as Mixed Reality.

Degrees-of-Freedom (DoF) DoF refers to the various ways an object can move through space: translationally, as in forward/backward, left/right, and up/down, and rotationally around the x, y, and z axes.¹ In VR, DoF refers to the number of ways the user can move their head through a simulated environment. 3DoF means a user can move their head only rotationally by tilting it, looking up and down, or side-to-side, while 6DoF means the user can move their head translationally as well.²

Extended Reality (XR) XR refers to any immersive environment generated by a computer and displayed on mobile or wearable technology. In that sense, XR is a substitute term for AR, MR, and VR.

Head-Mounted Display (HMD) A head-mounted display (HMD) is a display device worn on the head or as part of a helmet that has a small display optic in front of one or each eye. HMDs are also referred to as headsets.

Mixed Reality (MR) MR integrates digital information into the user's real-world environment, so they can interact with both digital information and the real world simultaneously. Digital information is displayed using HMDs with transparent lenses or cameras, which allow users to maintain visual connection with their surroundings. Headsets can be standalone (e.g. wireless) or tethered to a computer or gaming console. While headset devices like Microsoft's HoloLens functionally provide an AR experiences, they are classified as MR headsets.

Pass-Through Virtual Reality Headsets Pass-through VR headsets use cameras to relay the real world into VR, creating a VR environment that is identical to user's real-world environment. Like regular VR headsets, they cover the eyes completely, removing all visual connection between the user and the real world.

Point Cloud A point cloud is a set of raw data points representing a 3D object in space, including x, y, and z coordinates, colour, intensity, and position relative to up or down.³ Point clouds are generated using various 3D scanning technologies (e.g. lasers, images) and are themselves used to create 3D models.

¹ "Degrees of freedom", Google, September 21, 2018, <https://developers.google.com/vr/discover/degrees-of-freedom>.

² Ibid.

³ Swann Rack, "Was ist eine Punktwolke?", HoloCreators, October 25, 2019, <https://holocreators.com/was-ist-eine-punktwolke/>.

Spatial Audio Spatial audio, sometimes called 360° or immersive audio, uses a combination of audio techniques to replicate how we hear sound in the real world. Using spatial audio, designers and developers can mimic whether sounds come to the user from above or below, in front or behind, or from the left or right. Spatial audio can be fixed to a given location or made responsive to the user's movement in space.⁴

Spatial Computing Spatial computing uses cameras, sensors, and 3D scanning and mapping tools to facilitate 3D human-computer interfaces and interaction techniques.

Spatial Data Spatial data is any data that is used to describe the location, shape, and attributes of an object or group of objects, such as a coordinate, elevation, or the distance between two objects. Spatial data is used in different formats across many industries, including mining, oil and gas, architecture, and manufacturing, and engineering. Spatial data is also used to inform and create immersive technology applications.

Virtual Reality (VR) VR completely immerses the user in a computer-generated 3D environment, removing as much sensory connection as possible with the real world. Visuals are displayed to users through VR headsets and head-mounted displays, which can be standalone or tethered to a computer, gaming console, or mobile phone. Spatial audio, haptics, interactive controllers, and other hardware can also be used to further intensify the experience.

3D Graphics 3D graphics are the aggregate of multiple 2D graphic vectors layered over a wire-frame model to create the illusions of depth within the digital world.

3D Model A 3D model is the representation of an image that has the potential to exist within a three-dimensional digital plane. 3D models can be made from images and 3D scans which are processed using computer software.

3D Scanning 3D scanning is a technique used to create point clouds of 3D objects and environments. This technique is facilitated by a range of 3D scanning technologies, such as LiDAR scanners.

360° Video 360° video, sometimes called spherical video, enables viewers to see in all directions from a fixed location. 360° videos are filmed using an omnidirectional camera or a combination of many cameras and can be viewed on almost any device, including laptops, desktop computers, tablets, and mobile phones.

⁴ Milou Derksen, "Spatial Audio: The Continuing Evolution", Abbey Road Institute, May 27, 2019, <https://abbeyroadinstitute.nl/blog/spatial-audio-continuing-evolution/>.

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EXECUTIVE SUMMARY

Spanning the Virtual Frontier: Canada's Immersive Technology Ecosystem has more than 350 companies, spanning four main hubs of activity: Toronto, Vancouver, Montreal, and Alberta. There are several smaller hubs in Central and Atlantic Canada. Immersive technology is a family of technologies encompassing all forms of computer-altered and extended reality (XR), including virtual reality (VR), augmented reality (AR), mixed reality (MR), and 360-degree video. More than 100 new companies with immersive technology products and services were founded across Canada between 2014 and 2017, and XR is projected to add up to US\$1.5 trillion to the global economy by 2030,⁵ though this projection will likely be mediated by the impacts of COVID-19 in the short-term.^{6,7} Though many immersive technology companies in Canada are still relatively young, the industry has seen growth. Driving this growth is the subsequent release of smaller, more affordable, and more portable hardware that is making consumer adoption and commercial scalability easier and more widely accessible.

A first-of-its-kind analysis, ICTC traces the emergence of immersive technology in Canada and provides a detailed picture of Canada's immersive technology ecosystem today. Through consultation with industry leaders and comprehensive data collection, ICTC discusses business and labour market trends, talent and skill needs, and the opportunities and challenges related to uptake, financing, and deployment. The report presents a diverse ecosystem that continues to find new applications for VR, AR, and MR technology and is growing its reputation and connections nationally and internationally.

Canada's immersive technology industry has a near equal distribution of product and service companies. Product companies, which account for approximately 50% of the Canadian immersive technology segment, supply products such as video games and VR experiences for entertainment and sports purposes, and content development tools. Service companies, which build custom ICT solutions for their clients at a billable rate, account for 46% of Canadian immersive technology companies, while hybrid product-service companies account for the remaining 4%. Increasingly, immersive technology companies operate in sectors outside the entertainment industry. In recent years, new use cases for VR, AR, and MR have expanded their reach beyond entertainment. Today, 81% of Canada's immersive technology companies operate in industries such as national defence and first response; the medical and pharmaceutical industries; real estate; manufacturing and heavy machinery; and energy, mining, and other parts of the natural resources sector.

⁵ This projection captures economic interactions in the global economy related to "trade and spending between firms on one another's goods and inputs; spending by consumers on goods; investment decisions, and dynamics in the market such as demand for factors like capital and labour, trade, employment and wage effects". It was generated before the emergence of COVID-19 in late 2019 and therefore does not account for the impact of COVID-19 on the world economy. Importantly, physical distancing measures resulting from COVID-19 may impact demand for specific kinds of immersive technology: demand for tools focused on entertainment or remote collaboration may rise in the short term, while demand for other services like marketing and advertising may decrease. PWC, 2020. "Seeing is believing: How virtual reality and augmented reality are transforming businesses and the economy".

⁶ "Pandemic Tempers Growth in AR/VR Spending, but the Long-Term Outlook is Positive, says IDC", IDC, July 20, 2020, <https://www.idc.com/getdoc.jsp?containerId=prEUR146720420>

⁷ According to classification standards developed by Statistics Canada, small to medium-sized enterprises are businesses with fewer than 500 employees.

Despite its growth, Canada's immersive technology industry is still maturing. About 91% of companies in the industry are small to medium sized enterprises (SMEs).⁸ This figure jumps to 98% when considering just Canadian-owned companies and 100% for Canadian-owned companies that exclusively or almost entirely provide immersive technology products and services. A more detailed look at small immersive technology companies in Canada finds that 83% have fewer than 26 employees, and 63% have between 2 and 10. The high proportion of young companies and start ups across Canada's immersive tech industry may make the industry more vulnerable to economic impacts created by COVID-19 as current and potential clients experience a decrease in projected cash flow, possibly resulting in falling demand for investments in emerging tech and the unwinding of financially vulnerable companies.⁹ That said, there is some speculation among industry leaders that due to physical distancing measures in place in various jurisdictions around the world, demand for home entertainment-apps and tools focused on remote collaboration may increase.¹⁰

The interviewees consulted for this study highlighted challenges related to domestic financing and uptake of VR, AR, and MR. They suggested that it is difficult to secure funding from Canadian investors. Despite there being many suppliers of immersive technology products and services in Canada, adoption of the technology by Canadian companies is somewhat less prevalent. A reluctance among investors to take on riskier, emerging tech like VR, AR, and MR may worsen the availability of financing for Canadian companies. Similarly, reduced spending by current and or future potential clients may negatively impact demand for immersive tech products and services.

As a result of financing challenges, the growth of Canada's immersive technology industry has somewhat plateaued since 2016. VR and AR were thought to have reached an inflection point for broad consumer adoption that year, but larger scale uptake has not yet taken place. The number of new immersive technology companies launched each year has also declined in Canada since 2016, but industry consolidation, better hardware, and new promising use cases for immersive technology across industry lines provide unique opportunities for future growth and adoption. As new doors open to further growth and maturation, all eyes are on the next hardware breakthrough, which—as highlighted by interviewees in this study—could be a key component to ignite the next period of significant growth.



⁸ According to classification standards developed by Statistics Canada, small to medium-sized enterprises are businesses with fewer than 500 employees.

⁹ Alexandra Cutean, "Business Continuity in Lockdown: Four Stories Navigating COVID-19", Information and Communications Technology Council (ICTC), April 8, 2020, <https://www.ictc-ctic.ca/business-continuity-lockdown-four-stories-navigating-covid-19/>

¹⁰ Kris Kolo, "Interview: 'More people now do 'Social virtual reality' because they feel isolated at home'", VR/RA Association, June 9, 2020, <https://www.thevrara.com/blog2/2020/6/9/interview-more-people-now-do-social-virtual-reality-because-they-feel-isolated-at-home>

SECTION I

INTRODUCTION

Canada's Immersive Technology Ecosystem begins with a brief introduction to immersive technology, its history, and its connections with other emerging technologies and then looks at top use cases across Canada's industry verticals. The second section discusses the core components of an immersive technology team and the technical roles and skillsets important to that team. Software Engineers, Product Managers, and Senior Architects are identified as important for the development of immersive technology applications, and Creative Directors, 3D Artists, and User Interface and Experience Designers are identified as important for design. Other roles, such as Regulatory Advisors and Enterprise Deployment Specialists, are also discussed.

The third section presents a first-of-its-kind analysis of the companies that make up Canada's immersive technology industry and regional ecosystem hubs. From a dataset of 353 companies, prominent business models and value offerings are identified as well as trends related to company size, age, and their prospects for regional and international expansion. The third section concludes with a discussion of key trends and challenges to uptake, financing, skills, and diversity. Finding and securing financing is identified as the most pressing challenge for Canadian companies in the industry today.

WHAT IS IMMERSIVE TECHNOLOGY?

Immersive technology is a family of technologies that immerse users in various types of digital information to create a deeply engaging user experience. At a high level, VR, AR, and MR immerse users in three distinct ways: by displaying information to the user in three dimensions; by incorporating that information into the three-dimensional space around the user; and by enabling more natural and organic forms of interaction between users and digital information. For example, users can opt for voice commands or hand gestures in place of a keyboard, mouse, or track pad. In comparison, non-immersive technology displays information to users in a 2D format even when that information is more naturally displayed in 3D. Similarly, non-immersive technology constrains information on a 2D screen, limiting more creative forms of human-computer interaction.

Virtual Reality (VR) VR completely immerses the user in a computer-generated 3D environment, removing as much sensory connection as possible with the real world. Visuals are displayed to users through VR headsets and head mounted displays, which can be standalone or tethered to a computer, gaming console, or mobile phone. 3D-audio, haptics, interactive controllers and other hardware can also be used to further intensify the experience.

Augmented Reality (AR) AR overlays digital information onto the user's real-world environment in the form of words, images, video, and audio. Digital information is displayed using tablets, mobile phones, smart watches, and other wearables.

Mixed Reality (MR) MR integrates digital information into the user's real-world environment, enabling them to interact with digital information and the real world simultaneously. MR does this using headsets equipped with transparent lenses or cameras, which allow users to maintain visual connection with their surroundings. Headsets can be standalone or tethered to a computer or gaming console. MR is sometimes referred to as *wearable AR*.

VR, AR, and MR each use slightly different combinations of hardware and software tools to immerse users in a slightly different way. Some immersive technology is accessible through mobile phones and tablets and some is accessible through headsets, head-mounted displays, and other wearables. Visual displays, sensors, real-time location tracking, and cloud storage and computing can be packaged in countless unique configurations to enable a wide array of specific industry applications. Critically, the type(s) of immersive technology used in a given application depends largely on the underlying goal. Is the aim to completely immerse the user in a computer-generated environment, as is often the case with VR or 360-degree video? Is it to enrich the user's real-world surroundings with virtual information, as with MR and AR? Or rather, is the aim to enhance the communication of spatial or 3D data, as is the case for all four? The exact type(s) of immersive technology employed will depend on the answers to these questions.

Interestingly, despite having started out as three relatively separate technologies, through cross-platform integration and hardware convergence, VR, AR, and MR are becoming increasingly interlinked. One example is Varjo's MR headsets which can support both VR and MR simultaneously. Another is Modest Tree's Modest3D Xplorer platform, which enables users to collaborate on the same 3D models irrespective of their hardware platform (whether a mobile phone, headset, tablet, or desktop). For this reason, specific examples of the technology—such as an AR retail app or VR training program—should be thought of simply as reference points along a much larger spectrum of 3D and immersive tech.

THE HISTORY OF IMMERSIVE TECHNOLOGY

Immersive technology has a long history dating back almost 60 years, but it is only within the last four to five years that VR, AR, and MR have been able to deliver on their promised visions at a price point that enables broad consumer and industry adoption. For a long time, the individuals and companies driving research and development were constrained by the quality and capability of the hardware and software available to them. Below is a brief history of immersive technology from its initial inception in the late 1970s to today.

