Autonomous Vehicle Testing in Calgary – Business Case

Executive Summary

The objective of the overall report is to determine how best The City of Calgary can support the Autonomous Vehicle (AV) industry in Calgary. Thus, the end goal of this report is not so much about a direct benefit to The City of Calgary (which a typical business case might examine), but the potential for job creation and economic benefits in Calgary related to the AV industry.

Administration has taken a multi-faceted approach to investigate the merits of a potential on street testing program[1] and has investigated what The City of Calgary can do to support economic growth and job creation in the AV sector.

A review of the best practices and interviews with jurisdictions across North America was conducted to understand different approaches that have been taken to facilitate AV activities. Over 20 states in the United States and one province in Canada (Ontario) currently have legislation that facilitates on street testing. These jurisdictions are enabling AV testing largely for economic reasons, and jurisdictions are competing with each other for investment from technology and automotive firms. In order to be competitive, there are four critical success factors required of a testing program:

1. Finding a niche within the industry offers the highest potential for success and economic return
2. Less regulation attracts testing, companies and investment
3. Companies tend to self-regulate when it comes to safety, though certain precautions such as a required amount of testing hours, paired with insurance are necessary before testing vehicles on public roadways
4. A seamless process and a central point of contact are critical

Working with Calgary Economic Development (CED), Administration connected with several different companies as well as local academic institutions in order to understand Calgary's niche in the autonomous vehicle sector. The success of the oil and gas industry in Calgary has led to strengths in autonomous systems, particularly in the field of geomatics (the science of mapping, surveying and geospatial systems); which can be directly applied to technologies supporting AVs. There are currently over 2,300 companies in Calgary employing over 17,000 staff in this sector.

One of the challenges identified by industry is they lack of access to assets to test autonomous systems technologies. The autonomous systems technologies looking to be tested ranged from autonomous vehicles, telecommunications systems, LiDAR devices and a variety of other technologies associated with automation more broadly. The assets that are required for their testing included potential access to a variety of assets (roads, parking lots, buildings, etc.) or systems (travel information, signals). Given The City of Calgary owns a large variety of assets,

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[1] Establishing regulation and an on-street testing program fall under provincial jurisdiction. The City of Calgary can advocate to The Province for an on-street program, but cannot implement one for legislative reasons.

Administration felt that this was an area of potential collaboration and could be reasonably accommodated.

In order to give external groups access to assets, there needs to be a streamlined intake process so that The City can ensure that the testing occurring is safe; it minimizes negative impacts to Calgarians or City operations; and that the tester is liable for any damages. The City investigated what intake processes would be desirable from the external and City of Calgary side and found that Calgary Economic Development's film intake process would work well for an intake process for autonomous systems testing.

CED currently has an established process for Filming Permits in Calgary to give access to site locations for the film and television industry. The primary role of CED in this process is to coordinate and oversee requests to conduct filming in Calgary. This includes coordination with key City staff when accommodations are required (such as road closures, police resources, etc.). This process supports over 10,000 jobs in Calgary and led to over 400 permits in 2017. City assets are also used in roughly half of the filming permits; access to these City assets is also facilitated by CED.

The film process has several parallels to autonomous systems testing, in that:

- Both activities are focused on a specific location, with unique opportunities and issues
- Both activities can involve unconventional activities, which can involve a level of risk
- Both activities use similar City assets (roads, parks, police services, etc.)
- Facilitation of both activities is to fulfill broader economic objectives (diversity of industry, creation of jobs, etc.)

This process would allow for an arm's length and consistent approach for handling such requests, to support existing companies and potentially attract new ones. The process would expect that applicants would cover any costs incurred by The City and CED. While establishing the process can be done with minimal cost, a staff resource at CED would be required to facilitate the intake process and position it to be successful.

With over 20 states and one province already having established testing programs, coupled with Calgary and Alberta's niche in autonomous systems, there is minimal risk and potentially a high benefit for the Province to enact legislation that would allow for on-street testing. Additionally, there is a demand from industry and academia for off-street testing of autonomous systems technology. Working with CED, The City of Calgary can utilize its assets in order to support technological development and support economic growth in the autonomous vehicle / autonomous systems sector.

