Developing Innovation Ecosystems through Public-Private Partnerships:

Insights and Lessons from ENCQOR 5G

Contributors: Evangeline Philos, Romel Mostafa, Stephanie Scanlan

IVEY | Lawrence National Centre for Policy and Management

Research Brief
NOVEMBER 2021

EXECUTIVE SUMMARY

At the early stage in the evolution of a technology, uncertainty looms large in developing innovations, and an ecosystem that supports entrepreneurs to test their inventions becomes important in enhancing the chances of successful commercialization. While collaboration between private firms and government is deemed critical for developing such an ecosystem, there is little insight into how such partnerships can be developed and what factors govern their potential effectiveness. This report features ENCQOR 5G, an innovation ecosystem that was developed through a public-private partnership (PPP) between three levels of government and five technology anchor firms to enable SMEs and researchers to test and scale their pre-commercialized 5G applications. It discusses the genesis of the program, the processes associated with its evolution and program outcomes.

Drawing on insights from the case and existing evaluations on other cluster initiatives, this report also recommends a systems approach to developing innovation ecosystems that:

1. Builds on existing strengths;

2. Has a well defined problem and focused approach;

3. Achieves consensus across stakeholders through integrating goals;

4. Ensures accountability and transparency; and

5. Facilitates the development of complementary capabilities.

At a time when Canada struggles to maintain its edge in innovation, these lessons serve to provide guidelines for industry and government in their initiative to establish robust ecosystems for next generation innovations.

INTRODUCTION

Technological advancements are fundamental to our prosperity. In particular, general purpose technologies (GPTs), which have wide applicability across the entire economy, have underpinned long-term economic development for hundreds of years: Steam engines ushered in the first industrial revolution and computers gave rise to the digital age. Widespread adoption of GPTs leads to significant innovation in various application sectors, resulting in a transformation of the economy, ultimately leading to high growth and improvements in the standard of living. Unfortunately, Canada's ranking on innovation competitiveness has fallen over the years (Exhibit 1), with the country reporting limited growth in multi-factor productivity over the past decade[1]. Despite the availability of a strong labour force of scientists and engineers and a robust number of start-ups in Canada, studies have shown a lack of success in scaling up and converting technological opportunities into successful technological outputs[2].

During the early stage in the evolution of a technology, uncertainty looms large in developing innovations for market adoption, but an ecosystem that supports entrepreneurs to test their early-stage inventions and business models can increase the chances of successful commercialization and scaling of their businesses. This report focuses on the development of such an innovation ecosystem, ENCQOR 5G. 5G is considered an emergent GPT with potential applications across multiple sectors, from enabling the digitization of manufacturing to increasing the interconnectedness of society. Its potential in spurring growth is substantive; one study predicts that the deployment of 5G technology in the short-run (i.e. that is by 2026) could lead to $40B in incremental contribution to the Canadian GDP[3], with the long-run impact on GDP is expected to be greater as 5G is more widely adopted and multiplier effects felt across industries, over time.

Exhibit 1

Canada's rank on the Innovation Pillar of the Global Competitiveness Index, by year

YEAR	RANK
2007-2008	13
2008-2009	13
2009-2010	12
2010-2011	11
2011-2012	11
2012-2013	22
2013-2014	21
2014-2015	22
2015-2016	22
2016-2017	24
2017-2018	23

Source: Global Competitiveness Index Historical Dataset 2007-2017, Version 20180226, World Economic Forum: hhtp://reports.webforum.org/global-competitveness-index-2017-2018/downloads/.

The ENCQOR 5G program is an industry-driven, public-private partnership (P3) that brings together global industry leaders, three levels of government and small-medium-sized enterprises in an innovation ecosystem to accelerate 5G technology adoption in a pre-commercialization platform. The program was conceived to accelerate the adoption of 5G by enabling SMEs to develop, test and scale 5G technologies and in the process, generate growth across a variety of sectors.

Using publicly available and archival information supplemented with interviews with industry leaders, start-ups and institutional players, this case study discusses the genesis of the program, the processes associated with its evolution and program outcomes.

It also recommends a systems approach to developing innovation ecosystems that: Builds upon existing strengths; has a well-defined problem and focused approach; achieves consensus across stakeholders through integrating goals; ensures accountability and transparency; and facilitates the development of complementary capabilities.

At a time when Canada struggles to maintain its edge in innovation, these lessons serve to provide guidelines for industry and government in their initiative to establish robust ecosystems for next generation innovations.

5G POTENTIAL

5G has the potential to add substantial value within industries and organizations that are undergoing digitization, automation and cloudification. The devices on these networks would need to interact reliably and quickly, with 5G at the centre of this digital enablement. 5G can enable enhanced transportation and mobility through smart traffic control, precision agriculture through crop and soil management, efficient energy distribution through grid sensors, and improved internet connectivity in underserved communities. Smart manufacturing is quickly gaining ground as the way of the future, with use cases in robotics, remote real-time manufacturing, labour augmentation and connected operational intelligence and analytics[4]. But as with any new GPT, the full gamut of use cases is unknown, and the value of the technology can only be realized once its applicability could be demonstrated in real-world environments[5]. Many firms are keen to leverage this technology but are faced with barriers such as a lack of spectrum availability, clear business case and return-on-investment[6].

Some governments have been aggressive in developing 5G infrastructure. South Korea reformed legislation to facilitate 5G infrastructure deployment[7] while in China, early partnerships with firms have resulted in widespread intent to utilize 5G within

the country's industrial sector to enable smart manufacturing[8]. This growing global investment is beginning to highlight which nations will be leaders in 5G adoption and economic beneficiaries of its applications and which nations are at risk of being unable to catch up. Unfortunately, as recently as 2019, Canadians had low awareness and low intention to upgrade their technology to 5G, in contrast to consumers in China, South Korea and the US, which are considered "early enthusiasts."[9]

THE EVOLUTION OF ENCQOR 5G

In 2015, Canada was already two years behind the USA in developing 5G networking infrastructure. Canada's ability to successfully manage the pre-adoption phase of the technology life cycle curve was crucial in setting the pace for later stages of deployment, which would ultimately influence the nation's ability to leverage the technology. At the time, the call to action was clear: Canada would either need to step up and establish a clear 5G mandate or continue to lag behind.

The Canadian branches of five technology firms—Ericsson, Ciena, Thales, IBM and CGI observed the above trends within their own multinational organizations and recognized the risk involved in not mobilizing to promote 5G deployment in Canada. These firms were already R&D heavyweights in Canada, historically spending millions of dollars to develop products and solutions within the country and creating local ecosystems for innovation and technological advancement. The benefits to the Canadian economy from home-grown product development were acutely felt and anchor firms adeptly leveraged academic partnerships to develop solutions that benefited next generation technologies and de-risked technological advancements.