TIMELINE

1968	Ivan Sutherland and Bob Sproull created the first HMD, a device that delivered AR experiences by projecting images onto the real world. The device never progressed past the experimental phase due to design constraints (users found it heavy and uncomfortable). ¹¹
1975	Myron Krueger used a mix of computer graphics, light projection, cameras, and screens to measure user position and incorporated this into his AR lab, Videoplace. Videoplace is widely regarded as the first <i>interactive</i> VR system, although with no headset or HMD, in modern terms it functioned much more like an AR projection. ¹²
1985	VR pioneers Jaron Lanier and Thomas Zimmerman founded VPL Research, the first-ever company to sell VR headsets. Two years later, Lanier coined the term “ <i>virtual reality</i> .” ¹³
1990	Boeing researcher Tom Caudell coined the term “ <i>Augmented Reality</i> .” ¹⁴
1992	Louis Rosenberg from the US Air Force Research Lab created the first truly operational AR system called Virtual Fixtures. It was a robotic system that overlaid information on top of users’ real-world environments to drive efficiency—in other words, an earlier version of what most AR applications currently do today. ¹⁵
1993	Sega announced a VR headset for its videogame console Sega Genesis at the Consumer Electronic Show. The device was marketed as providing an accessible at-home consumer VR experience, including head tracking and built-in stereo sound. Due to technical difficulties, the headset remained a prototype and was not released for consumer purchase. ¹⁶
1995	Nintendo followed Sega’s attempt at consumer home VR with the Nintendo Virtual Boy. The device was successful in providing a portable VR experience but was designed to remain in a fixed position, excluded head tracking. A year after its original release in Japan and North America, the sale and production of the Nintendo Virtual Boy was discontinued. ¹⁷
1997	Georgia Tech and Emory University used VR to treat PTSD in war veterans. Controlled exposure to traumatic triggers became an integral part of PTSD therapy and remains a crucial aspect of PTSD treatment and research today. ¹⁸

¹¹ Joseph Flynt, “The History of VR: When was it created and who invented it?”, 3D Insider, August 12, 2019, <https://3dinsider.com/vr-history/>.

¹² “Videoplace”, elmcp, Accessed April 2020, <https://elmcp.net/creative-work/videoplace>.

¹³ “Timeline of Virtual Reality History & Important VR Chronological Events”, All Virtual Reality, Accessed April 2020, <https://allvirtualreality.com/tutorials/timeline-virtual-reality-history-important-vr-chronological-events.html>.

¹⁴ “AR at Boeing (1990)”, Boeing Inc., Accessed April 2020, <http://www.idemployee.id.tue.nl/g.w.m.rauterberg/presentations/HCI-history/tsld096.htm>.

¹⁵ Jeremy Norman, “HistoryofInformation.com”, The First Fully Immersive Augmented Reality System, Accessed April 2020, <https://www.historyofinformation.com/detail.php?entryid=4696>.

¹⁶ “History of Virtual Reality”, Virtual Reality Society, Accessed April 2020, <https://www.vrs.org.uk/virtual-reality/history.html>.

¹⁷ *Ibid.*

¹⁸ *Ibid.*

1999	NASA created a hybrid synthetic vision system for the X-38 spacecraft to improve navigation during test flights. ¹⁹
2000-01	Hirokazu Kato created and released ARToolKit, an open source development software that, for the first time, enabled interaction between real and virtual objects. ²⁰
2005	One of the first AR mobile apps, a tennis game was created for a Nokia phone. ²¹
2008-09	The first AR enhanced print ads, which featured digital components triggered by QR codes, were published by BMW and Esquire. ²²
2010-12	Palmer Lucky created Oculus' first VR headset prototype and subsequently launched a successful crowd funding campaign worth US\$2.4million for his VR Kit, Oculus Rift. ²³
2014	Facebook acquired Oculus for US\$2.3billion. ²⁴ The acquisition marked a clear line of division between the series of commercial failures that had defined VR at the turn of the century and the modern VR revolution that we're experiencing today. Alongside Google Cardboard, Google released Google Glass, a product marketed as the first wearable AR device. Though Google Glass lacked broad consumer adoption and developer support for immersive applications, it did show the potential of what wearable augmented reality could be. ²⁵
2015-16	Oculus (Facebook) released the first consumer version of its headset the Rift. Sony, HTC, and Google released additional VR headsets and HMDs as Facebook and YouTube moved to support 360-degree video on their platforms. With more options and lower prices, VR products became meaningfully accessible to consumer markets for the first time. Microsoft also released the HoloLens 1, the first wearable AR headset to be marketed as MR. Some argue that the HoloLens provided businesses outside of entertainment sector with an MR product at a low enough price point to enable workplace deployment and experimentation.
2017-19	Oculus (Facebook) and Google released additional VR headsets and HMDs, as Google, Magic Leap, Microsoft, and Varjo released new MR headsets. Over time, headsets have become smaller, cheaper, more accessible, and more sophisticated than those that came before. Today, a number of headsets include sophisticated capabilities like cloud connectivity, eye tracking, gesture tracking, analytics, and computer vision.

¹⁹ "The History of Augmented Reality", *Assmblr Blog*, December 11, 2018, <https://blog.assemblrworld.com/the-history-of-augmented-reality/>.

²⁰ *Ibid.*

²¹ Charlotte Yianni, "Infographic: History of Augmented Reality", *blippar*, June 8, 2020, <https://www.blippar.com/blog/2018/06/08/history-augmented-reality>.

²² *Ibid.*

²³ Luke Dormehl, "8 virtual milestones that took it from sci-fi to your living room", *Digital Trends*, November 13, 2017, <https://www.digitaltrends.com/cool-tech/history-of-virtual-reality/>.

²⁴ *Ibid.*

²⁵ Michael Isberto, "The History of Augmented Reality", *Colocation America*, May 9, 2018, <https://www.colocationamerica.com/blog/history-of-augmented-reality>.

CONNECTIONS TO OTHER EMERGING TECHNOLOGIES

Immersive technology is made possible by a collection of other technologies including visual displays, real-time location tracking, and sensors. Over the years, as new emerging technologies like cloud computing services and artificial intelligence²⁶ (AI) have become available, they too have been integrated into the collection of technologies that make up VR, AR, and MR. This section explains the relationship that immersive technology has with other prominent, emerging tech.

Cloud Computing Cloud computing services²⁷ make immersive technology applications more sophisticated by facilitating cross-platform integration between headsets, computers, and mobile phones and tablets, and enabling collaborative, multi-user environments. Combined with high-bandwidth network environments, cloud computing services can also enable the offloading of data analytics, data processing, and other computing functions from local hardware devices.

AI Natural language processing (NLP),²⁸ machine learning (ML),²⁹ and computer vision³⁰ play a key role in leading-edge immersive technology applications. Several interviewees in this study noted that their products and applications use AI in some capacity, whether for video compression, content creation, human-computer interaction, data analytics, or computer vision. Some also noted that they incorporate ML into their applications to create smart and responsive environments; for example, in training applications, responsive environments make way for individually tailored levels of difficulty, which can thereby improve training outcomes. Increasingly, AI functionalities are also integrated directly into headsets and development kits. Microsoft and Magic Leap, for example, have incorporated computer vision into their products to facilitate object recognition, gesture recognition, and spatial mapping, as well as NLP for commands and ML for data analytics.

Internet of Things (IoT) The growing number of connected devices has enabled a novel set of data inputs for immersive technology applications. Perhaps the most advanced example of IoT combined with immersive technology is digital twins: MR, VR, and AR provide new value to digital twins by naturally and more effectively displaying the associated spatial information. For example, information regarding the location of mistakes made during a manufacturing process could be captured by IoT sensors, fed into a digital twin, and displayed to technicians in AR or MR, in real time. IoT sensors could also be used to update IoT enabled 3D models in real time to enable a VR viewing of geological changes to an offshore mining site in real time.³¹

²⁶ Ryan McLaughlin; Trevor Quan, *On the Edge of Tomorrow – Canada's AI Augmented Workforce*, Information and Communications Technology Council, December 2019, p. 5.

²⁷ "What is cloud computing", Microsoft, Accessed April 2020, <https://azure.microsoft.com/en-ca/overview/what-is-cloud-computing/>

²⁸ McLaughlin, Quan, *On the Edge of Tomorrow – Canada's AI Augmented Workforce*, p. 5.

²⁹ *Ibid.*

³⁰ *Ibid.*

³¹ The IoT is a collection of internet and network connected devices (e.g. sensors, wearables, etc.) which act as inputs for various data-powered systems—smart homes, smart cities, or digital twins, for example.

5G Interviewees were divided as to the exact implications of 5G for immersive technology applications.³² Some believe 5G is extremely important for the continued development of immersive technology and its potential applications, while others urged that the industry can still be successful without it. Today, many immersive technology applications, such as basic 3D models conveyed through AR or MR devices, require no more than a stable internet connection.³³ In some cases, a single high-speed internet connection can support up to 10 MR headsets streaming basic, low-fidelity 3D models from the cloud. While there is ample evidence that immersive technology can be successful in many contexts without 5G, the quality and reach of future VR, AR, and MR solutions will likely benefit from improved network capacity resulting from 5G. Faster download speeds and lower latency, for example, is critical for remote collaboration, where many collaborators will be able to tune in to the same 3D models or experiences from different locations. As one interviewee put it, when many collaborators connect from the same location, a reliable internet connection is enough, but when collaborators join from separate locations—from their homes, from the office, or on-site—existing internet connections can become unstable, thereby inducing the need for 5G.

Further, some interviewees noted that 5G may lay the groundwork for more portable (and in turn, more widely accessible) hardware devices. Currently, hardware manufacturers are constrained in their ability to make headsets and HMDs self-contained, smaller, and lighter because of the high computational power that is needed to run VR, AR, and MR applications locally.³⁴ Interviewees commented that together, 5G and edge computing may enable hardware manufactures to shift some computational functions from local devices to the network. This would reduce the amount of local computing capacity required in devices (and with it, the size of devices), and potentially the associated impact on battery life. In effect, headsets would potentially become smaller, cheaper, and less complex, with batteries that last longer.

³² "What is 5G", Government of Canada, July 20, 2017, <https://www.ic.gc.ca/eic/site/069.nsf/eng/00077.html>.

³³ Kognitiv Spark, Accessed April 2020, <https://www.kognitivspark.com/remotespark/>.

³⁴ A self-contained headset or HMD has all of the required hardware components built into the device itself. This eliminates the need for a tethered computer or gaming console for computational power or the need for various kinds of sensors (such as location tracking) to run applications.

TOP USE CASES

At the most basic level, immersive technology is a communications and spatial computing tool, designed to emulate or augment the physical world using digitally generated visual experiences. Immersive technology has a unique ability to communicate complex information within a 3D environment and with a high degree of user manipulation—the list of use cases that can benefit from this ability are virtually endless. Nonetheless, a collection of popular use cases has emerged over the past few years (such as guided assistance, simulation training, and design testing), many of which are interoperable between variations of the technology. For example, guided assistance is possible through both mixed reality headsets and augmented reality apps, and similarly, virtual collaboration can occur with both mixed and virtual reality. For this reason, interviewees participating in this study often cautioned against assigning particular use cases to one technology or another. Instead, they asserted that immersive reality had several potential and overlapping uses, while some may be slightly better developed, more easily deployable or simply more mature than others.

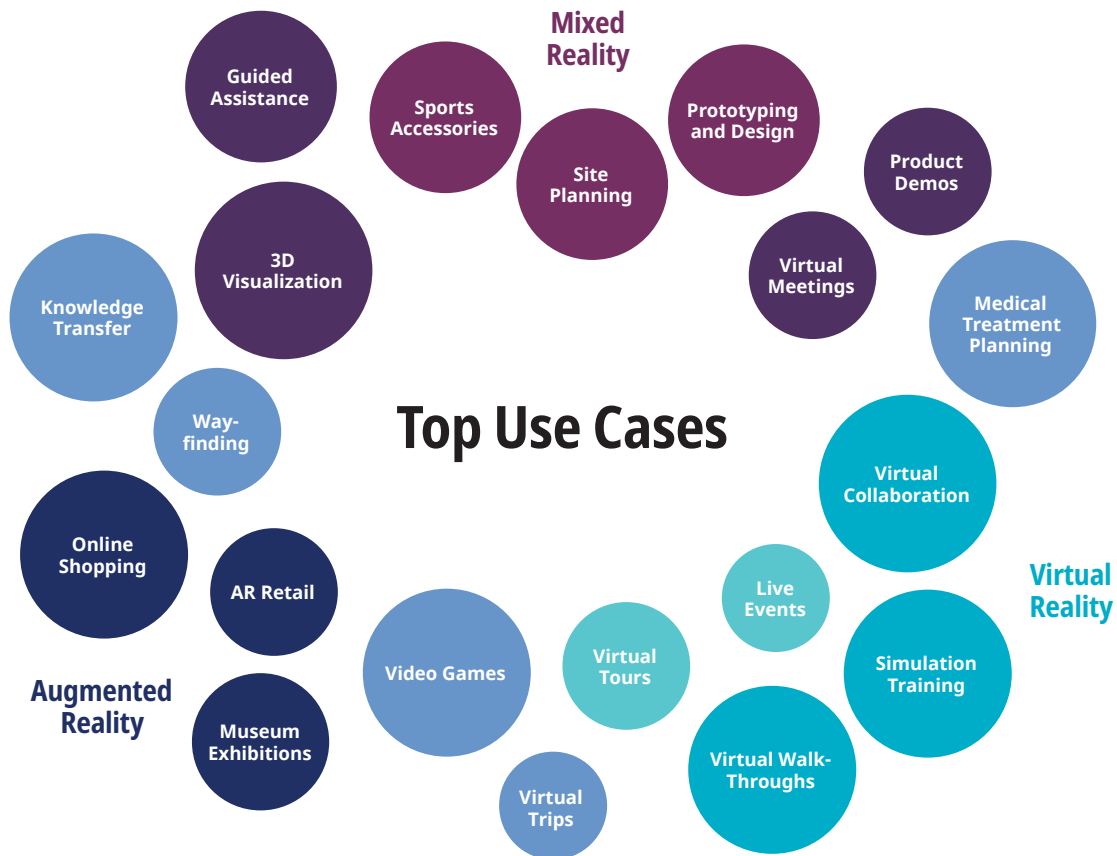


Figure 1. Top use cases, AR, MR, VR. ICTC, 2020.

TOP USE CASES ACROSS CANADA'S VERTICAL INDUSTRIES

Immersive technology provides many benefits to enterprise organizations, including tangible benefits like space, time, and cost savings, and less tangible benefits such as enhanced user experience and enhanced communication of spatial data. According to interviewees, immersive technology is most valuable when it improves or replaces costly, time consuming, and dangerous processes, and/or where it enables new processes that were once not feasible. With respect to Canada's vertical industries, immersive technology is particularly valuable to interactive digital media, advanced manufacturing, health and biotechnology, clean technology and clean resources. This section provides a snapshot of prominent use cases in each of these sectors.



INTERACTIVE DIGITAL MEDIA

Interactive digital media exists at the intersection of ICT and the digital and creative industries. It provides businesses with new, creative ways of displaying internal and external information.³⁵ Home to immersive technology itself, the subsector is ripe with use cases for VR, AR, and MR.