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Background and Status of Autonomous Vehicle (AV) Technology

What is autonomous vehicle technology?

Autonomous Vehicle (AV) technology is an umbrella term encompassing different types of technology that hand over some or all functionality of driving from the human driver to the vehicle's computer. As defined by SAE International Inc., there are six different levels of automation, from a vehicle where all features are controlled by the human driver (Level 0), to technology that helps drivers keep in their lane (level 1-2) to vehicles that can drive by themselves with human supervision (level 3) to vehicles that can operate without human intervention or presence (level 4-5). As time progresses, new AV technologies will likely be developed and refined.

Status of technology

Level 1 (Driver Assistance) and 2 (Partial Automation) vehicles can currently be purchased and are currently operating on Calgary's roads. For example, Mercedes-Benz offers a number of vehicle models with DISTRONIC PLUS with Steer Assist technology, which keeps the vehicle in its lane while being able to follow the vehicle ahead at a safe distance (Mercedes-Benz, 2017) Level 3 (Conditional Automation) technologies are being tested on public roadways throughout North America, Europe and Asia. Notably, in 2016 Transportation Network Company (TNC) UBER has level 3 vehicles in Pittsburgh, Pennsylvania; the vehicles still have a driver/engineer in them to take over when the vehicle's computer encounters a circumstance it is unable to handle (UBER, 2016). Level 4 (High Automation) and 5 (Full Automation) technologies are currently being tested in North America, Europe and Asia.

There are a variety of estimates as to when level 4-5 AVs will begin to operate on public roadways ranging from the early/mid-2020s to mid-2030s. It is predicted that by 2050, level 4-5 AVs will compose approximately 50% of the vehicle fleet (VTPI, 2017) and that trucking and company vehicle fleets would be the first to adopt the technology due to high driver costs and the higher turnover rate of commercial vehicles (The Guardian, 2015). For example, car company Ford is projected to own and operate fleets of shared AVs (Ford, 2016) and Uber announced it plans to buy 24,000 self-driving cars from Volvo in shift from ride-hailing app to taxi operator (Financial Post, 2017)

Legal status of autonomous vehicles on Calgary's Roads

Level 1-2 vehicles operate legally on Calgary's roadways currently. Drivers of Level 1-2 vehicles are still legally required to adhere to the distracted legislation and cannot use cell phones and other handheld devices while driving.

There is nothing in provincial legislation or municipal bylaws that explicitly blocks the operation of level 3-5 AVs. Rather, the operation of an AV would likely be indirectly barred by various requirements in the legislation with respect to vehicle legislation, distracted driving legislation and operator licensing.

What is The City of Calgary's role for AV technology?

Unlike past transportation improvements that were implemented by the public sector like light rail transit (LRT) and the roadway network, the push for AV technology is coming from the private sector. The private sector is working towards and is responsible for creating a safe, robust vehicle that can follow local traffic laws and operate in various environments such as roads covered in snow and ice and different traffic conditions. Provincial and Federal levels of government are actively working to resolve issues related to the legislative status of automated vehicles; the regulation and licensing of related services; and the public interest issues of data privacy and safety. The City of Calgary would be responsible for the following items:

Municipal Responsibility	Description and Action
Building and maintaining infrastructure	The City is responsible for building and maintaining the transportation network for all transportation modes. The City chooses how to allocate resources to various modes such as bicycle lanes, interchanges or transit infrastructure to create a multimodal transportation network.
Traffic Congestion Management	The City is responsible for managing traffic flow through Intelligent Transportation Systems (ITS) and traffic demand through Transportation Demand Management (TDM).
Land Use Bylaw and Planning	The City can set bylaw requirements for development, which may change with a new transportation technology. For example, if autonomous car share is more popular in the future, then The City can relax the parking requirements for developments, but may need more space for pick-up/drop-off zones.
City Bylaws	AV technology will need to be operated in accordance with the Street Bylaw 20M88 and the Calgary Traffic Bylaw 26M96. A review of City bylaws will have to be conducted to understand which bylaws need to be amended – Bylaw amendments need to be in alignment with the Provincial Traffic Safety Act.
Parking	The City is responsible for ~ 20% of parking lots in Calgary's downtown. The presence to level 4-5 AVs may cause less usage of some lots, and may allow The City and/or private sector to redevelop underutilized lots.
City Vehicle Fleet	The City could purchase different levels of AV technology for its public transit or vehicle fleet. For example, buses could be equipped with level 2 AV technology that keeps them in their lane in a narrow right of way, or Parks could purchase an autonomous mower for park maintenance.
Licensing Taxis	Assuming the Province does not regulate driverless taxis/shared AVs, The City would have jurisdiction to do so, but it is not required to do so – that is, Council may decide that regulating driverless taxis/shared AVs is unnecessary.
Social	The City has a social mandate to provide the citizens safe and affordable transportation options.

Legislative Activities

Administration has been meeting on an ongoing basis with staff from both Transport Canada and Alberta Transportation regarding the potential for enabling legislation for AV testing. Each has a specific role in facilitating the use of AVs on public roads.

Federal Activities

Transport Canada's main role in the process is to oversee regulations regarding the vehicles for use on public roads. With respect to AVs, the main area of oversight is the safety of vehicles. This is governed by the *Canada Motor Vehicle Safety Act* and the *Motor Vehicle Transport Act*. As AV systems and features are developed for new vehicles, vehicle manufacturers will need to meet the requirements set out by Transport Canada in order for new vehicles to be considered roadworthy and available to the public. While vehicle features continue to advance, Administration did not find any vehicles that are available publically at a level 4 or 5 stage of automation. Some level 3 vehicles are now available, such as several Audi models, which include a traffic jam assist feature which allows drivers to relinquish control of the vehicle under certain conditions.

For the purposes of facilitating testing, Transport Canada does allow for vehicles to be imported or deployed for research activities. Thus, it is possible for manufacturers and others to trial more advanced features. This complements a potential testing initiative in Calgary.

Provincial Activities

Alberta Transportation's (ATs) role is to oversee regulations regarding the operation of motor vehicles on public roads. AT has expressed general support for AV testing and is quite aware of the legislative developments across North America in support of AVs. The main body of legislation governing AVs in Alberta is the *Traffic Safety Act*. AVs are not explicitly prohibited in the current legislation; rather, the existing legislation does not contemplate them. AT is in the process of reviewing the legislation to identify discrepancies which may need to be addressed before AVs can operate on public roads. The main objectives of AT are to ensure that the vehicles can operate safely in mixed traffic and complement the broader provincial transportation system. This includes ensuring the crash-worthiness of vehicles if they are in a collision with a non-AV (this is of particular concern on automated shuttle vehicles, such as the vehicle envisioned for the low-speed pilot at the Zoo LRT station). It is expected that AT will be releasing a framework to facilitate operations on public roads in 2018. In the meantime, AV activities can be conducted on private property, which are not governed by the *Traffic Safety Act*. This would allow for limited testing (the nature of private property as defined by the *Act* would need to be reviewed in each case to ensure testing is aligned with legislation). Providing this report to AT offers a formal ask of The City to support AV legislation.

Why are cities looking to have autonomous vehicles on their roadways?

Currently one province (Ontario) and over twenty states in the United States permit testing on public streets and highways (NCSL, 2017). There are two main reasons jurisdictions are looking for companies to bring autonomous vehicle technology to their jurisdiction.

1. They are looking for ways to help improve traffic safety and ease congestion. Driver error is responsible for more than 90% of collisions and human factors play a large role in congestion. The hypothesis is that removing the the driver from the equation, will reduce collisions and congestion.

2. Jurisdictions around the world are looking to be part of the new economy, and a way to get a foothold into the industry is to allow for technological development and testing in the jurisdiction. A 2017 study from Intel and the research firm Strategy Analytics claims that driverless vehicles will contribute to $7 trillion (USD) worth of economic activity and new efficiencies annually by 2050 (Strategy Analytics and Intel, 2017).