From an employment perspective, they provided thousands of high-quality jobs within the country, working directly with local universities to pursue and develop talent. To retain these competitive advantages in Canada and continue to grow their local R&D facilities, these anchor firms were motivated to join forces to accelerate national 5G adoption[10].

To provide a clear incentive for industries and governments to adopt 5G, use cases and corresponding technical requirements needed to be defined. This required proof-of-concept in a "field setting", where use cases could be tested pre-commercially and adjusted based on rapidly evolving telecommunications standards. To this end, a pre-commercial 5G testbed with open access to small- and medium-sized enterprises (SMEs) was set up[11].

The testbed would provide a platform for SMEs to field test their technology on a fully enabled 5G network before it was available nationally and allow access to an ecosystem that would catalyze their ability to commercialize and monetize their inventions. As early adopters, agile development in a low-risk environment is key. By taking advantage of feedback loops, developers could modify and adapt their solutions. Once a product is rolled out domestically or internationally, the cost complexities of correcting a major mistake are huge and for smaller organizations, they can be crippling. The testbed would provide an innovation ecosystem for SMEs to reduce the uncertainty of converting their inventions into viable and marketable products and solutions.

> **Once a product is rolled out domestically or internationally, the cost complexities of correcting a major mistake are huge and for smaller organizations, they can be crippling. However, the testbed would provide an innovation ecosystem for SMEs to reduce the uncertainty of converting their inventions into viable and marketable products and solutions.**

By identifying leading market adopters and understanding 5G use cases, the anchor firms could integrate learnings into forward-looking strategic plans and understand future technology requirements. For Ericsson and Ciena, field testing their products would provide an opportunity to develop a knowledge base and a reference network architecture that could be used as a solution template[12]. The Canadian branch of Thales owns the R&D mandate for the transportation business, relying on 5G technology to enable their products and solutions such as train controls, automation and driverless systems. Partnerships with SMEs that have compelling technology and business cases would provide a mutually beneficial arrangement, whereby Thales would have access to local talent, ideas and resources and offer global sales opportunities for SMEs to expand and grow[13]. This potential to scale globally was seen as critical for achieving widespread adoption, as the Canadian market represented only a small portion of the full business potential.

However, experience showed that to achieve buy-in of complex technologies in a pre-commercial market, multiple thrusts were required: private, academic and government. Without all of these partners, adoption would continue to lag, and Canada would not be at the forefront of solutions development and innovation. Thus, the idea for a public-private partnership program centred around an integration platform as a service (iPaaS) testbed – what would become known as ENCQOR 5G – was born.

> **Experience showed that to achieve buy-in of complex technologies in a pre-commercial market, multiple thrusts were required: private, academic and government. Without all of these partners, adoption would continue to lag, and Canada would not be at the forefront.**

The major technical challenge for the anchor firms was in designing the network architecture of the testbed (Exhibit 2). It was difficult to decide what kind of services would be required when the use cases were still uncertain, with each anchor firm having their own set of priorities. However, the diversity of the anchor firms was also their strength. While aligned in their core objectives, each anchor firm was focused on its own sphere of expertise. Ericsson supplied radio solutions, hardware and software verification systems and the IoT accelerator, which enables a connection between the network and IoT devices. Ciena provided wireless backhaul solutions and an Emulation Cloud, permitting rapid application development and cloud integration. Thales focused on supporting vertical applications and identifying sustainable solutions to urban challenges, their core focus in Canada. IBM provided silicon photonics components, allowing faster communication and processing throughout the network. CGI developed software-as-a-service smart grid capabilities. This complementarity provided a broad spectrum of functionality without needing firewalls to guard against competitive overlaps.

As a unified front, the anchor firms were well positioned to articulate the value proposition of the program. They had champions internally within their organization to drive the initiative. They subsequently needed to involve partners that could administer the program and apply for funding support from two levels of government – federal and provincial Governments. Each level of government was aware that an acceleration in effort to secure domestic research and development capabilities was needed, and between 2015 and 2017, each began to introduce their own economic development mandates that centred around the digital economy. To take advantage of this opportunity, the anchor firms reached out to the Quebec organization, Prompt, a not-for-profit that facilitates R&D partnerships and financing between businesses and the public research sector[14]. Additionally, the Ontario Centre for Innovation (OCI) formally the Ontario Centres of Excellence (OCE) joined the discussions to help drive potential participation and roll out in Ontario.

Exhibit 2
ENCQOR 5G iPaaS testbed
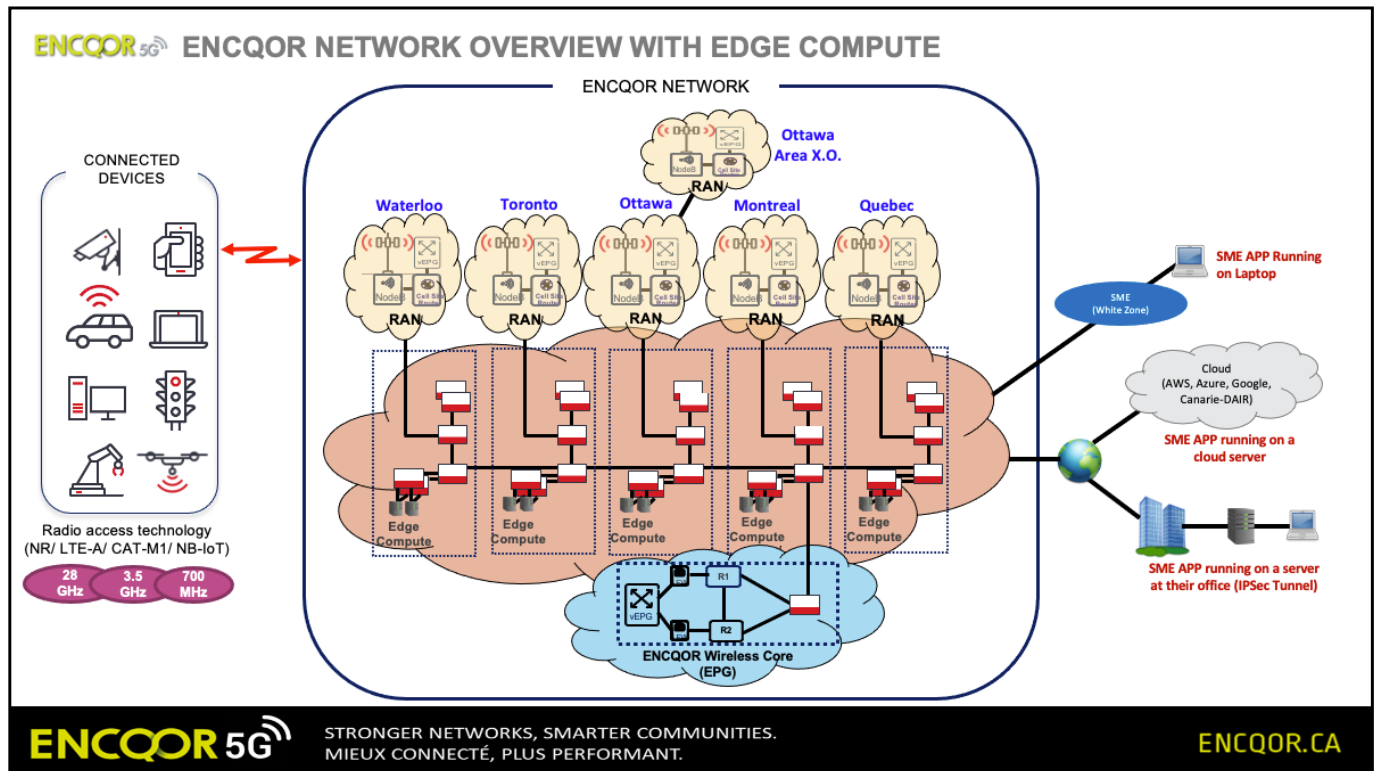
The Ontario-Quebec corridor, an area from Windsor to Quebec City (Exhibit 3), contains the greatest concentration of ICT businesses in the country and more than half of Canada's population. Drawing in SMEs from this region and support from the two governments became an integral part of the strategy.