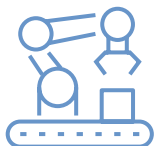
MARKETING, TRADE SHOWS AND VIRTUAL WALK-THROUGHS

Immersive technology is particularly useful in sectors that employ heavy machinery: manufacturing, automotive, aerospace and defence, and mining and energy. These sectors require regular transportation and storage of large, heavy machinery to facilitate basic business processes like sales, marketing, and training. Without immersive technology, these companies must dedicate significant financial resources for transporting and showcasing their products. Immersive technology significantly reduces the cost and complexity of organizing this type of service: using VR, an isolated heavy machinery company can bring its products to a central conference or office at little additional cost.

Immersive technology also facilitates new ways of carrying out traditional processes for business-to-business and business-to-consumer companies alike. Custom solutions allow businesses to provide customers with virtual, hands-on experience of products and services irrespective of time and location. They facilitate virtual walk-throughs of distant work sites and real estate that can expand potential markets to include customers around the world. Similarly, immersive technology solutions can enable companies to provide tours and/or demonstrations of products and buildings not yet built.

³⁵ Alexandra Cutean, Rosina Hamoni, Ryan McLaughlin, et al., *Canada's Growth Currency: Digital Talent Outlook 2023*, Information and Communications Technology Council (ICTC), October 2019, p. 17.

On the entertainment side of marketing, businesses have begun to commission aspirational content for consumers to engage with. This content exists beyond the sale of anything specific, as brands seek to align themselves with experiences that may not be within reach during an average person's day to day. Toms, a shoe company headquartered out of, Venice, California, uses VR in their flagship store to take customers on a unique experience where they are guided through a remote village in Peru during one of the company's shoe-giving trips.³⁶ Through this engagement, customers get to experience firsthand the company's mission of giving while allowing them to experience a remote location that may not be within reach for many people.



ADVANCED MANUFACTURING

The advanced manufacturing sector uses next-generation manufacturing capabilities, incorporating technologies like advanced robotics, IoT, machine learning, 3D printing, and immersive technology to build familiar or novel products.³⁷ The efficiencies obtained through advanced manufacturing come from digitally enabled processes that often depend on the use and coordination of information, automation, computation, software, sensing, and networking.

GUIDED ASSISTANCE

Immersive technology—specifically, MR and AR—has proven especially useful for guiding front-line and field workers through a variety of tasks such as assembling vehicles or equipment, operating and repairing complex machinery, and/or navigating vast warehouses or worksites. MR and AR are well suited to these kinds of on-site and on-the-job applications, as they add an additional layer of information to the physical world, as opposed to isolating the user from their environment.

Immersive technology for guided assistance comes in two common variations: automated assistance for specific tasks, or human assistance by a centralized subject-matter expert. The latter facilitates more efficient transfer of knowledge throughout organizations and among colleagues and overcomes barriers related to distance or time. For example, New Brunswick-based Kognitiv Spark enables senior or more experienced staff to provide guidance to less experienced workers at remote sites from a centralized location. Such guided assistance enables faster onboarding processes, as new workers can be deployed to the field before being fully independent.

Automated assistance is, on the other hand, tailored to specific, repetitive tasks that, at scale, significantly impact the amount of time it takes to complete a project. Particularly well suited to this type of solution are tasks that involve spatial or 3D information, such as navigating a warehouse or placing parts on a manufactured object. In these contexts, guided assistance can enable workers to do their jobs faster or more accurately. For example, Lockheed Martin developed an MR solution to guide technicians responsible for attaching small parts to the Orion spacecraft. The solution enabled workers to complete work that once took eight hours in just 45 minutes.³⁸

³⁶ Jonathan Nafarrete, "TOMS Brings Virtual Reality Giving Trips to Retail Customers", *VR Scout*, July 24, 2015, <https://vrscout.com/news/toms-virtual-reality-giving-trips/>.

³⁷ Cutean, Hamoni, McLaughlin, et al., *Canada's Growth Currency: Digital Talent Outlook 2023*, p. 17.

³⁸ Kathryn Bloxham, "Webinar: XR for Enterprise: How to Gain Buy In and Prove its Value", *VR Intelligence Ltd*, January 7, 2020, <https://www.vr-intelligence.com/webinar-xr-enterprise-how-gain-buy-and-prove-its-value-0>.

PROTOTYPING

Manufacturing companies have found novel use cases for immersive technology in the designing and testing of products. Though enhanced testing, designers and engineers can make informed decisions regarding material choices and design layouts, leading to significant time and cost savings due to limited rework work orders. By engaging with designs in an immersive environment, designers can manipulate and adjust designs on the fly and run tests in digital test environments that allow for rapid prototyping. Within a factory setting, use cases for VR further include the mapping, manipulation, and testing of assembly line configurations to assess the efficiency and feasibility of a specific production process. Trialling various production layouts within a digital twin of the production floor enables manufacturing companies to mitigate labour costs and health risks associated with moving heavy machinery, in addition to the time spent on other non-productive tasks.



HEALTH AND BIOTECH

Health and biotechnology include traditional healthcare product and service delivery; the use of biotechnology in other industries like agriculture, green tech, and industrial manufacturing; and increasingly, the use of bioinformatics and big data for gene sequencing, disease-related research, and drug identification.³⁹ Healthcare spending accounts for a significant portion of Canada's economy, making health and biotechnology a natural home for experimentation with new tech.⁴⁰

IMMERSIVE TRAINING AND EDUCATION

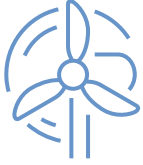
Companies and organizations in the healthcare sector use VR to improve training and education, enabling medical practitioners to hone their skills without the usual risk or danger to patients. In a digital immersive environment, healthcare professionals can view minute detail of any part of the body in a digital reconstruction and thus create training scenarios that replicate common surgical procedures. British Columbia-based company PeriopSim has created a collection of immersive training simulations for professionals involved in surgery. Similarly, California-based Osso VR has developed an immersive training platform for orthopaedic surgeons and found that their users performed surgery nearly twice as well as those trained by traditional means.⁴¹

Critically, immersive technology headsets still face significant barriers in health care, as they are not yet capable of displaying the level of detail needed in colour and intensity (visual fidelity). Interviewees noted that medical applications tend to require 3D models with significant dynamic contrasting; slight variations in grey, black, and other colours are used to identify different body parts or types of tissue in the medical world. To date, portable MR headsets are unable to provide the required contrast. Devices like Microsoft's HoloLens 1 & 2 use light to overlay images onto the real world, making it difficult for them to accurately portray dark shades of colour or black. Pass-through MR headsets like the Varjo XR-1 can provide the level of colour detail required for medical applications but at US\$10,000 a piece are often far too expensive for widespread deployment. The XR-1 is also unable to operate untethered (without a powerful, external computer).

³⁹ Cutean, Hamoni, McLaughlin, et al., *Canada's Growth Currency: Digital Talent Outlook 2023*, p. 17.

⁴⁰ Canadian Institute for Health Information. *National Health Expenditure Trends, 1975 to 2019*. Ottawa, ON: CIHI; 2019. <https://www.cihi.ca/sites/default/files/document/nhex-trends-narrative-report-2019-en-web.pdf>.

⁴¹ Osso VR, Accessed April 2020, <https://ossov.com/the-osso-story/>.



CLEANTECH

Cleantech is a subsector that is focused on the development and sale of environmentally friendly goods and services. Businesses in the cleantech market develop and deploy technologies that generate efficiencies while simultaneously minimizing industrial impacts on the environment.⁴²

IMPROVED PLANNING AND DESIGN

Testing a product within an immersive technology space goes beyond specific 3D modelling. Designers and engineers can digitally simulate varying environmental conditions that will impact the design's final structural implementation. AR can be used in cleantech to expedite design and decision-making processes—for example, to construct 3D prototypes much earlier in the design process, assess the visual impact of a proposed wind farm on its surrounding area, or create a model of how contaminants move through the atmosphere surrounding to a factory.



CLEAN RESOURCES

While similar to cleantech, the clean resources sector represents businesses that focus on the extraction or use of natural resources in ways that are environmentally friendly, carbon-neutral, or climate positive. A long-standing pillar of the Canadian economy, natural resources account for a significant portion of Canada's economic output.⁴³

IMPROVED TRAINING

Clean resource companies are able to deploy VR to obtain efficiencies and scalability in engineer training. An interviewee for this study indicated green energy companies use their VR solutions to train engineers, targeted at preventive maintenance and technical support. The shift to a virtual training experience ensures that the activity could take place in a hazard-free environment, safe from equipment-related harm. It was noted by the interviewee, that this method of training saved travel time, cost, and carbon release for 7,000 employees.

GUIDED ASSISTANCE

As with advanced manufacturing, mixed and augmented reality have proven especially useful for guiding frontline and field workers in clean resources. Both automated assistance and human assistance are used in the clean resources sector to guide field technicians and other workers through an array of tasks, including repairing infrastructure, operating and repairing complex machinery or vehicles, and work sites. Again, MR and AR are well suited to these kinds of onsite and on-the-job applications because, functionally, they add an additional layer of meaning on top of the physical world, as opposed to isolating the user from it.

⁴² Cutean, Hamoni, McLaughlin, et al., *Canada's Growth Currency: Digital Talent Outlook 2023*, p. 16.

⁴³ Cutean, Hamoni, McLaughlin, et al., *Canada's Growth Currency: Digital Talent Outlook 2023*, p. 16.

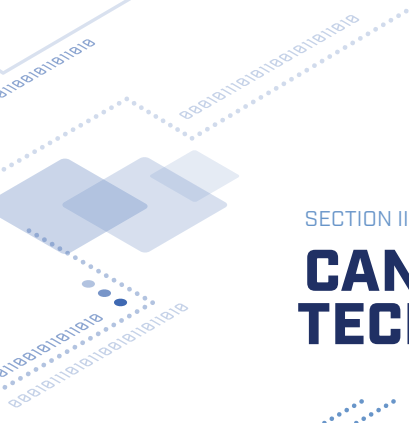
BARRIERS TO ADOPTION

Prior to the release of untethered headsets (headsets that do not need to be tethered to a powerful laptop, computer, or game console to function), companies across all sectors were much more limited in their ability to apply mixed and virtual reality. For example, untethered headsets could not be used in contexts where there were no outlets or other power sources. Similarly, they were not practical in situations where wires are dangerous or restricting. Today, self-contained headsets and HMDs⁴⁴ work *without* computers, giving companies more leeway in the types of use cases and applications they can pursue. Self-contained wireless headsets have also reduced the complexity of troubleshooting technical issues.

That said, immersive technology hardware is not without other barriers to adoption. While the cost of headsets and other hardware has decreased substantially, it is still not inexpensive, making it difficult for some smaller companies to adopt and deploy at scale. Interviewees in this study highlighted that scalability is critical for adoption even when there is a strong return on investment. Equipment and maintenance costs and user experience (e.g. ease of use, comfortability, to what degree the technology is compact and mobile, etc.) are important considerations for industry when evaluating whether the investment in immersive technology is worthwhile. Similarly, if a company is already collecting and engaging with spatial data on a regular basis, the cost of creating digital assets like 3D models is significantly reduced. When an application can be used comfortably, at scale, and at a low cost, immersive technology can be a very effective tool.

⁴⁴ Self-contained headsets like Microsoft's HoloLens 2 contain all the required elements within a self-contained headset, eliminating the need to manage loose wires and sensors.





SECTION II

CANADA'S IMMERSIVE TECHNOLOGY INDUSTRY



Canada has some of the best XR companies in the world.
We're really punching above our weight class.

— CEO, AR Company

OVERVIEW OF THE IMMERSIVE TECH LANDSCAPE IN CANADA

Comprised of more than 350 companies, Canada's immersive technology industry spans four main hubs of activity in Toronto, Vancouver, Montreal, and Alberta, and several smaller hubs in Central and Atlantic Canada. The technology's growing success in Canada is partly attributable to its roots in several other robust industries, notably the video game and VFX industries in Montreal and Vancouver; digital media in Toronto; enterprise technology in Alberta; and defence in Eastern Canada (national defence organizations were early adopters of immersive technology). Collectively, Canada's immersive technology industry was valued at approximately \$0.6 billion in 2018 and is projected to grow to approximately \$8 billion by 2022, with AR and MR accounting for most of this growth.⁴⁵

Between 2014 and 2017, an uptick in startups was spurred by an emerging market opportunity and the personal interests, backgrounds, and skillsets of various entrepreneurs, particularly among immersive-technology companies. At the same time, immersive technology research and development arms surfaced at existing companies with experience in videogame, web, mobile app development, programming and software development, VFX, and enterprise operations and technology.

Companies in the industry fall into two main categories. Firstly, those whose business models centre almost entirely, if not exclusively, on immersive technology; and secondly, those that engage mostly in other types of work (digital transformation, videogame development, and marketing and advertising, for example) with only some immersive technology capacity. The former category is referred to in this report as "immersive technology companies" and the latter as "other companies" in the industry. Given the similar tools and skillsets that are required for different kinds of immersive tech development, most immersive technology companies refrain from specializing in, or offering, just AR, VR, or MR. Immersive technology companies account for 56% of the industry, while "other" companies make up the remaining 44% (see Figure 5). Looking at Canadian-owned companies exclusively, almost two-thirds (61%) focus almost entirely on immersive technology.

⁴⁵ Statista, Accessed April 2020, <https://www.statista.com/statistics/866903/canada-augmented-virtual-reality-market-size/>.