Exhibit 3
Windsor-Quebec City corridor
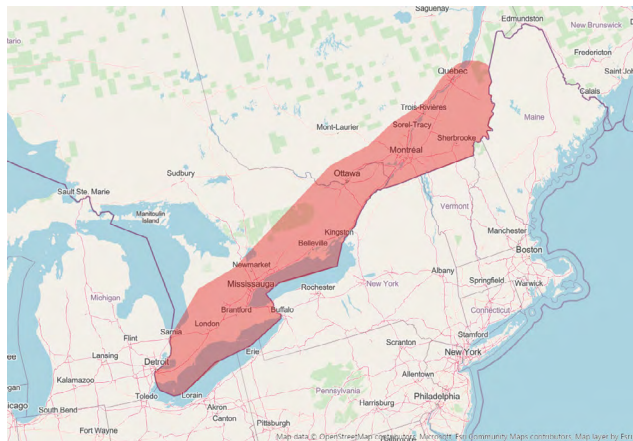
At the time, the Quebec government was developing the 2017 – 2022 Quebec Research and Innovation Strategy with a focus on talent, skills and renewal, research and innovation in all forms, and transfer and commercialization[15]. The total investment for this strategy was $2.8B, with seven flagship projects carried out over five years. The ENCQOR proposal seemed to align with the broader objectives of the province's overall research and innovation strategy as it focused on facilitating 5G adoption for local companies.

Since the 1970's, the Ontario government has focused on stimulating innovation and has continued to invest in research funding and tax credits to bolster R&D in the province. While these programs have have contributed to annual exports of $1B in R&D services, there exists a commercialization gap whereby firms are slow to adopt new technologies[16]. The ENCQOR program would provide a pre-commercialization opportunity for local SMEs to create market ready solutions and scale up. As such, there was potential to bolster the Ontario economy and increase Canadian entrepreneurship globally.

The federal government was viewed as another crucial player. In 2015, the Government of Canada began to focus on investing in the country's start-up and innovation sectors. The Innovation and Skills Plan was written into the 2017 federal budget with the purpose to make Canada a global leader in innovation, create well-paying jobs and to help strengthen and grow the middle class. The Strategic Innovation Fund (SIF) was set up to provide funding through four streams (Exhibit 4) and had a budget of $1.26B over five years[17]. Government education was an important component, with governments needing to fully understand the potential benefits of the program and 5G technology in general. OCI and the ENCQOR team also noted Canada's limited window of opportunity to move ahead with 5G, reinforcing the investment that had already been made by other nations while Canada lagged behind.

Exhibit 4
The Government of Canada's Strategic Innovation Fund (SIF)

Stream 1: Encourage R&D that will accelerate technology transfer and commercialization of innovative products, processes and services

Stream 2: Facilitate the growth and expansion of firms in Canada

Stream 3: Attract and retain large scale investments to Canada

Stream 4: Advance industrial research, development and technology demonstration through collaboration between the private sector, researchers and non-profit organizations.

Over three decades, OCI has supported the federal and provincial government visions of transforming the Canadian economy to one that is innovation-driven and globally competitive[18]. It has achieved government trust and confidence that it will be able to deliver on outcomes-driven programs through transparency on funding utilization and historical collaboration with a large number of academic institutions and businesses.

OCI took the lead in organizing workshops with the anchor firms to define the program's value proposition and how the players would collaborate. The funding allocation process required multiple steps. Once the allocation agreement was reached, work needed to be done to articulate specific program offerings and implementation strategies. This application process between OCI and the Ontario government continued for several months. The anchor firms and OCI had conversations with Ontario ministry, to ensure the value of the program and benefit to Ontario could be realized. Dedicated resolve and strong leadership were required to ensure stakeholders collaborated successfully, and that all partners were aligned[19].

Given this initiative involved three governments and five large companies proposing to co-invest in a future technology platform first of its kind, the program development and contract negotiations came with a level of complexity. Lawyers participated in the negotiations, balancing the interests of all stakeholders. The program's value proposition, targets and funding requirements were based on government policy and corporate strategy, with all needing to be reconciled. All partners had to progress in unison, with all three governments working at the same speed. If one of the pillars fell, then all of it would collapse. OCI acted as a glue during these negotiations, continuously providing feedback to governments on why the program was important and how it would be implemented. The Communications Research Centre Canada, a federal telecommunication applied research centre, was instrumental in educating their government counterparts, asserting the value of 5G for the economy and securing buy-in from the right people.

> **All partners had to progress in unison, with all three governments working at the same speed. If one of the pillars fell, then all of it would collapse.**

Due to the complexity and length of time it took to negotiate with the government, the personal investment required from anchor firm champions to keep driving the initiative was exhaustive. Indeed, at one point in the development of the project, Ericsson and Ciena needed Letters of Support from the Ontario and Quebec governments in order to proceed, as the firms were running out of commitment internally. Anchor firms needed to ensure that the program benefits were continuously aligned over the years with corporate mandates surrounding 5G; this was not to be viewed as a membership or a subscription, but a long-term, significant investment. Getting continuous buy-in from senior leadership was an ongoing, but crucial, challenge in securing corporate funding. While corporate contracts generally consist of a revenue stream and clear risks, government agreements are associated with a greater reputational risk to the company. This made getting buy-in for ENCQOR internally within the anchor firms more challenging, as approval was required at the highest echelons. For example, at Thales, the CEO of Thales Canada needed to approve the agreements before they were ratified. Similarly, Ericsson's champions needed continuous buy-in from their own internal sponsors, soliciting resources from Sweden and highlight the significant business development and brand recognition that would be achieved as additional program benefits.

In February 2017, all three governments met to align on their interests and develop the financial constructs of the program. The funding contract specified a 50/50 split between industry and government for program funding; every $3 funded by industry would be matched by $1 from the Ontario government, $1 from the Quebec government and $1 from the federal government's SIF. The total combined funding for the program amounted to $400M over five years.

In Ontario, OCI was contracted with the Ontario government to act as the program administrator. Conversely in Quebec, a new not-for-profit, Innovation ENCQOR, was created to hold contracts and administer funds from the federal and Quebec governments. A number of contracts needed to be established between all of these organizations to detail how the funds would flow from each government to the delivery agent. Once those contracts were established, another set of agreements were developed between the delivery agent and the anchor firms on how funds would flow. Ultimately, it took two years (2015 to 2017) for negotiations to close and another year (2018) for contracts to be fully developed; the final contract was executed in January 2019. Despite the complex challenges and novelty associated with contract development, multiple funding contracts and service level agreements were established that detailed the commitments between all stakeholders (Exhibit 5).

Exhibit 5
Key Stakeholders of ENCQOR 5G

Source: ENCQOR 5G

PROGRAM EXECUTION

The ENCQOR program officially launched in March 2018. Five hub locations were selected across Ontario and Quebec: Ottawa (Invest Ottawa), Toronto (MaRS), Waterloo (Communitech)[20], Quebec City and Montreal. The Ontario sites were already operating as incubators with a mandate to advise SMEs and companies on how to scale; ENCQOR was a natural fit. This program would be beneficial to them by complimenting their offerings and adding new clients. OCI, who holds the contract with the hubs in Ontario, played an integral role coordinating installation of the testbeds. Conversely in Quebec, the Innovation ENCQOR were responsible for overseeing this process. Job retention targets were integrated into the contracts with all anchor firms.

In Ontario, the program was established with several key streams:

1. iPaaS Access Projects;

2. Demonstration Projects;

3. Technology Development Projects;

4. Talent Development Internships and;

5. Business Advisory Services.

To be considered, an SME must apply and meet a specific list of criteria.

The iPaas access stream provides applicants with no cost access to the iPaas testbed to develop and test new 5G technologies. SMEs are required to submit project and outcome metrics at project conclusion. No funding is associated with this stream. Furthermore, the application to participate in this stream is confidential. Participants accessing the iPaaS network have open access to three different 5G antennas (high, mid, and low) to test their technologies. Further, participating in the program connects SMEs with ENCQOR 5G's anchor firms and other networking opportunities within the 5G ecosystem in Canada.

The Demonstration Projects Stream supports SMEs in developing 5G products by providing access to the iPaaS testbed for testing and validation along with funding support of up to $50k for one year, with SMEs matching the financial investment 1:1. The solution must be within technology readiness levels (TRL) 1-7 (Exhibit 6). Applications are evaluated based on the potential impact of the solutions, for both the SME and the Ontario province in terms of economic growth, the expertise of the SME team, and the clarity and thoroughness of the SMEs business strategy and vision. The applications are reviewed by internal and external reviews teams that include the ENCQOR technical committee, and expert external reviewers. The Demonstration stream also allows for SMEs to apply in collaboration with a strategic partner. Eligibility allows for the strategic partner to be a public sector organization, such as a municipality or a private sector industry partner.

The Technology Development Projects streams, one for academic collaboration and one for SME collaborations, feature Challenge Statements posted by anchor firms Ericsson, Ciena and Thales that are addressed in partnership with SMEs or academia. Projects are diverse and may focus on a range of 5G related technologies, for example, the application of 5G in new markets, machine learning algorithms and how to create responsive networks, cybersecurity, IoT and end user applications, or cloud connections and information sharing between private and social and public groups[21].

These projects must drive the development, integration, testing or validation of pre-commercial technologies that form the Innovation Platform as a Service (iPaaS) testbed and, similarly to Demonstration Projects, must be within TRL 1-7. Projects must show the potential for commercial impact for the applicant and ENCQOR 5G anchor firm, and economic benefit for Ontario. The funding available for costs incurred is defined by the Challenge Statement and ranges from $50k - $500k.

Exhibit 6

Government of Canada Technology Readiness Levels

The Government of Canada lists nine possible Technology Readiness Levels based on the stage of development of the technology, with 1 being the least ready and 9 being used in real-life conditions.

Level 1: Basic principles of concept are observed and reported
Scientific research begins to be translated into applied research and development. Activities might include paper studies of a technology's basic properties.

Level 2: Technology concept and/or application formulated
Invention begins. Once basic principles are observed, practical applications can be invented. Activities are limited to analytic studies.

Level 3: Analytical and experimental critical function and/or proof of concept
Active research and development is initiated. This includes analytical studies and/or laboratory studies. Activities might include components that are not yet integrated or representative.

Level 4: Component and/or validation in a laboratory environment
Basic technological components are integrated to establish that they will work together. Activities include integration of "ad hoc" hardware in the laboratory.

Level 5: Component and/or validation in a simulated environment
The basic technological components are integrated for testing in a simulated environment. Activities include laboratory integration of components.

Level 6: System/subsystem model or prototype demonstration in a simulated environment
A model or prototype that represents a near desired configuration. Activities include testing in a simulated operational environment or laboratory.

Levels 7 through 9 represent the pre-commercialization gap for innovations. These are the three levels where innovations are eligible for the Build in Canada Innovation Program.

Level 7: Prototype ready for demonstration in an appropriate operational environment
Prototype at planned operational level and is ready for demonstration in an operational environment. Activities include prototype field testing.

Level 8: Actual technology completed and qualified through tests and demonstrations
Technology has been proven to work in its final form and under expected conditions. Activities include developmental testing and evaluation of whether it will meet operational requirements.

Level 9: Actual technology proven through successful deployment in an operational setting
Actual application of the technology in its final form and under real-life conditions, such as those encountered in operational tests and evaluations. Activities include using the innovation under operational conditions.

Participation in the Technology Development Project streams has benefits not only to the SMEs but also to ENCQOR 5G's anchor firms. The collaboration and support creates an important relationship between Ontario based SMEs and global market and industry leaders within the Anchor firms. The development of cutting edge 'made-in-Ontario' products adds to increased job creation and a robust Ontario based supply chain of technology providers.