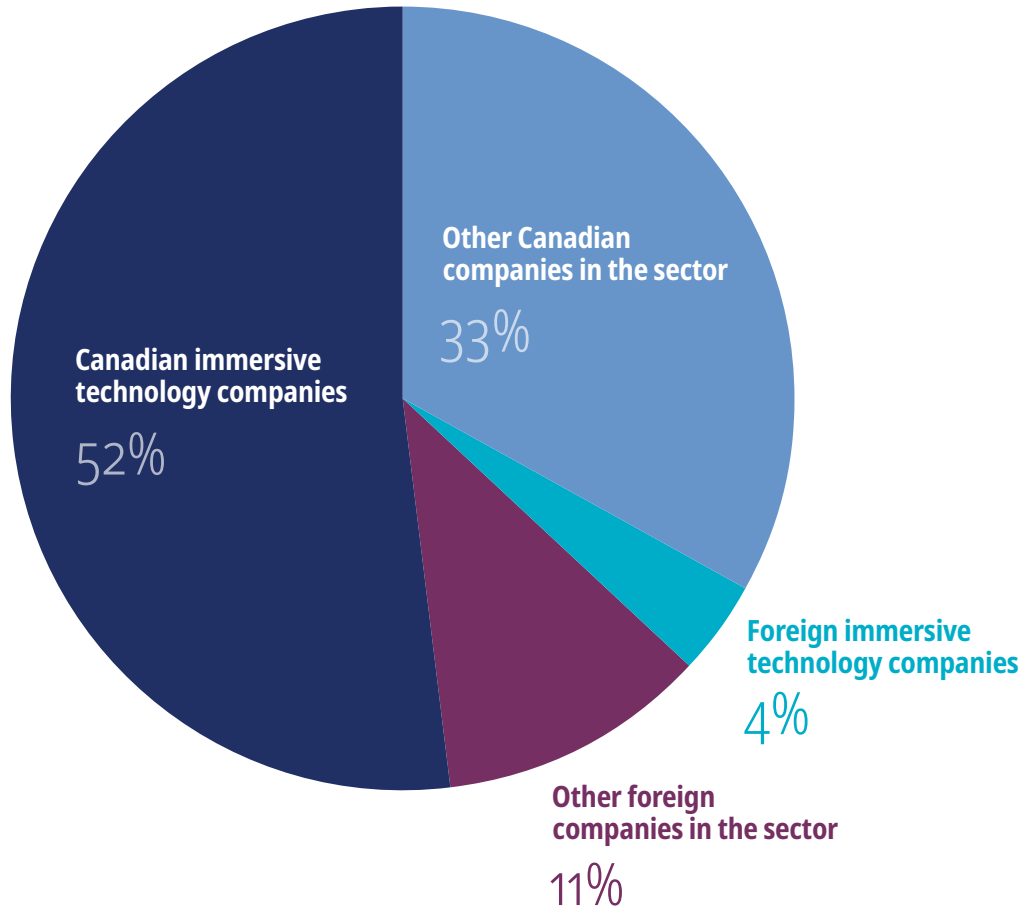


Figure 2. Breakdown of Canada's immersive technology industry by core-value offering and country of ownership. Based on publicly available company data for 353 companies. ICTC, 2020.

PROVINCIAL COMPARISONS

In this section, several indicators are used to measure the size and depth of provincial ecosystems, including overall strength of private industry and the technology sector, academic institutions in key technology fields, and ecosystem supports, including availability of industry associations. For a more detailed breakdown of indicators assessing provincial strength in immersive technology, please see Appendix C. As with many emerging technologies, the size and depth of provincial ecosystems depends largely on size, population, and availability of skilled talent with key digital skills. Larger provinces with higher saturation of digitally skilled talent have larger immersive technology ecosystems, whereas in smaller provinces, the technology is less present. Notably, Ontario, British Columbia, and Québec have the largest provincial ecosystems in Canada. Private sector presence within each provincial ecosystem is measured using the number of provincially owned companies, foreign-owned companies, offices, and job postings. All four indicators point to Ontario as Canada's largest immersive technology ecosystem, British Columbia and Québec as second and third largest, and Alberta as fourth. The remaining provinces are tied with only a handful of private sector companies in each.

COMPANIES AND OFFICES BY PROVINCE

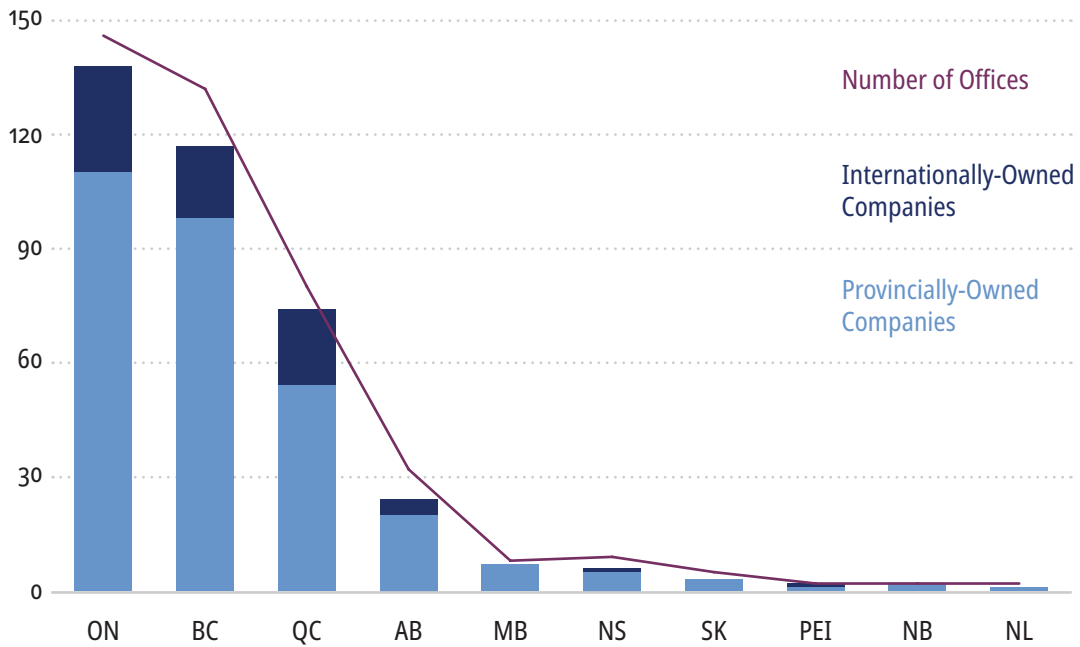


Figure 3. The number of companies and offices in each province. Based on publicly available company data for 353 companies. ICTC, 2020. *No immersive technology companies were found in the Northwest Territories, Yukon, or Nunavut.

UNIQUE JOB POSTINGS BY PROVINCE (2017 TO 2020)

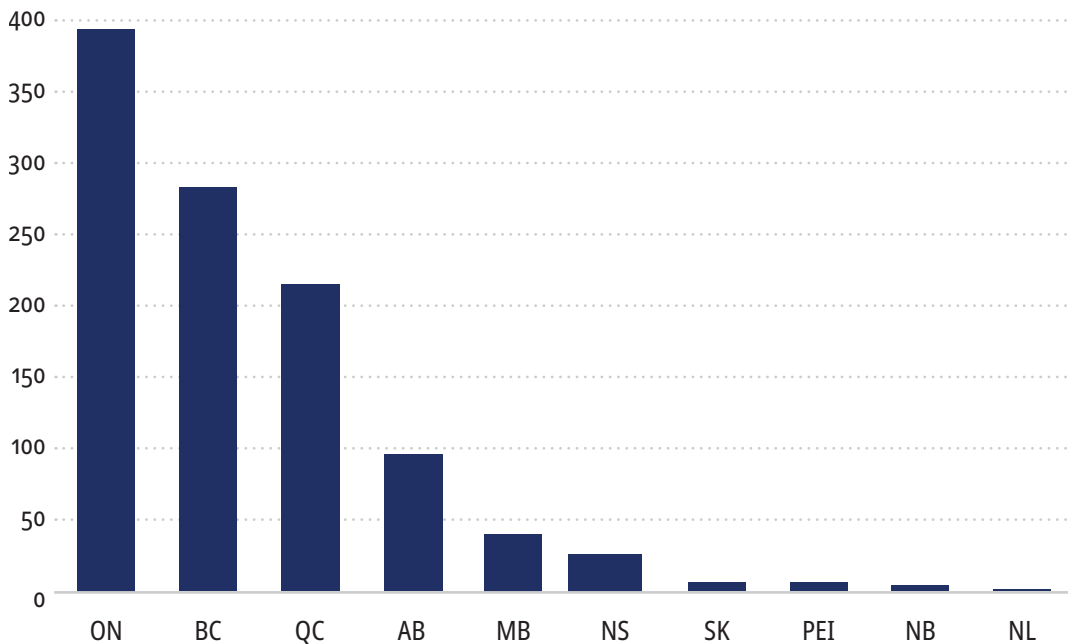


Figure 4. The number of unique job postings by province. Includes jobs posted from 2017 to 2020 on select websites. The lower number of job postings in BC could possibly be due to the high number of companies that were founded there between 2015 and 2016. Emsi data. ICTC, 2020.

In addition to private sector presence, the strength of academic institutions and other industry activity was measured using publicly available data regarding academic programs, industry associations, and social groups. Canada’s largest provincial ecosystems, Ontario, British Columbia, Québec, and Alberta were found to have academic programs specifically dedicated to VR, MR, or AR in addition to closely related programs on 3D design or game development. Similarly, they were found to have industry associations specifically dedicated to immersive technology. The number of social groups in each province on meetup.com followed a similar pattern, with Ontario, British Columbia, Québec, and Alberta showing the strongest presence. Despite there being only one Manitoba-based meetup group on meetup.com, there is a surprisingly large member-base.

ACADEMIC PROGRAMS AND INDUSTRY ASSOCIATIONS

	ON	BC	QC	AB	MB	NS	SK	PEI	NB	NL
Academic program(s) specific to VR/AR/MR	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
Academic program(s) in 3D design or game development	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue
Industry association(s) specific to VR/AR/MR	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue	Light Blue
Industry association(s) for interactive digital media	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Dark Blue	Light Blue	Light Blue

Figure 5. Academic programs and industry associations by province. ICTC, 2020. No academic programs or industry associations were found in the Northwest Territories, Yukon, or Nunavut. Although, the Pinnguaq Association, a not-for-profit organization in Iqaluit, delivers courses on game design, 3D modelling, 3D art, and more. It is possible that some programs were missed in this analysis due to limited online presence or programs being established post data collection.

MEETUP GROUPS BY PROVINCE

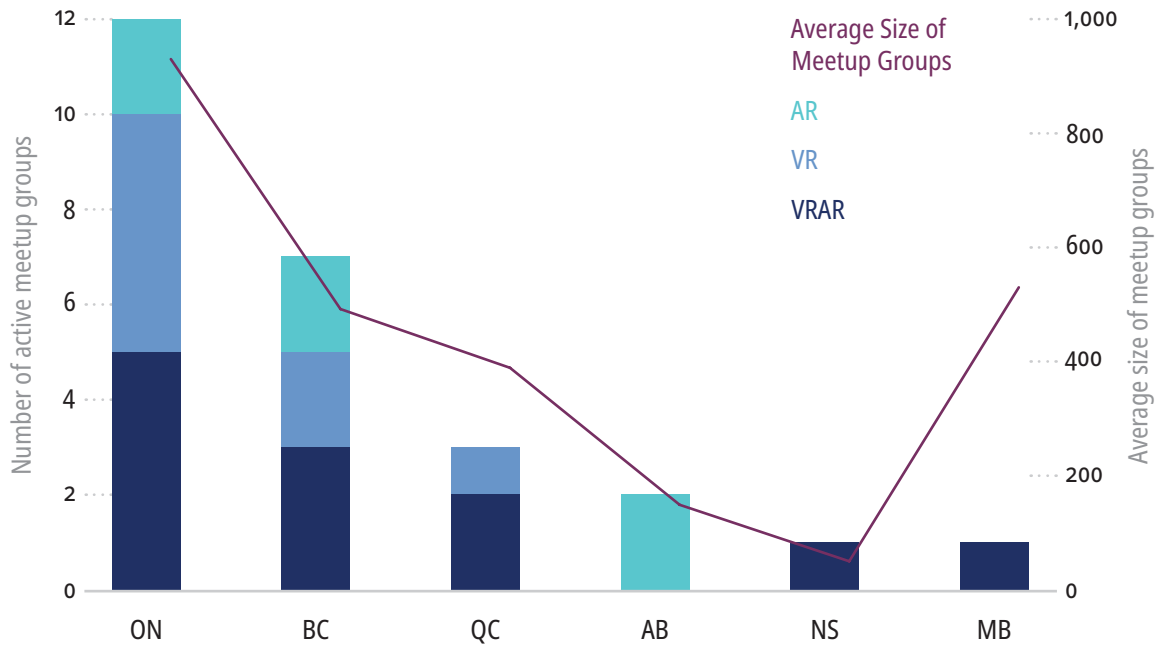


Figure 6. Based on publicly available data from Meetup.com data. ICTC, 2020. No meetup groups were found in regions not listed.

INDUSTRY MATURITY

Canada’s immersive technology ecosystem is new but showing signs of maturity. There has been significant growth in the number of new companies and job postings over time, with 2013 and 2014 marking pivotal years for both the technology and the industry in Canada, and many new immersive technology programs. Regarding size, there is a wide distribution of companies in the industry ranging from 2 to 10 employees, to more than 10,000. In terms of regional and international expansion, 14% of companies in the immersive tech field have opened a second office either in Canada or abroad.

NEW COMPANIES

Despite hinging on relatively new technology, Canada’s immersive tech movement has roots in several well-established industries. As a result, the emerging ecosystem has a firm foundation, with some companies dating back to pre-1990. Growth in the number of new companies has progressed steadily over time, with a noticeable surge in new immersive technology companies founded between 2013 and 2016. Following a “startup peak” in 2016, the industry has further consolidated, and the yearly growth in the number of new companies is now on a downward trend. However, several interviewees participating in this study noted that funding has become scarcer in the industry over time, perhaps explaining the recent drop in new companies founded.⁴⁶ Interestingly, just under half (49%) of the companies in

⁴⁶ When asked why funding may be becoming scarcer in the industry, interviewees provided several possible explanations. For one, they mentioned that there was a huge influx of investment over a short period of time from 2014 to 2016; the high influx of investment then may partially explain the relative downturn since. Some interviewees also noted that a significant portion of the VR, AR, and MR start-ups that were founded in 2014, 2015, and 2016 never became profitable and have since dissolved. Interviewees mentioned that the investors who invested in those companies may be unwilling to invest in immersive technology again. Finally, interviewees discussed that some investors may be waiting for the next “big leap” in immersive technology to decide where and how to invest. This is because breakthroughs in the quality and abilities of headsets and other hardware, cross-platform integration or distribution software, and even other closely related technologies like 5G could significantly impact the direction the industry takes going forward.

Canada's immersive technology industry were established before 2013, when Oculus released the first VR headset. Some of these companies developed new product or service arms internally, while others pivoted their business entirely to cater to the emerging industry. The remaining 51% of the industry is comprised of startups ranging from one to seven years in age.