Finally, the Talent Development Internships support internships for students and recent graduates of Ontario universities and colleges. In this program, $10k is granted per four-month internship, lasting up to 12 months. SMEs apply for funding for interns as part of the iPaaS Access, Demonstration and Technology Development Projects. Companies have access to top talent emerging from Ontario's post-secondary institutions. Interns have an opportunity to work directly with SMEs developing leading edge technologies, while also accessing networking opportunities within OCI's wide network of industry leaders, policy makers and researchers.

To provide Ontario SMEs with not only access to technology, partnerships and talent the Ontario ENCQOR hubs, Invest Ottawa, MarS and Communitech also provide business advisory services to ENCQOR SMEs. These services are tailored to the SMEs needs and assist the companies in scaling their business through activities such as growth coaching and mentoring from Executives in Residence in a wide range of business areas. In Quebec, similar program streams with specific project and organization criteria are available for SME participation. This includes streams for iPass access, technology adoption and collaborative R&D projects.

PROGRAM OUTCOMES

The various program streams of the ENCQOR 5G aim to achieve economic, technical and business benefits. As of September 2021, over 800 SMEs have joined the program in both provinces, a milestone that highlights a high demand for the program's unique offerings. ENCQOR 5G is poised to maintain more than 4,000 technology jobs and create 1,800 specialized jobs in 5G. The internship program has also helped to train and provide professional experience to 70 graduates and students within 50 SMEs in Ontario. As of September 2021, 552 SMEs representing a diverse set of industries and 23 academic research groups have participated in the program in Ontario. In February 2020, Innovation ENCQOR spearheaded a collaboration with six of Canada's largest telecommunications service providers (Bell, Cogeco, Abmra Solutions, Rogers, Telus and Videotron) where a memoranda of understanding was signed to catalyze further partnerships between operators and SMEs in preparation for market deployment.

ENCQOR provides SMEs and academic researchers with the ability to harden, tweak, improve and add new capabilities to their existing technologies, identify bottlenecks and test their theories, products and business case[22] in a supportive and forgiving environment. It allows them to generate valuable data, gain experience and have a market-ready solution available for any domestic or global 5G deployment, thereby shortening the timeline for success and growth[23]. The extensive capability of the testbed, especially edge computing, enables SMEs to be competitive with larger players in their industry; this type of field testing would otherwise have been unattainable for start-ups with access to limited capital[24]. One SME spoke about the importance of early access to 5G technology, stating: "it's hard to convince someone that something is really good; you have to show them." [25]

SMEs and academic researchers who have taken part in the program are already seeing the benefits of their participation (Exhibits 7 & 8). Arvizio, an Ottawa-based SME who uses the power of augmented and mixed reality to create enterprise software for 3D visualization, joined the ENCQOR 5G program to test and demonstrate the use of 5G wireless technology and edge computing. Throughout their testing, Arvizio was able to expand the offerings of their mobile app, including several features which were previously uniquely available on a desktop version. As a result, the software use has expanded, allowing Arvizio to attract larger companies, increase their customer base, continue testing new technologies and solutions while growing their team to support new demand.

Another key advantage for SMEs is the ecosystem to access business networks and mentoring. Many great inventions struggle to flourish because of insufficient understanding of where value is created in a product or service[26]. By accessing a mentoring network, SMEs receive support in taking an early concept, articulating its value proposition and understanding how to scale it up into a commercial proposition. The opportunity to integrate into the ICT space allows SMEs to understand the actors and identify which players hold influence in 5G deployment and in other technology programs[27].

> **Many great inventions struggle to flourish because of insufficient understanding of where value is created in a product or service. By accessing a mentoring network, SMEs receive support in taking an early concept, articulating its value proposition and understanding how to scale it up into a commercial proposition.**

The program also provides SMEs with the runway to consider long-term R&D. While many start-ups focus on bringing minimum viable products (MVP's) to market on 3G and 4G networks, access to additional funding and the 5G network allows them to anticipate and plan for future hardware and software needs. One SME presented a circuit board that is being specifically designed for future upgrades for 5G networks. This will allow the SME to use the same hardware in the future without requiring new equipment, thereby saving on future development costs.

Exhibit 7

SME Profile: Longan Vision

LONGAN VISION   www.longanvision.com

The reality of firefighting is that it is an unpredictable and dangerous profession. The creative minds at Longan Vision believed there was an opportunity for firefighters to see things differently by developing smart augmented reality (AR) devices for the next generation of firefighters. Through the ENCQOR 5G program Longan Vision was able to test and refine the real time data flow and inter-device connection capabilities of their augmented reality (AR) smart visor system for firefighter's helmets. Saving lives by enabling real time streaming, across the whole fire crew, of thermal video and sensor data through all firefighters' devices.

Project Success
- New prototype developed
- Accepted into the T-Mobile Accelerator Immersive Technology Program
- Won Gold in the Industrial and Life Science Design/Safety Designs from the International Design Awards (IDA)
- Accepted into Google for Startups Accelerator

"Longan Vision will help firefighters have more sensing abilities during operations and better communication abilities by the features offered by the project. Those improvements will help firefighters and first responders save more lives and themselves".

Despite its many benefits, the ENCQOR program is not without its challenges. The new technology used by the ENCQOR testbed is still in its nascency, allowing for a knowledge gap to exist for SMEs applying to participate. However, the program offers onsite technical support for companies who may be unfamiliar with the testbed technology. This is specifically helpful for SMEs who do not have internal telecommunications experts.

From a logistics perspective, some SMEs noted challenges related to the physical locations of the testbeds. SMEs who have HQs outside of the test bed regions must account for additional costs related to travel. The difficulties were exacerbated by the 2020 – 2021 Covid-19 pandemic, resulting in unforeseen challenges in movement and collaboration. While more testbed locations could minimize mobility for SMEs and their employees, the cost is currently prohibitive to expand upon the current sites. The location of the testbeds represent centralized, accessible regions along the country's abundant tech and innovation corridor.

The ENCQOR program, like any public-private-partnership, is complex and requires a stringent reporting process. Given the multiple funding partners, the level of complexity makes the process for reporting and funding distribution different than traditional government programs. SIF (federal) funding requires SMEs to estimate their expenses in their application, and submit receipts for reimbursement at the end of the program. This may result in cash flow issues for start-ups that do not have reserves of capital available. While SMEs are provided with background information and lengthy reporting expectations up-front, there is an opportunity to streamline the reimbursement process in the future. These challenges notwithstanding, uptake in testbeds by SMEs continue to increase during the Pandemic, suggesting that potential benefits of the testbeds outweighed challenges faced by the participants during the program.

Exhibit 8

SME Profile: blueRover

blueRover www.bluerover.ca

Bluerover leveraged the ENCQOR 5G program to develop test and validate a brand new hardware device for the food industry. Their new device uses CAT-M and NB-IOT networks to communicate data to the servers and allows for multi-year battery life, high quality environmental monitoring, and plug & play capabilities. The first of its kind available for use in the food safety markets, this device offers cold chain supply companies more efficient ways to operate their cold storage assets and provide monitoring and tracking of mobile cold transportation units.

Project Success
- New product launched
- B-tested at Sobey's, London Drugs, Tim Hortons
- Secured 7 new customers
- Close to $500K in incremental sales

"Participating in the ENCQOR 5G program has accelerated our product line and helped grow our customer base both here at home and in the U.S".

The experience of SMEs also suggest the need for expediting the development of 5G infrastructure in the nation to fully leverage their emerging technologies. As the results obtained from ENCQOR testbeds are specific to site facilities, testing in remote areas, in buildings with varying construction materials and wall thicknesses, and with different equipment vendors would facilitate SMEs understanding of performance variances and how to adapt to them and adopt their technology more broadly. Additionally, some SMEs are concerned about the uncertainty around the cost to implement at scale. For example, telecommunications operators have not established the cost of edge computing, but it is a functionality that is enabled by the test bed and relied upon by SMEs to validate their use case.

Since its launch three years ago, ENCQOR 5G's five innovation centres have connected over 700 SMEs to 5G testbeds, allowing companies to test, tweak and harden their technologies while growing their businesses. SMEs like RoadLaunch, an intelligent logistics firm headquartered in Paris, Ontario, have grown from being simply a supply chain logistics platform to partnering in transaction management. Clickmox Solutions out of Sudbury, Ontario participated in the program to test their mining surveying technology which will survey underground and unexplored cavities to ensure the area is safe for miners to conduct their work. They expect to grow the business and add jobs while continuing to test their technology.

KEY INSIGHTS FROM ENCQOR 5G PROGRAM

Our analysis of the ENCQOR 5G program provided insights into a number of factors that can shape the development and execution of innovation ecosystems through public-private partnerships.

Synergistic Partnerships Amongst Anchor Firms

The anchor firms involved in ENCQOR 5G partnered organically with one another and individually, each firm was heavily R&D focused within Canada and contributed expertise in a specific niche or technical component of 5G technology. This configuration ensured that there would be no direct competition in products or customers but brought about synergies through overlapping knowledge spaces and unique capabilities. This complementary nature of anchor firms engendered an alignment in interests and a common vision, with each firm developing internal commitment to the program and a strong belief in its value for both corporate success and Canadian technology leadership.

Experienced Delivery Partners for Coordination

With this foundation established, the involvement of delivery partners, OCI and Prompt, was instrumental in implementing the anchor firms' vision and strategy. These organizations were tested and proven delivery partners that were able to coordinate, execute and problem solve. OCI in particular was a crucial player that fulfilled the roles of an arbiter of funds from the Ontario government; driver of SME outreach province-wide; and an adjudicator of SME proposals. OCI and Prompt provided resources and connections to other players that fit well within the complex jigsaw puzzle that would become ENCQOR 5G. When the involvement and buy-in from governments became a central piece, they were enablers in brokering the relationships. This capacity to build bridges shows that trust and experience built through time are central to stakeholder mobilization.

Stakeholder Champions Dedicated to the Vision

Establishing champions within each stakeholder group enabled the program to move forward through the lengthy implementation process, when many would have abandoned the vision. Dedicated players in government and within anchor firms pushed ahead and rallied others to the cause. These strong leaders believed the long-term benefits would outweigh the short-term challenges and developed solutions that maintained momentum over two years of negotiations. Collaboration, teamwork and dedication between governments and corporate partners were critical in establishing and executing this program.

Capitalizing on the Political and Policy Landscapes

The political and global landscape was a broader factor in the success of the program. The delivery partners and anchor firms recognized that timing was crucial, with the impetus to drive a 5G program accelerated by international investment and an existing federal and provincial focus on digital innovation. Innovation policy priorities held by all levels of government resulted in a thorough consultation, review and eventual approval of the project.

Reconfiguring Existing Capabilities Instead of Building from the Ground Up

By relying on existing relationships with organizations that already had presence and previous success in innovation projects allowed ENCQOR to succeed. Canadian intellectual capacity and talent is among the top in the world, and by leveraging these existing capabilities in the Ontario-Quebec network, the ENCQOR 5G program took advantage of the region's strengths, re-configuring them in ways to deliver something new. The partners built upon foundational elements, creating a novel ecosystem with reduced risk and focusing resources on adapting, rather than revolutionizing, existing infrastructure.

Balancing Accountability with Operational Agility

The ENCQOR 5G program has also revealed the importance of balancing accountability with operational agility. The complex governance structure was intrinsically linked to the number of stakeholders, who had their own constituencies and were responsible to their own stakeholders. Specifically, governments have their own accountability frameworks and have fiscal responsibility to the public. Anchor firms have a fiduciary duty to their shareholders and, in the case of subsidiaries, are accountable to their corporate headquarters. An unintended consequence of these multiple accountability pathways is a cumbersome governance structure, where transparency is paramount and every stakeholder down the chain must be satisfied. Being able to simplify and streamline administrative and reporting procedures would reduce costs and drive value by rendering processes more conducive to innovation and eliminating some of the operational hurdles experienced by SMEs.

LESSONS FOR DEVELOPING INNOVATION ECOSYSTEMS

Our analysis of ENCQOR 5G and evaluations of other cluster initiatives points to five key lessons that industry and government leaders should consider when developing and supporting innovation ecosystems.

Building upon existing strengths

The development of a successful innovation ecosystem requires building upon existing strengths. To support an innovation ecosystem, government and industry leaders need to analyze the strengths and weaknesses of a proposed project, the region, the players involved and utilize the information to construct key pillars of existing strengths as a foundation to success. The ENCQOR 5G initiative leveraged pre-existing strengths in R&D capabilities of anchor firms as well as in delivery programs of established government agencies, such as OCI and Prompt; positioned itself within a strong regional innovation corridor with collections of SMEs interested in 5G applications needing a testbed; drew in resources and substantial support from multiple governments with a pre-existing mandate to invest in innovation. Studies examining some other cluster projects in Canada suggest a key contributing factor to those projects' limited success is a lack of pre-existing strengths; for example, an effort to establish a cluster in region without a critical number of entrepreneurial firms can lead to a siloed research environment, with coordination across firms and universities from different areas limited by jurisdictional restraints. See, for example, a 2016 evaluation completed by the National Research Council of Canada focused on the National Institute for Nanotechnology[28].