TOTAL CANADIAN COMPANIES OVER TIME

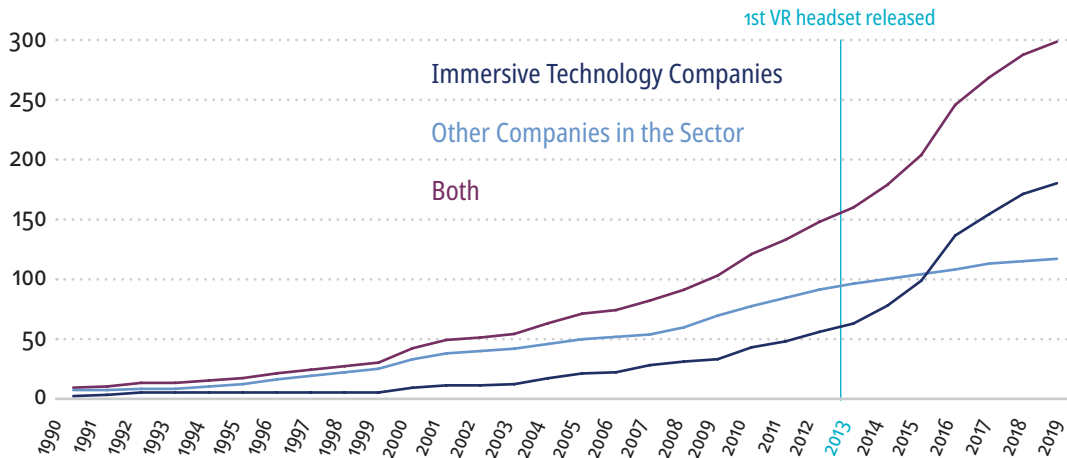


Figure 7. The number of Canadian companies in the industry. Does not include foreign-owned companies. Based on publicly available company data for 299 companies. ICTC, 2020.

CANADIAN COMPANIES FOUNDED PER YEAR, STACKED

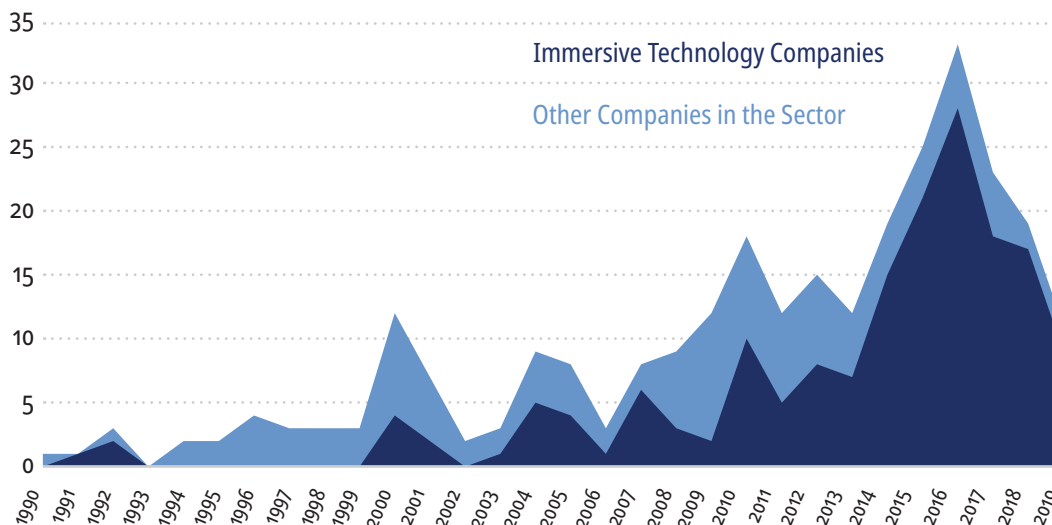


Figure 8. The number of companies founded per year by core value offering. Does not include foreign-owned companies and companies that no longer exist. Based on publicly available company data for 299 companies. ICTC, 2020.

UNIQUE MONTHLY JOB POSTINGS

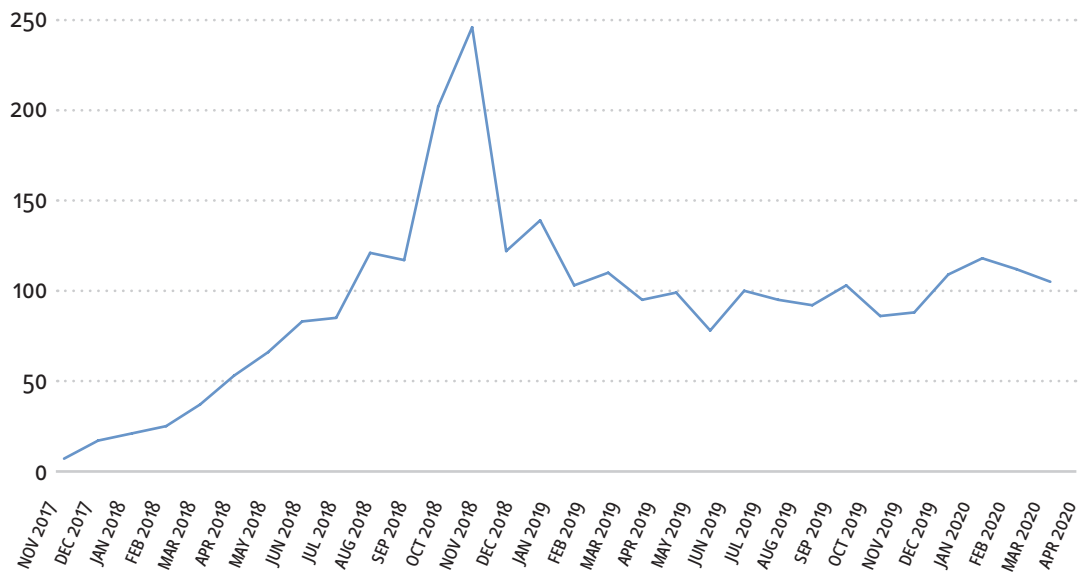


Figure 9. Number of unique job postings per month since November 2017. Figures include only Canadian jobs posted on select websites. Emsi data. ICTC, 2020. ICTC, 2020.

COMPANY SIZE

Traditional approaches to company size place 91% of Canada’s immersive technology industry in the small to medium sized enterprise (SME) category.⁴⁷ This figure jumps to 98% when considering Canadian-owned companies alone, and again to 100% when considering just Canadian-owned immersive technology companies. In other words, no Canadian-owned companies that focus almost entirely on immersive technology products qualify as large enterprises. A more detailed look at small immersive technology companies in Canada finds that 83% have fewer than 26 employees, while 63% have between two and 10. For a Canadian emerging industry, these figures are not out of the ordinary. In fact, SMEs make up 99.8% of all businesses in Canada.⁴⁸ Canadian ICT companies also tend to be small. In 2018, 85.3% of all Canadian ICT companies had between one and nine employees.⁴⁹

⁴⁷ According to classification standards developed by Statistics Canada, small to medium-sized enterprises are businesses with fewer than 500 employees.

⁴⁸ “Key Small Business Statistics - January 2019”, Government of Canada, December 6, 2019, https://www.ic.gc.ca/eic/site/061.nsf/eng/h_03090.html.

⁴⁹ 2018 Canadian ICT Sector Profile: Automotive, Transportation and Digital Technologies Branch, Government of Canada, 2019, p. 4.

CANADIAN COMPANIES BY SIZE AND VALUE OFFERING

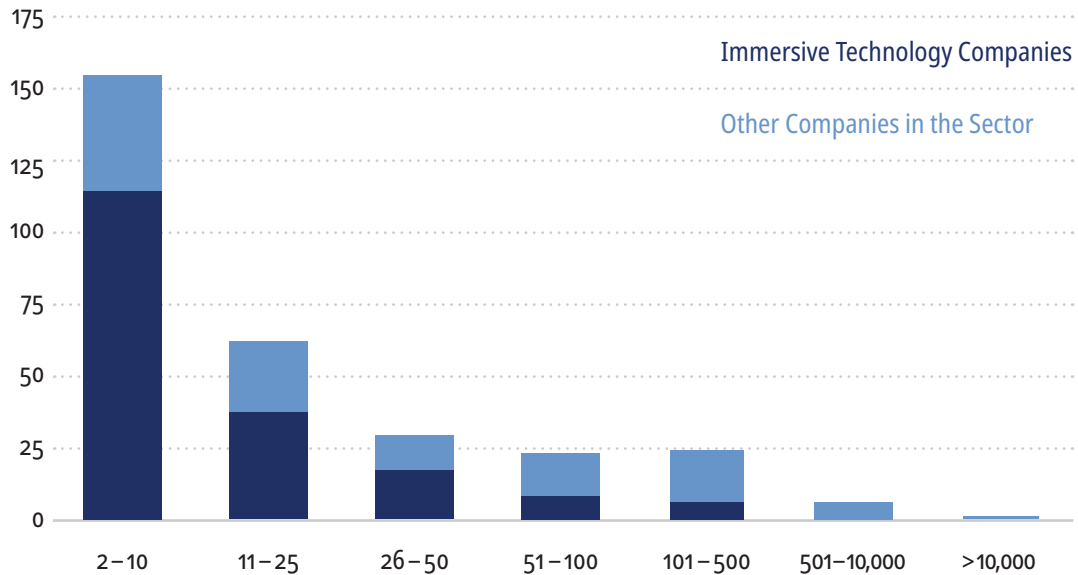


Figure 10. Distribution of Canadian companies in the industry by size and core-value offering. Foreign companies not included. Based on publicly available company data for 299 companies. ICTC, 2020.

The number of immersive technology companies founded in the past seven years shows that operating a business in this industry is enticing for Canadian entrepreneurs, as is the interest in either adopting or pivoting toward immersive tech since its invention. Interestingly, however, in terms of size, certain types of companies have remained relatively small over time. Figure 17 compares the growth of Canadian immersive technology companies with companies in the industry that supply other types of products and services in addition to immersive technology (such as video games and digital media products). Companies whose business models focus exclusively or almost entirely on immersive technology products and services are typically smaller than other companies in the industry, irrespective of when they were founded.

AVERAGE SIZE OF COMPANIES BY YEAR FOUNDED

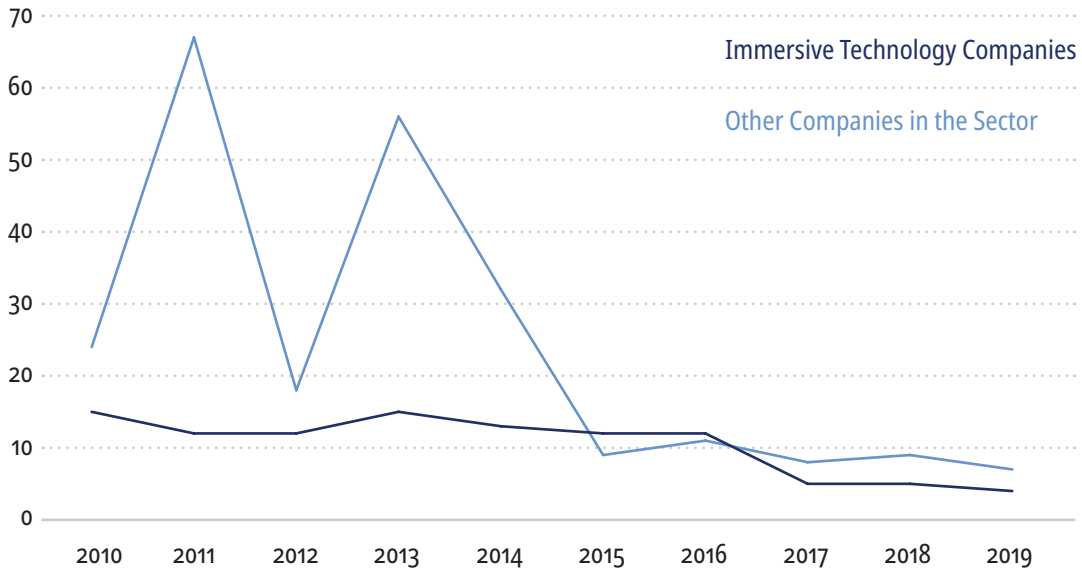


Figure 11. Average size of Canadian companies in the industry by year founded and core-value offering. Based on publicly available company data for 299 companies. ICTC, 2020.

DOMESTIC AND INTERNATIONAL EXPANSION

Beyond company size, the percentage of companies with a physical presence in more than one location can be seen as good indicator for ecosystem maturity. Among all Canadian companies in the industry, 20% have at least two offices, 15% have a foreign office, and 9% have more than one office in Canada. However, among Canadian companies that offer more or less entirely immersive technology products and services, these figures slightly lag, at 15%, 12%, and 7% respectively (see chart below).



Figure 12. Percentage of Canadian immersive technology companies in the industry that have more than one office, more than one domestic office, and at least one foreign office. Does not include foreign companies or other-type Canadian companies in the industry. Based on publicly available data for 182 companies. ICTC, 2020.

Most companies with offices abroad are based out of British Columbia, Ontario, Québec, and Alberta. When moving abroad, Canadian immersive technology companies are mostly likely to open offices in the United States, Asia, and the United Kingdom, a trend that appears to resonate with the rest of the ICT sector as well.⁵⁰ Conversely, foreign companies in the industry are most likely to come from the United States, with a handful based in Asia, Europe, and the United Kingdom. When choosing where to settle in Canada, these companies generally open offices in Toronto, Montreal, or Vancouver.

PERCENTAGE OF PUBLIC AND PRIVATE COMPANIES IN THE IMMERSIVE TECH INDUSTRY

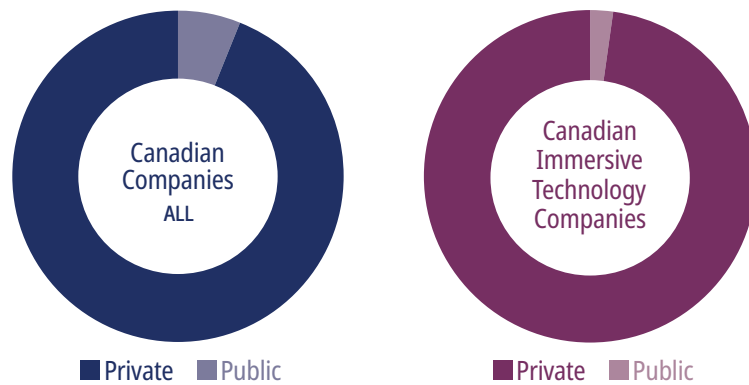


Figure 13. About 6% of Canadian companies in the immersive technology industry are public companies. This number drops to less than 2% when considering Canadian immersive technology companies alone. That said, it is important to note that public companies tend to have a more established online presence and, therefore, may be more likely to show up in online searches. For that reason, actual percentages may be lower than expressed in this data set.

BUSINESS MODELS

One defining feature of immersive technology is its inherent versatility; as a communication and spatial computing tool, there is almost no limit to the number of possible applications that exist. In terms of business models, however, the possibilities are much more limited. Immersive technology companies generally fall into one (and sometimes two) of the following categories: service companies, product companies, and studios.

SERVICE COMPANIES

Value Offering Service companies build custom ICT solutions for their clients at a billable rate. For some companies in the immersive technology industry, the range of ICT solutions is much more limited, focusing exclusively or almost entirely on solutions that use AR, MR, or VR in some capacity. For others, the service offering is much more expansive. Depending on the business, it can include traditional web and mobile app development, marketing and advertising, and digital transformation.