Having a well defined problem and focused approach

As new technology emerges there is often a rush to act upon it without fully realizing the key problems needing to be addressed. Indeed, a lack of focused approach and well-defined strategies have been identified as another contributing factor to limited success of some cluster initiatives[29]. When the problem statement is nebulous, defining objectives and formulating strategies become extremely difficult. Conversely, ENCQOR 5G had a clear problem statement; the primary reason to set up ENCQOR 5G centred around addressing one, but significant problem in harnessing 5G technology: the absence of a platform to test and scale new applications that utilize this technology. With the 'what' clearly articulated, next comes the 'how.' ENCQOR 5G identified the necessary steps required to proceed: partnerships, resources, and a delivery mechanism. To create the test bed infrastructure, firms with existing technology structure and expertise need to be drawn in to determine the viability of the project. A location which leverages regional strengths such as proximity to anchor firms, academic institutions and SMEs needs to be chosen. Investments from multiple levels of government who have a clear innovation mandate needs to be considered. In addition, a delivery partner with experience rolling out large scale initiatives and support needs to be selected. A clearly articulated problem with an equally clear strategy allows for a well organized project to seek success.

Achieving consensus across stakeholders through integrating goals

Multiple stakeholders with multiple interests can create multiple challenges. Achieving alignment amongst differing priorities requires a high level of collaboration for a successful private-public initiative. Partners come into the project with a unique set of goals and interests. In the case of ENCQOR 5G, anchor firms want to improve their understanding of the technology and their ability to develop supporting infrastructure; governments want to create jobs and spur innovation while ensuring any public dollars go towards supporting the project's mandate; SMEs want to test their applications and products with a goal to scale up. While the stated goals and priorities of stakeholders seem somewhat diverse, a clear and focused approach to problem solving can create unamity and a path forward. A well articulated problem combined with building upon existing strengths allows all parties to see the broader impact a solution could have. Therefore, while the individual goals might be diverse, they can be integrated in ways that achieve alignment across stakeholders and partners. The creation of the platform helps SMEs scale up, adds jobs, and generates technology that can actually get adopted. This leads to improvements in the applications sector, potential exports and economic growth for Canada. Further, it is important to have strong advocates and champions within each stakeholder camp who are willing to push the agenda forward to solve the problem and create an innovation eco-system despite differences.

Ensuring accountability & transparency

Effective innovation ecosystems require accountability and transparency processes for both the partners and users. In typical P3 projects, every stakeholder is investing money, time and resources; with a high degree of stakeholder engagement and multiple goals and interests to align, being upfront, clear and transparent at every level of the project is instrumental. Ensuring transparency and accountability in turn requires a robust administrative process. This requirement can lead to implementing lengthy procedures, remittance policies and administrative bureaucracy; however the initial administrative processes may be streamlined over time as norms and trust are established, while allowing for a transparent approach. Additionally, partners and users require accountability to meet the intended goals, expectations and mandate of the project agreed upon by all stakeholders involved. In establishing ENCQOR 5G, there was a high degree of uncertainty with the emerging 5G technology, and success depended in part on the capabilities of anchor firms for building a reliable platform along with strong delivery partners who could push the project forward and meet key milestones along the way. Achieving accountability means holding each partner to account, not only only in regards to accurate accounting, but also in terms of effective implementation of project deliverables.

### Facilitating the development of complementary capabilities

Developing complementary services within the P3 can spur long term success for the users, the partners and the economy writ large. ENCQOR 5G brings together stakeholders and SMEs to test their pre-commercialized technology. However, they also offer complementary supports to the platforms' users, such as access to talent, internship programs, skill development and business advisory services. Such complementary services help achieve the stated goals of the project, creating long term effects felt across the innovation eco-system and beyond. The SMEs required a testbed for their precommercialized technology and applications. However, given many of these companies are in start-up phase, they benefit from additional resources to help grow their businesses. While the aim of ENCQOR 5G was to address an overarching problem, broader goals can be realized through the development of an innovation accelerator that eventually integrates complementary services.

A successful recipe for developing an innovation ecosystem through a PPP requires a systems approach to policy and strategy (Exhibit 9). The five key lessons suggest that such a successful recipe depends on understanding regional strengths and weaknesses; identifying technological opportunities and challenges in bringing innovations to market; aligning interests of stakeholders with diverse goals for their fervent participation; creating robust accountability processes to ensure effective implementation of the project; and deploying complementary resources and services for participants. Policymakers and industry leaders seeking to establish such an ecosystem should neither consider these key factors in isolation, nor only focus on a subset of the factors.

Doing so is expected to limit the chances of success. For example, when the stated objectives of an ecosystem is not well defined it will be difficult to draw out common goals among stakeholders with different interests, limiting the prospect of achieving consensus among them. A plan that has a clear problem focus, accountability mechanisms, detailed complementary programs, and unflinching support from key stakeholders, can still fail when it does not build on innate regional strengths critical for the delivery of the core and complementary programs. Because of the interconnectedness and interdependence of the contributing factors, a systems approach that considers all of them in combination is needed in developing an innovation ecosystem through a PPP and maximizing its impact.

Exhibit 9

Recipe for Developing an Innovation Ecosystem Through a PPP
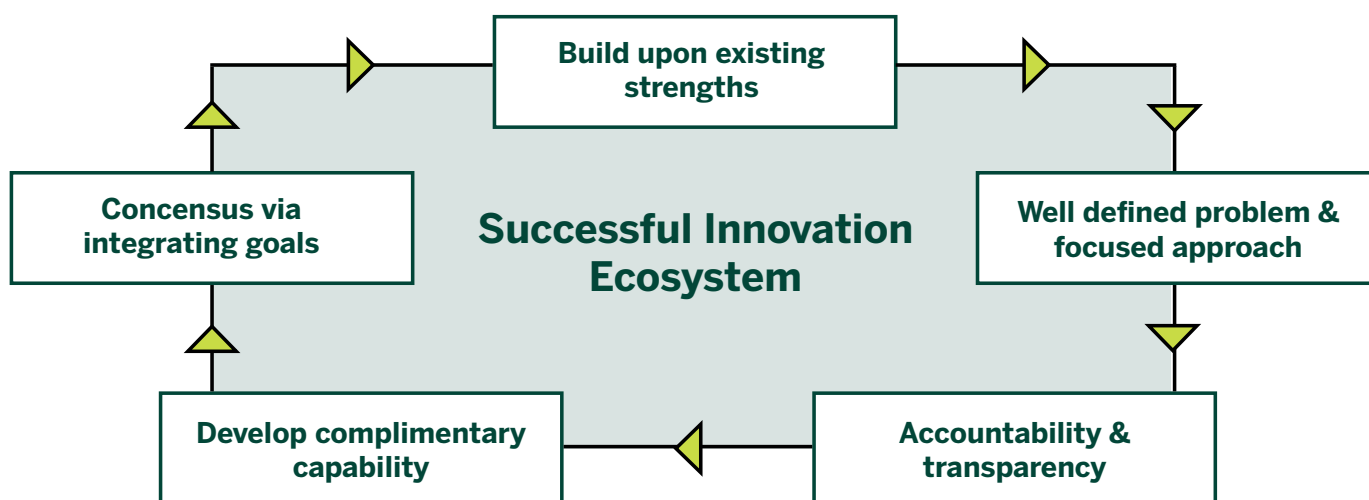
CONCLUSION

The ENCQOR 5G program has brought together multiple levels of government, industry leaders, academic institutions and new collaborators aiming to leverage the full potential of 5G in Canada when fully commercialized. While the program is nearing the end of its five year mandate in 2022, negotiations are underway for an extension, with some changes and evolution of focus. The initial version of the ENCQOR 5G program represents the first phase of Canada's 5G deployment plan, with the testbed playing a central role in testing 5G infrastructure and use cases. In 2020, Rogers, Bell, Telus and Videotron announced commercial deployment of 5G networks in specific Canadian cities[30]. This pushes Canada into the next phase of 5G deployment and ENCQOR can potentially evolve again to focus on driving innovation in industry verticals. Applications of 5G within specific industries such as healthcare, agriculture and transportation are becoming the new focus of technology providers (Exhibit 10).

In a post-pandemic nation, the trifecta of academia, government and industry is needed to push innovation forward. This landscape may be akin to the post-World War II world of Vanevar Bush, an engineer and public official who had argued that America's innovation engine would be steered by a three-way partnership of government, business and academia. This triangle propelled the US economy forward during a time and gave rise to revolutionary technologies such as transistors, microchips, computers, GPS and the internet, among others[31].

ENCQOR 5G has served to demonstrate that Canada has all of the necessary building blocks to lead in 5G technology and its applications. The innovations supported by this program can potentially reverberate throughout industry, cities and society as mass deployment of 5G becomes a reality. It also remains an inspiration for other emergent technologies, demonstrating how to accelerate pre-commercialization testing and scaling by SMEs to drive global competitiveness.

Exhibit 10
5G vertical use cases

Source: Ericsson

ENDNOTES

1   Statistics Canada, 2020. https://www150.statcan.gc.ca/n1/daily-quotidien/200309/dq200309c-eng.htm

2   World Economic Forum. (2018). https://www3.weforum.org/docs/GCR2017-2018/05FullReport/
TheGlobalCompetitivenessReport2017–2018.pdf

3   Rao, Tejas. (2019). Accelerating 5G in Canada: Benefits for Cities and Rural Communities. https://www.accenture.com/_acnmedia/
PDF-112/Accenture-Accelerating-5G-in-Canada-PoV-2019.pdf#zoom=50

4   Ibid.

5   IEEE. (2019). https://spectrum.ieee.org/telecom/wireless/key-challenges-in-5g-nr

6   Raconteur from Telecoms Intelligence, 2015.

7   KPMG. (2019). https://assets.kpmg/content/dam/kpmg/uk/pdf/2019/12/encouraging-5g-investment.pdf

8   GSMA, 2020. The Mobile Economy White Paper. https://www.gsma.com/mobileeconomy/wp-content/uploads/2020/03/GSMA_
MobileEconomy2020_Global.pdf

9   Ibid.

10   Luszczek, John. Ericsson. Personal Interview, February 16, 20201.

11   Business Development Bank of Canada from Innovation, Science and Economic Development Canada. https://www.bdc.ca/en/articles-
tools/business-strategy-planning/manage-business/10-things-didnt-know-canadian-sme

12   Wilson, Rodney. Ciena. Personal Interview, February 17, 2021.

13   Shorey, Mark. Thales. Personal Interview, February 10, 2021.

14   Prompt, 2021. https://promptinnov.com/en/about-prompt/

15   Government on Quebec, 2017. https://www.quebec.ca/en/government/ministere/economie/publications/2017-2022-quebec-
research-innovation-strategy/

16   Ontario 360, 2018. https://on360.ca/wp-content/uploads/2018/04/ON360-Innovation-and-Commercialization.pdf

17   Government of Canada, 2018. https://www.canada.ca/en/innovation-science-economic-development/programs/strategic-
innovation-fund.html%3Bjsessionid%3D0001hi7ciyoic1s7wj2b7ga51hx:1sf2v7t5gu

18   Ontario Centre of Innovation, 2021. https://oce-ontario.org/about-us

19   Boucher, Pierre. Innovation ENCQOR. Personal Interview, February 11, 2021.

20   MaRS Discovery District, Communitech, and Invest Ottawa provide start-ups with advisory services, connections to talent, customers
and investors. These hubs focus on incubating and scaling-up start-ups and providing a platform for researchers and global companies.
In 2019, the Federal government invested $52.4M as part of the Scale-Up Platform, a program wherein the three hubs collaborate to
help 30 Ontario companies achieve revenues of $100M or more.

21   Everingham, D., Kostyniuk, T., Wilson, R. (2019, May 2). *ENCQOR 5G Webinar - 5G and SMEs: What Is It and Why Should My
Company Be Paying Attention?* [Webinar]. Ontario Centres of Excellence. https://www.youtube.com/watch?v=VwhPDftur10&ab_
channel=OntarioCentresofExcellence%28OCE%29

22   Formi. Personal Interview, March 2, 2021.

23   Mero Tech. Personal Interview, March 4, 2021.

24   Yuser. Personal Interview, March 4, 2021.

25   Long Term Tech. Personal Interview. March 4, 2021.

26   Everingham, D., Kostyniuk, T., Wilson, R. (2019, May 2). *ENCQOR 5G Webinar - 5G and SMEs: What Is It and Why Should My
Company Be Paying Attention?* [Webinar]. Ontario Centres of Excellence. https://www.youtube.com/watch?v=VwhPDftur10&ab_
channel=OntarioCentresofExcellence%28OCE%29

27   Longan Vision. Personal Interview, March 8, 2021.

28   https://nrc.canada.ca/sites/default/files/2019-03/Final_NINT_evaluation_report_2016.pdf

29   https://nrc.canada.ca/sites/default/files/2019-03/Final_NINT_evaluation_report_2016.pdf

30   WhistleOut, 2021. https://www.whistleout.ca/CellPhones/Guides/5g-availability

31   Isaacson, Walter. The Code Breaker. 2021.

About Lawrence National Centre

Established in 2002, the Lawrence National Centre has been at the forefront of national policy dialogue in Canada, bridging the gap between academia, business and government to enhance Canada's global competitiveness. It is an independent public policy centre that contributes to policy dialogue and development by producing evidence-based research, providing a convening platform to engage and inform businesses and policymakers, and developing leading educational programs in policy and strategy.

Lawrence National Centre for Policy and Management

IVEY | Lawrence National Centre for Policy and Management

Ivey Business School at Western University
1255 Western Road
London, Ontario N6G 0N1

Telephone: 519-661-2111 ext. 84253
Email: LNC@ivey.ca
www.ivey.uwo.ca/lawrencecentre