⁵⁰ *Ibid*, p. 5.

Similarly, service companies vary by degree of automation: some have a streamlined and semi-automated process for creating AR, MR, or VR solutions for their clients, while others build almost everything from scratch for each new project. Oftentimes, the degree of automation involved in production can impact how costly a company's services will be for the client. Below are two examples of industry consultants explaining their company's value offering.



Basically, we do everything. We create the content, but we also create the technology and baseline programming that runs all the content. And in addition to that we provide all the hardware and professional services to make sure it's effectively integrated with our clients' existing technology infrastructure, as well as maintenance support when needed.

— **CEO, VR/AR Company, Toronto**



We create immersive or interactive experiences for educational and experience-related purposes. These range from 360-degree video to video-game type experiences, to training simulations.

— **CEO, VR/AR Company, Calgary**

Benefits The main benefit associated with the service model is that clients can constitute an alternative and additional source of upfront financing when other financing options are not available. This can help fund other business lines, such as research and development. Product companies and studios must often seek financing long before their products become available on the market, whereas service companies can to some extent rely on clients for sustainable funding throughout the course of a project.

Challenges Interviewees who shared their insights in this study highlighted several challenges related to the service model. First, they mentioned that businesses based on the provision of custom-built solutions can be more difficult to scale, as their outputs are often tied to a single client with specific needs. This means that outside of maintaining and updating completed projects, service companies need to find new clients on an ongoing basis to continue drawing in revenue. With an increasing number of service companies and—for now—only a finite number of clients available, finding new clients can be time consuming and costly for some, and the newer the technology is to a potential client, the longer the sales cycle is likely to take.

PRODUCT COMPANIES

Value Offering Product companies create generalized products that can be used by customers in a variety of situations. These products typically fall into one of three buckets:

Hardware and software tools used to create immersive technology solutions, such as 3D scanners, motion trackers, VR headsets, IoT components, content development tools and platforms, content distribution and management platforms, analytics software, etc.

Off-the-shelf immersive technology solutions sold as products themselves, such as generalized training simulations, AR Sports goggles, remote worker support tools, etc.

Creative content, such as video games, location-based entertainment games, creative content, narrative content, etc.

The profit structure employed depends largely on the type of product. Companies may choose to sell their products at a fixed price per unit or under a licence or subscription-based model.

Benefits Interviewees highlighted the greater ability to scale as the main benefit associated with the product model. While the cost of onboarding new customers or maintaining existing customers can vary, once the product is built there is typically little cost associated with new customers.⁵¹ Product companies can therefore have greater capacity to take on new customers. Service companies, on the other hand, can be limited by the number of clients and projects that their team can accommodate simultaneously. Industry consultants also indicated that the sales cycle tends to be shorter for products as opposed to services, especially when the hardware and the experience required to use the product is limited or low cost.

Challenges A major challenge faced by product companies is financing. Some interviews highlighted that, as product companies, they had to secure financing before building their products and releasing them to market. Unlike service companies that pivoted from offering service development to creating a product, they generally were not able to rely on customers as an alternative source of upfront financing. These interviewees instead relied almost exclusively on government funding, angel investors, private equity, and venture capital. Another challenge is creating development tools or off-the-shelf technology solutions that are interoperable between different devices. For solutions to remain relevant, they must be able to continue to function with new headsets, wearables, and other devices as they are released.

⁵¹ Product companies are likely to have upkeep and maintenance costs associated with existing customers and marketing, sales, and onboarding costs associated with new customers but are not as likely to have the high new customer costs that service companies experience. For service companies, getting a new client can mean ideating with that client, establishing a plan for what will be created, developing the custom solution, and then integrating that solution into an existing IT infrastructure and assisting with onboarding and testing.

HYBRID PRODUCT AND SERVICE COMPANIES

Value Offering Some companies transition from selling either products or services to both products and services. For example, this occurs when a service company decides to productize the software tools that they use to create solutions. Interviewees highlighted that by offering both products and services to market, they can sometimes diversify their value offerings and revenue streams, resulting in a more stable business model.

DISTRIBUTION OF CANADIAN COMPANIES BY BUSINESS MODEL

Canada's immersive technology industry is diverse, with a near equal distribution between product (50%) and service (46%) companies. Among product companies exclusively, there is also a variety of product company types. Creative content companies supplying video games and VR experiences for entertainment purposes account for 38% of Canadian product companies, while those supplying hardware and software tools account for 36%. The remaining 26% consists of companies that supply off-the-shelf solutions like generalized training simulations, AR sports goggles, and remote worker support tools.

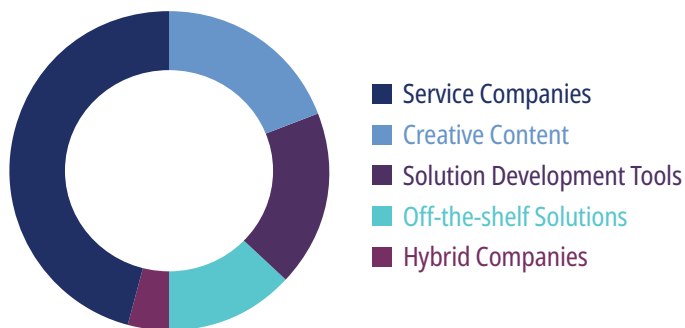


Figure 14. Distribution of Canadian immersive technology companies by business model. Does not include foreign companies and other-type companies in the industry. Based on publicly available data for 183 companies. ICTC, 2020.

On average, over the past five years, just 12% of immersive technology patents filed in Canada were filed by Canadian companies. Several interviewees mentioned being advised by funders to prioritize patent filing in the US over Canada, a trend which, if widely spread, may influence how many patents are filed in Canada by Canadian companies. Interviewees also noted that from a cost-benefit perspective and with funding becoming increasingly rare in recent years, expenses related to securing a patent can be difficult to justify.

PATENTS FILED IN CANADA PER YEAR

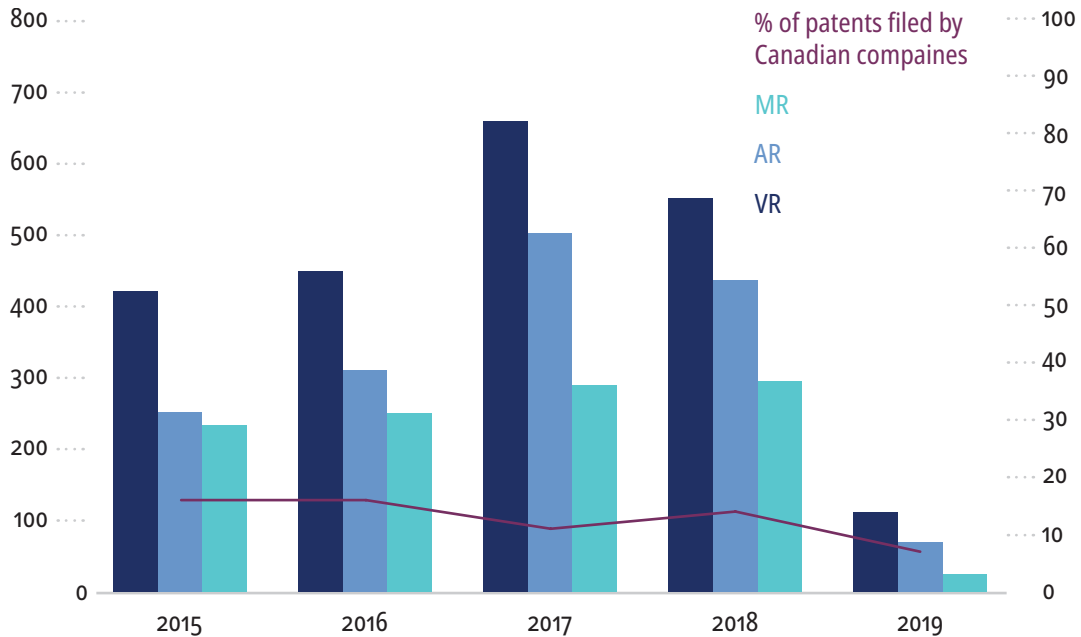


Figure 15. Number of immersive technology patents filed in Canada per year, and percentage of immersive technology patents filed in Canada by Canadian companies. Publicly available data from the Canadian Intellectual Property Office. ICTC, 2020.

SECTOR CHALLENGES

SECURING CANADIAN INVESTORS

Apart from government grants and tax credit programs, it is challenging for immersive technology companies to find and secure funding in Canada.⁵² In 2018, industry representatives from Toronto and Vancouver stated that Canada’s immersive technology industry was showing signs of shallow homegrown investment.⁵³ Two years later, similar comments were made by interviewees in this study. Almost all companies interviewed by ICTC for this report source most of their funding from foreign investors—for the most part, venture capital firms or angel investors from the United States. Interviewees noted that having to rely on foreign investors increases the cost of doing business for Canadian companies: it takes more time and money to develop and maintain foreign relationships. Others commented that foreign investors lack awareness of Canada’s funding and tax credit programs and noted that it often falls on Canadian companies to provide that information. When asked why it is so difficult to acquire funding from Canadian investors, interviewees highlighted two challenges:

⁵² Some interviewees noted that funding has become more scarce in the industry, perhaps explaining the recent drop in new companies founded.

⁵³ “Canadian augmented and virtual reality industry lacks homegrown investors,” *The Canadian Press*, February 1, 2018, <https://www.cbc.ca/news/business/augmented-virtual-reality-investors-1.4513809>.

“In many ways, Canadian investors are very risk averse.” Interviewees highlighted that when it comes to investing in new startups or new technology, Canadian investors are risk averse. They tend to invest in late stage companies (companies that are almost profitable), whereas immersive technology startups need early-stage financial support.

“Knowledge of the technology is low.” In addition to being risk averse, interviewees stated that Canadian investors are not as familiar with immersive technology (and its benefits) as foreign investors tend to be. This can make pitches and other investment-related discussions challenging. Knowledge of the technology tends to be lower outside Canada’s main immersive technology hubs.

Finally, many interviewees noted that when Canadian investors were willing to make an investment in their companies, their terms were out of touch with industry realities. For one, they noted that, compared with foreign investors, Canadian investors wanted more equity for less for money. They also placed more conditions on funding than their foreign counterparts, such as overly burdensome, labour-intensive reporting requirements. Foreign investors were, on the other hand, described as more willing, and more likely to put forward reasonable terms.

FINDING CANADIAN CLIENTS



We’re great technology producers, but we’re not great technology adopters.

— **CEO, VR/AR Company, Vancouver**

Despite many suppliers of immersive technology products and services in Canada, the adoption of immersive technology by Canadian companies is somewhat less prevalent. One-third of companies interviewed by ICTC (n=17) rely either exclusively or almost entirely on foreign clients, which may explain why 7% of Canada’s immersive technology companies chose to open a foreign office before opening a second Canadian office, and why 12% of have offices abroad. The remaining two-thirds of companies interviewed by ICTC work with foreign and Canadian clients, but those with Canadian clients work mainly with established companies and government organizations.⁵⁴ Although adoption in Canada is increasing,⁵⁵ it appears that for many of Canada’s SMEs, immersive technology is still somewhat out of reach. When asked why adoption remains low among Canadian companies, interviewees highlighted several possible reasons:

⁵⁴ Dan Burger, Alex Chuang, *Reality Check: The State of Vancouver and BC’s VR/AR Ecosystem*, Vancouver Economic Commission, Vancouver VRAR Society, and VIFF, April 2020.

⁵⁵ While adoption in Canada has been increasing steadily over the past year, industry consultants anticipate that post COVID-19 there will be a spike in interest among Canadian and international companies. Often, companies are interested adopting immersive technology solutions to accommodate new work-from-home and learn-from-home requirements. Now that it is more difficult, costly, and in many cases dangerous to travel, the benefits of immersive technology solutions such as remote collaboration, virtual events, and virtual tours increasingly outweigh the cost.

“Immersive technology still isn’t cheap.” Costing anywhere between \$250,000 to \$500,000 a piece, several interviewees highlighted the cost of custom-built immersive technology products as a potential barrier to entry. Canadian companies tend to operate on lower budgets than their multinational counterparts, which may render services too expensive for many. That said, the high cost of custom-built products has opened new markets for easy-to-use, content-development software. Alongside more affordable hardware, this kind of software is making immersive tech more widely accessible at a lower cost.

“They haven’t been shown what’s possible.” Several interviewees highlighted the perceived complexity of immersive technology as an explanation for low adoption. Many companies are not aware of what immersive technology can do or what its practical applications are and, therefore, are not sure how to apply it within their business. Others noted the excessive complexity of “do-it-yourself” content-development platforms (content development platforms that are available for clients to create their own immersive technology content).

Several interviewees highlighted that while other parts of the world, such as the United States, United Kingdom, and Europe, are very agile when it comes to adoption, Canadian companies want to make sure new technologies are safe and that their value has been tested and validated by others first. Adoption may increase among smaller Canadian companies as the accompanying hardware (e.g. computers, laptops, controllers, etc.) becomes less expensive and as companies familiarize themselves with the easy-to-use and near autonomous development tools that are on the market today. One of main benefits of immersive technology is that it is intuitive and easily incorporated into existing business practices in industries where there is already high use of 3D or spatial information, such as in oil and gas, mining, and architecture and design. This is because many of these industries already use the fundamental building blocks for 3D models (point clouds and other types of spatial information). As one industry consultant put it, “At this point, VR and AR tools are no more difficult to learn than Microsoft Word.”

Adoption may also progress with the emergence of cross-platform functionality as an industry best practice. By making immersive technology solutions accessible from any device and on any screen (e.g. headsets, mobile phones, desktop computers, laptops, etc.), more employees can access 3D models and other content whether they have the specialized hardware available to them or not. This would mean that companies could start out small and scale up incrementally as needed, without having to make the entire hardware investment upfront.

NOT A SKILLS GAP, BUT A LEARNING CURVE



Because the technology is so unique, it's near impossible for us to say, 'You need to understand VR development specifically.' But if they have the fundamental skill sets—Unity, C#, or 3D modelling—they can easily transfer those skills to VR.

— **CEO, VR/AR Company, Toronto**

Overall, immersive technology companies are accessing the talent they need to grow their businesses. Interviewees whose companies develop immersive solutions suggested that talent with a software development background is a fairly good fit for development roles in AR or VR but require some additional upskilling or training while on the job. Although some regions—Central and Atlantic Canada and Montréal, for example—appear to experience more challenges than others in accessing skilled talent, most interviewees explained that they do not experience challenges accessing the right talent.⁵⁶ Nonetheless, many of Canada's college and university academic programs in VR, AR, and MR are new, with some of the earliest courses and certificates dating back to 2017.⁵⁷ This means that much of the current workforce was self-taught: people with existing backgrounds in programming, software development, and game development learned to use new applications, hardware, and software development kits as they were released.

Many of the roles that are important to immersive technology today previously existed in other sectors in some capacity, including Software Engineers, UX/UI designers, and 3D Artists. While the learning curve involved in transition to immersive tech was described as relatively small by interviewees in this study, it varies between roles. For a 3D Artist or Software Engineer working in an adjacent industry, interviewees asserted that it is relatively easy to make the switch to immersive technology; however, for someone working in UX or UI design, the transition can be a bit more challenging. Consider the complexities that come along with new styles of interaction like eye tracking and hand gestures or novel considerations regarding the user's field-of-view.

Similarly, interviewees noted that talent with experience in videogame development or other entertainment-oriented industries can face a learning curve when hired by enterprise-oriented companies. Designing and building products for consumers for entertainment purposes is very different to designing and building products for enterprise-level companies. In the latter context, the main goal is solving a business problem and the integration of new tools into existing IT and security infrastructure is an important skill; in the former, the main goal is consumer entertainment, and there is no need for enterprise integration.

⁵⁶ Interviewees from Montréal, for example, described fierce competition from video game companies for top 3D talent. Interviewees from Alberta explained that it can be challenging to find talent with practical, hands-on experience selling tech solutions as opposed to oil and gas products.

⁵⁷ Jocelyne Leszczynski, "Microsoft announces education partnership for BCIT", *BCIT News*, November 1, 2017, <https://commons.bcit.ca/news/2017/11/37584/>.

LACK OF DIVERSITY IN LEADERSHIP ROLES

Gender imbalances are prevalent across the ICT sector generally, and even more so among technically oriented roles. Women account for 31.8% of the ICT sector generally, however, just 20% of ICT roles in the ICT sector.⁵⁸ While there are significant gender imbalances in immersive technology talent, the disparity is most evident in leadership roles; according to data collected by ICTC, just 8% of Canadian immersive technology companies have female leaders, whether that be in the capacity of CEO, president, or executive director. Male-led companies, on the other hand, account for a resounding 89%, while the remaining 3% of companies are co-led by female-male duos (see breakdown below).

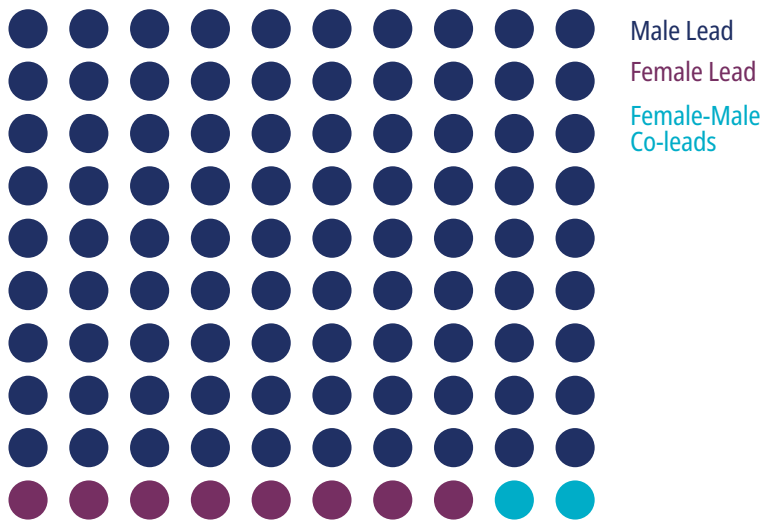
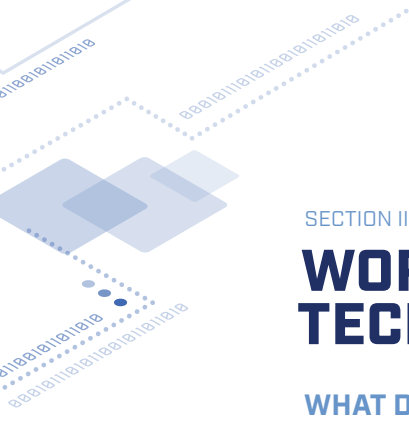


Figure 16. Percentage of Canadian immersive technology companies with male leads, female leads, and female-male co-leads. Based on publicly available company data for 182 companies. ICTC, 2020.

⁵⁸ Statistics Canada, ICTC.



SECTION III

WORKING IN THE IMMERSIVE TECHNOLOGY SECTOR

WHAT DO IMMERSIVE TECHNOLOGY TEAMS LOOK LIKE?

While the exact makeup of an immersive technology team will depend on the company's size and business model, at the most basic level, all immersive technology teams need some individuals with technical development skills and others with creative design skills. Smaller teams tend to have less members with more diverse, overlapping skillsets, while larger teams tend to have more members with distinct and separate roles. Most teams have a combination of Software Developers and Engineers, Product Managers, and System Architects on the development side, and Creative Directors, 3D Artists, and User Interface and Experience Designers (UI/UXI) on the design side.

Interviewees noted that, increasingly, technical development teams will also have a domain-specific technical advisor. One example is Privacy Advisors for applications with strong privacy implications such as those that require eye tracking or audio recording. Other examples include Medical or Regulatory Advisors for applications used as medical devices or in medical training, and Accessibility Advisors to ensure applications meet accessibility requirements. Companies that develop custom solutions for clients may also have Enterprise Operations and Deployment Specialists or Quality Assurance Specialists to navigate client relations. Similarly, companies that incorporate big data, analytics, or ML into their solutions may also have Data Scientists or Data Engineers.

On average, two out of three employees at companies interviewed by ICTC require technical ICT skills, while the remaining one-third are in sales, marketing, human resource, and business development positions. In addition to technical skills, interviewees identified a fundamental requirement for business-related skills (e.g. pitching, fundraising, etc.) due to the high number of startups and new companies in the space. Similarly, ability and aptitude to learn was highlighted as an important skill due to the relative newness and evolving nature of the technology field. According to interviewees in this study, new devices, hardware, and software programs are released and incorporated into the existing ecosystem as often as every six months, which necessitates a talent base that is agile and constantly upgrading their competencies.

THE IMMERSIVE TECHNOLOGY TEAM

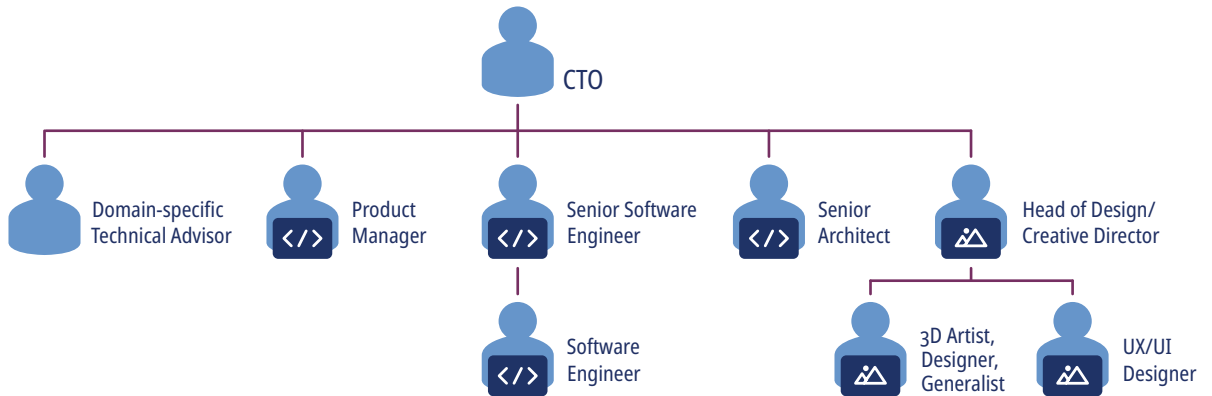


Figure 17. Technical immersive technology roles. This infographic summarizes top immersive technology roles. Roles were identified through web scraping (e.g. job postings, talent profiles) and discussions with industry representatives. ICTC, 2020.

TOP JOB TITLES 2017 TO 2020

An analysis of 1,070 unique job postings from 2017 to 2020 shows the following top six job titles across the immersive technology sector.⁵⁹ In order to be included, jobs had to be located within Canada’s ICT sector, and job postings had to include one of the following key terms: augmented reality; AR; réalité augmentée; virtual reality; VR; réalité virtuelle; and mixed reality.

- 1 Software Engineer
- 2 User Interface Designer
- 3 Web Developer
- 4 Programmer⁶⁰
- 5 Animator
- 6 Graphic Designer

TOP SALARY POSTINGS

Analysis of 112 job postings from 2017 to 2020 showed an average advertised salary of C\$80,300, and most frequent salary of between C\$70,000 and C\$95,000 in the immersive technology sector. To be included in the analysis, jobs had to be located within Canada’s ICT sector. Job postings had to include both publicly available salary data and one of the following key terms: augmented reality; AR; réalité augmentée; virtual reality; VR; réalité virtuelle; and mixed reality (only 10 % of job postings acquired from this period advertised salary publicly).

⁵⁹ Emsi, 2020.

⁶⁰ Proficiency in programming languages C#, C++, and C weighted strongly.

WHAT SKILLSETS DOES TOP TALENT IN THE IMMERSIVE TECHNOLOGY INDUSTRY HAVE?

Interviewees consulted in this study highlighted university and college programs as important to the development of new immersive technology talent. Specifically, programs related to game development, software development, and computer engineering were deemed important for technical development roles. Similarly, programs related to interactive digital media, arts, and design were identified as important for design-centred roles. An analysis of 100 companies in Canada's immersive technology sector found "Computer Science, Computer Engineer, and Software Development" to be the most common academic backgrounds among immersive technology talent. "Video Game Development, Animation, and Interactive Media" and "Graphic Design, Multimedia Design, and Visual Communications" follow closely behind.

- 1 Computer Science, Computer Engineering, and Software Development
- 2 Videogame Development, Animation, and Interactive Media Design
- 3 Graphic Design, Multimedia Design, and Visual Communications
- 4 Marketing and Advertising
- 5 TV and Film
- 6 Visual and Performing Arts
- 7 Civil, Mechanical, and Electrical Engineering



TECHNICAL ROLES IN IMMERSIVE TECHNOLOGY

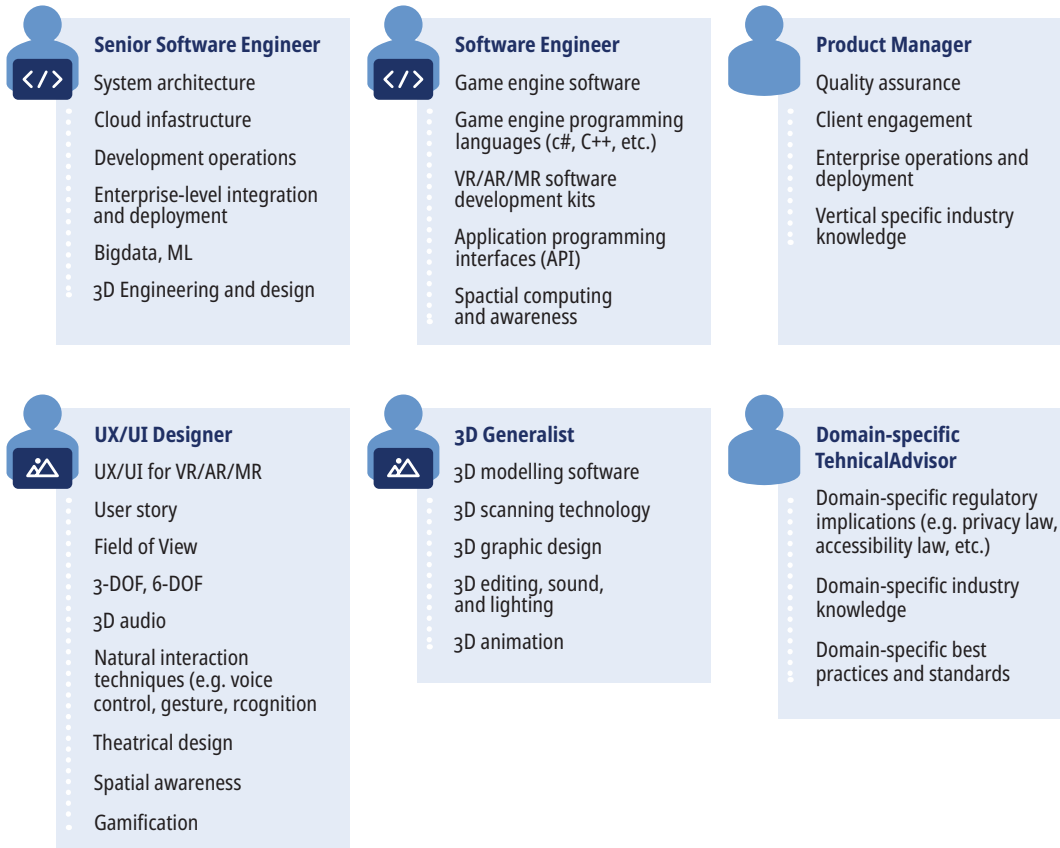


Figure 18. Core immersive technology skills. This infographic summarizes top immersive technology skills. Skills were identified through web scraping (job postings, talent profiles) and discussions with industry representatives. ICTC, 2020.

CONCLUSION

Immersive technology has a long history dating back more than 50 years, but despite this history, AR, VR, and MR have only recently become sophisticated enough to see enterprise-level experimentation and adoption. The first modern VR and AR headsets were created in 2013 and 2014. Since then, more than 150 new companies with immersive technology products and services have been founded in Canada. Today, the immersive technology industry totals more than 350 companies mostly located in Ontario, British Columbia, Québec, and Alberta. A growing number of these companies are finding success outside the immersive industry's entertainment-based roots in sectors like health and biotechnology, clean tech and clean resources, and advanced manufacturing. Despite this, the adoption of VR, AR, and MR by Canadian companies is somewhat less advanced. The industry currently faces some challenges in accessing Canadian financing and clients.

Increased adoption of immersive tech in the coming years is likely dependent on headsets and other hardware devices becoming cheaper and more accessible, and use cases and their benefits becoming more widely understood in Canada. With greater adoption, immersive technology has the potential for notable impact across traditional non-tech sectors, providing efficiencies and unique solutions to business problems. Examples include “on-site” planning via VR for remote locations in the natural resource sector and automated assistance in a factory setting through an AR overlay to assist with repetitive tasks. In a more remote and connected future, immersive tech may achieve a broad product/ market fit for both consumer and commercial audiences. Defining and building clear use cases, securing necessary funding, and securing and supporting a skilled talent base will be key to unlocking new consumer demand for this budding Canadian industry.



APPENDICES

APPENDIX A: CASE STUDY: BUILDING AN MR WAY-FINDING TOOL

Consider the steps involved in building an MR way-finding tool to assist warehouse workers in navigating a new, 600,000 square foot warehouse to find and identify specific pieces of equipment within it. Why MR? Functionally, workers would need to maintain visual connection with their real-world surroundings to safely navigate the warehouse with their hands unencumbered so as to carry pieces of equipment. In other words, for this application, an MR headset would likely be the most suitable hardware option.

BUILD A DIGITAL TWIN

The first step in the process is building a 3D model of the warehouse. This can be done from scratch using a 3D engine like Unity or Unreal from a point cloud using a 3D scanner (e.g. LiDAR or camera-based software), or a combination of both.

MAP THE DIGITAL TWIN

The second step is to assign unique values to each section of the warehouse and correlate those values with each piece of equipment. This will enable the application to guide workers from point A (the worker's location) to point B (the equipment's location) within the warehouse.

INCORPORATE A TRACKING MECHANISM

The third step is to integrate a tracking system to track the worker's location in real time. Depending on the scale of the tracking required, this can be done using basic GPS, a third-party 6DoF tracking system, or an AR headset already equipped with 6DoF tracking. This will enable the application to track the worker as they move throughout the warehouse and update instructions in real time.

PROGRAM THE INSTRUCTIONS

The fourth step is to program a set of instructions to guide workers around the warehouse and toward specific pieces of equipment. One way to do this would be to program a set of macro-level instructions to guide workers between identified sections of the warehouse (e.g. warehouse separated by isles), followed by a set of micro-level instructions to guide workers within those sections (e.g. isles separated by identified subsections, for example, by bottom, middle, and top shelves).

ENABLE EQUIPMENT VERIFICATION

The final step is to create 3D models of each piece of equipment and incorporate them into the application. A basic version of the application might display 3D images of the equipment to the warehouse worker, while a more advanced version may integrate a computer vision to autonomously verify each piece.

APPENDIX B: DETAILED BREAKDOWN OF INDICATORS ASSESSING PROVINCIAL STRENGTH IN IMMERSIVE TECHNOLOGY

PRIVATE SECTOR

- 1** The number of companies founded in that province (e.g. provincially owned companies)
- 2** The number of companies founded in that province (e.g. provincially owned companies).
- 3** The number of companies founded outside of Canada that have opened offices in that province (e.g. foreign-owned companies).
- 4** The total number of offices in that province (e.g. number of offices).
- 5** The number of unique job postings for immersive technology roles posted on select sites between 2017 and 2020 (e.g. unique job postings).

ACADEMIC SECTOR

- 6** Whether there are academic programs dedicated to immersive technology (e.g. academic program(s) specific to VR/AR/MR).
- 7** Whether there are academic programs in a related field (e.g. academic program(s) in 3D design or game development).

ECOSYSTEM SUPPORTS

- 8** Whether there are industry association(s) for immersive technology companies and professionals (e.g. industry association(s) specific to VR/AR/MR).
- 9** Whether there are industry association(s) for a related field (e.g. industry association(s) for interactive digital media).
- 10** The number and size of meetup groups related to immersive technology (e.g. meetup groups by province).

APPENDIX C: METHODOLOGY

The findings in this report were informed by primary and secondary research conducted by ICTC. This section on methodology discusses the sources used in addition to the research limitations.

PRIMARY DATA SOURCES

QUALITATIVE

Key Informant Interviews Between January and March 2020, ICTC conducted 17 semi-structured key informant interviews with individuals from Canada's immersive technology industry. Participants held high-level positions within their companies and organizations, with titles Chief Executive Officer, Chief Revenue Officer, Founder, President, and Director. In conducting these interviews, ICTC's objective was to identify national and regional trends in the immersive technology industry related to talent and skills, financing and uptake, use cases, and new innovations. Interview questions were informed by a literature review conducted at the outset of the project.

Participants were identified based on current job title and their company or organization's position in the immersive technology industry. A diversity of participants and companies were chosen to ensure a broad range of perspectives and input for the report (company size, location, maturity, type of products and services provided). Participants were sourced from Ontario, British Columbia, Alberta, Québec, New Brunswick, and Nova Scotia. Ontario and British Columbia accounting for 52% of interviewees. Founding dates for companies interviewed range from 1990 to 2019, with 46% of companies having been founded between 2014 and 2016. Company size ranged from small (2 to 10 employees) to large (101 to 500 employees). There was a near even split between companies that provide only immersive technology products and services, and companies that provide other types of products and services such as marketing and advertising, digital media, or ICT solutions. Similarly, among immersive technology companies, there was an even distribution of product and service companies.

Advisory Committee ICTC held two advisory committee meetings in tandem with the interviews to discuss and validate research findings and to receive feedback from industry. These meetings were held in March and May, one closer to the outset, and one toward the end of the project. Nine advisory committee members were drawn from industry and civil sector organizations, which also varied in size, location, and function. Committee members were from British Columbia, Ontario, Nova Scotia, and Alberta. These organizations ranged from 2 to 50 people in size.

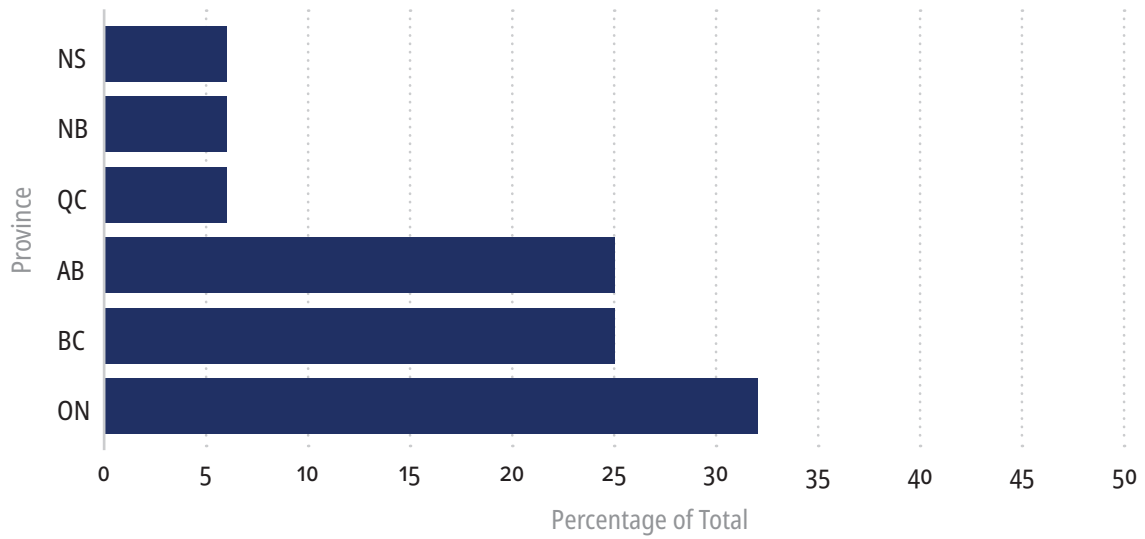


Figure 18. Distribution of interviewees by province (percentage of total). ICTC, 2020.

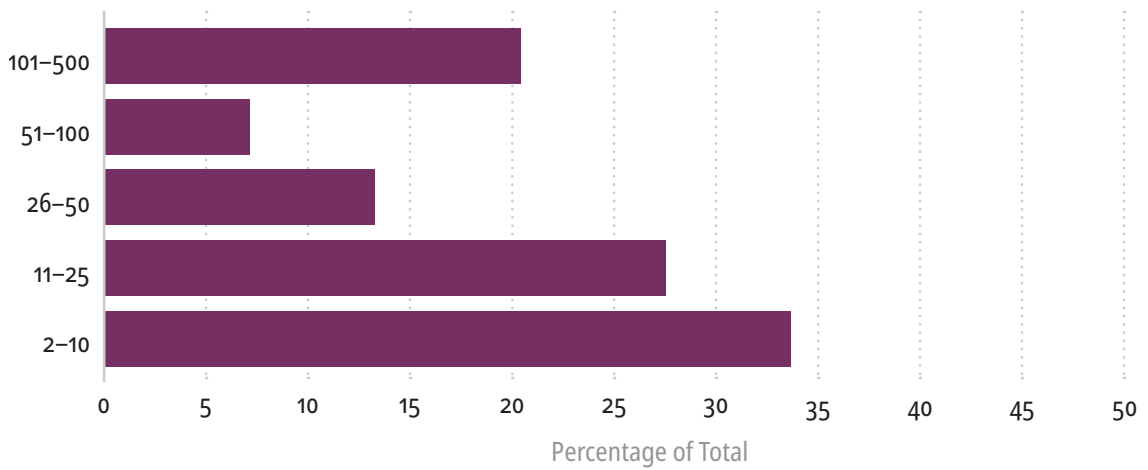


Figure 19. Distribution of interviewees by company size (percentage of total). ICTC, 2020.

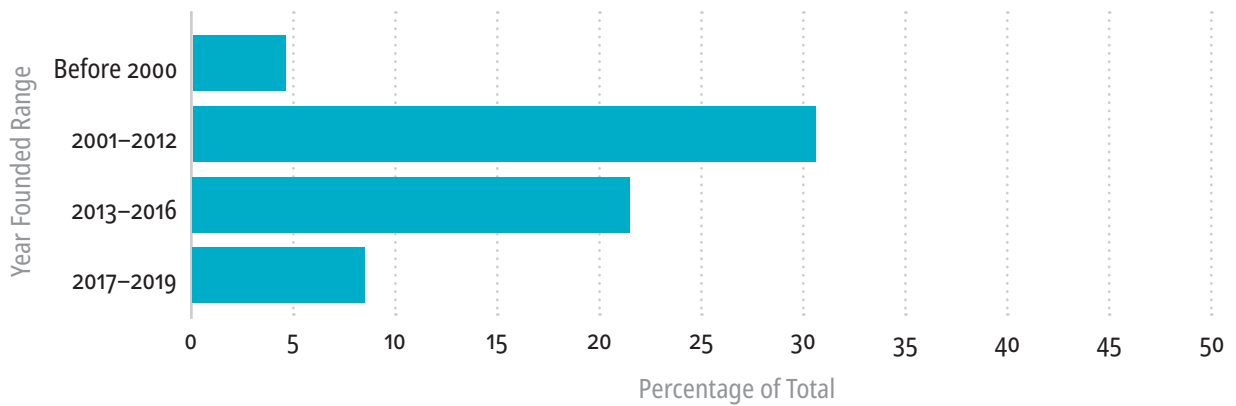


Figure 20. Distribution of interviewees by company founded date (percentage of total). ICTC, 2020.

QUANTITATIVE

Company Data Web Scraping Companies active in Canada's immersive technology industry were identified through comprehensive web scraping of publicly available information. The terms augmented reality, AR, réalité augmentée, virtual reality, VR, réalité virtuelle, mixed reality, MR, and immersive technology were used in various search engines and data bases to identify the first round of companies, at which point a waterfall approach was used. Company data included size, date founded, status as a publicly traded or privately held company, business model, province or country of ownership, location of offices, and gender of CEO. The search excluded companies that appeared to be inactive (i.e., inactive website and no social media activity) or false positives (i.e., using immersive technology keywords in marketing materials or articles but without offering a service or product related immersive technology). Companies that offer other types of products and services in addition to immersive technology were included in the larger database, however, some statistics in this report reference only those that supply exclusively or almost entirely immersive technology products and services. These companies are identified throughout the report.

Skills Data Web Scraping ICTC used web scraping techniques to identify skills that are important in the immersive technology industry. Sources used for scraping include publicly available information from university websites, job aggregation websites, etc. This information was validated during the interviews and advisory committee meetings.

SECONDARY DATA SOURCES

Literature Review Primary research, including qualitative and quantitative data collection, was informed by a comprehensive review of existing literature on the topic. Publications were sourced from industry, academia, and civil sector, and provided to ICTC by key informant interview participants and advisory committee members. Preliminary findings from the literature review were used to identify potential interviewees and advisory committee members at the outset of the project, and to design research questions.

In addition to the literature review, ICTC accessed secondary data sources, including Canadian patent data, job posting data, and data from Meetup.com.

Patent Data Patent data from the Canadian Intellectual Property Office was accessed using keywords "Virtual Reality," "Augmented Reality," and "Mixed Reality." Data was gathered April 24, 2020.

Meetup Data Meetup data appears in Figure 6 and was gathered on April 24, 2020. The search terms augmented reality, AR, réalité augmentée, virtual reality, VR, réalité virtuelle, mixed reality, MR, and immersive reality were used for each provincial and territorial capital city in addition to large cities within each province other than the capital (for example, Toronto, Calgary, Vancouver, and Saskatoon). The search gathered data on the largest meetup for each search term, the number of members in each meetup, and confirmed each meetup was active.

Job Posting Data Job posting data from Emsi was accessed in May 2020. Postings were filtered using several parameters including region, occupation, keyword searches, and timeframe. In order to be included, jobs needed to be located in Canada's ICT sector and include one of the following key words: augmented reality, AR, réalité augmentée, virtual reality, VR, réalité virtuelle, mixed reality, MR, or immersive technology. Occupations searched included the following: computer engineers, software engineers and designers, computer programmers and interactive media developers, web designers and developers, and graphic designers and illustrators.

LIMITATIONS OF RESEARCH

Along with efforts to mitigate potential biases, two advisory committee meetings were held to validate ICTC's research findings. Nonetheless, given the relative newness of immersive technology coupled with constraints regarding the number of possible interviews, some inaccuracies may have been overlooked. This section highlights those research limitations.

Key Informant Interviews As discussed, ICTC conducted 17 interviews with individuals from companies across Canada, a sample pool that is too small to be considered representative of the entire industry. Statements and other qualitative data sourced from the interviews should therefore be regarded as insights to the industry, and not objective trends.

Web Scraping ICTC made a significant and comprehensive effort to ensure as many companies as possible were included in its company database. While ICTC estimates that Canada's immersive technology industry has roughly 400 to 450 active companies, at the time of publishing, the database includes a total of 353 companies, of which 299 are Canadian owned. As such, the statistics included in this report should be considered as a representative sample but not absolute.

Data There is a significant lack of data available for Canada's immersive technology industry, and much of the data that does exist is vague and inaccurate or provided in aggregate with data from the United States. While this is changing—industry and organizations are starting to publish data and comprehensive reports—the current gap should be considered a limitation of this report.