While jurisdictions around the world are worried about displacement for jobs that involve driving, there is an understanding that we operate in a global economy and innovations and inventions produced elsewhere have an impact whether or not that jurisdiction is supportive of a technology. It is unlikely any city could influence global policy to halt technological advancements in the automotive sector; nor would cities necessarily want to. Data and studies suggest that technology has created more jobs than it has destroyed over the past 140 years (Deloitte, 2015) While Calgary has a limited influence on the direction of new economic trends, it does have influence on how it participates in the economy.

The City of Calgary investigated and talked to2 the jurisdictions in North America who are leading autonomous vehicle testing in North America to understand how their programs work, lessons learned and keys to their success.

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[2] Michigan and Arizona were not interviewed for the report.

Case studies – Canada

Ontario

Overview

On January 2016, Ontario became the first province in Canada to create a pilot regulatory framework to test automated vehicles on its roads. The pilot intends to help attract and enable research, positioning the province as a global leader in the AV market. In November 2016, Ontario launched the first on-street AV pilot in Canada, led by The University of Waterloo, the Erwin Hymer Group and BlackBerry QNX (Government of Ontario, 2016).

In February 2016, Federal Transportation Minister Marc Garneau requested the Senate's Transportation and Communications Committee to report on the regulatory, policy and technical issues for smooth introduction of automated vehicles. The 2016 Federal Budget approved $7.3 million over two years to support the development of a regulatory framework for emerging vehicle technologies including automated vehicles (Government of Canada, 2016).

In November 2017, the Ontario government established the Autonomous Vehicle Innovation Network (AVIN) to build upon the autonomous vehicle framework in Ontario. The program has four distinct programs: an AV research and development partnership fund, a talent development program, a demonstration zone, and regional technology development sites. Stratford has been set up as the demonstration zone, where vehicles can be tested using existing infrastructure so long as they adhere to applicable laws and regulations. A city-wide Wi-Fi network is in place to facilitate communications, and all traffic signals have been made to be connected. The initial focus is on connected vehicle activities, with inclusion of autonomous vehicle testing later on (Government of Ontario, 2017).

There are several contributing factors to the success of the Ontario approach. The main impetus for the regulatory framework was from the auto and tech industries, so there was an industry led drive to find a way to facilitate testing and keep activity in Ontario (as opposed to elsewhere). The Ontario Ministry of Transportation (MTO) have been very supportive of the plan and have acted as a champion. Leadership of the initiative rests in MTO's Safety, Policy and Education department, who receives and processes applications. Approximately 10 staff, not including manager and director level, support the AV testing program (not all are exclusive to the program).

Legislation

The testing was accommodated under existing legislation in the Ontario Highway Traffic Act, which has a section permitting pilot projects. The framework was developed in consultation with a wide range of stakeholders, with an aim to minimize process while addressing any safety concerns. Applications are limited to automotive or technology companies. Applicants meet with MTO staff who review the process and assist with the formal application (a one-page form). Once approved, the company may test anywhere in Ontario. A "driver" is required to be present in the vehicle during testing and $5 million worth of insurance coverage is required for testers. Currently, there are six approved applicants that have undergone this process (roughly half of the testing companies are Canadian).

MTO is exploring further flexibility with the legislation which may remove the requirement for a human driver. The 10-year pilot program will allow the MTO to conduct a comprehensive review and formalize permanent legislation.

Benefits

More autonomous car and tech companies are starting to set up shop in Ontario. For example, In March 2017, Ford announced that it will be investing $337.9 million to open a research engineering center in Kanata that will focus on infotainment, driver-assist features and autonomous vehicles (Kanata North BIA, 2017).

Technology companies are sponsoring universities in order to train highly skilled people and supporting the research of autonomous vehicles and artificial intelligence.

Allowing testing provides a signal to the world that Ontario is open to industry and new technology – it brands the Province and the cities as progressive and not just in Toronto, but throughout Waterloo to Ottawa.
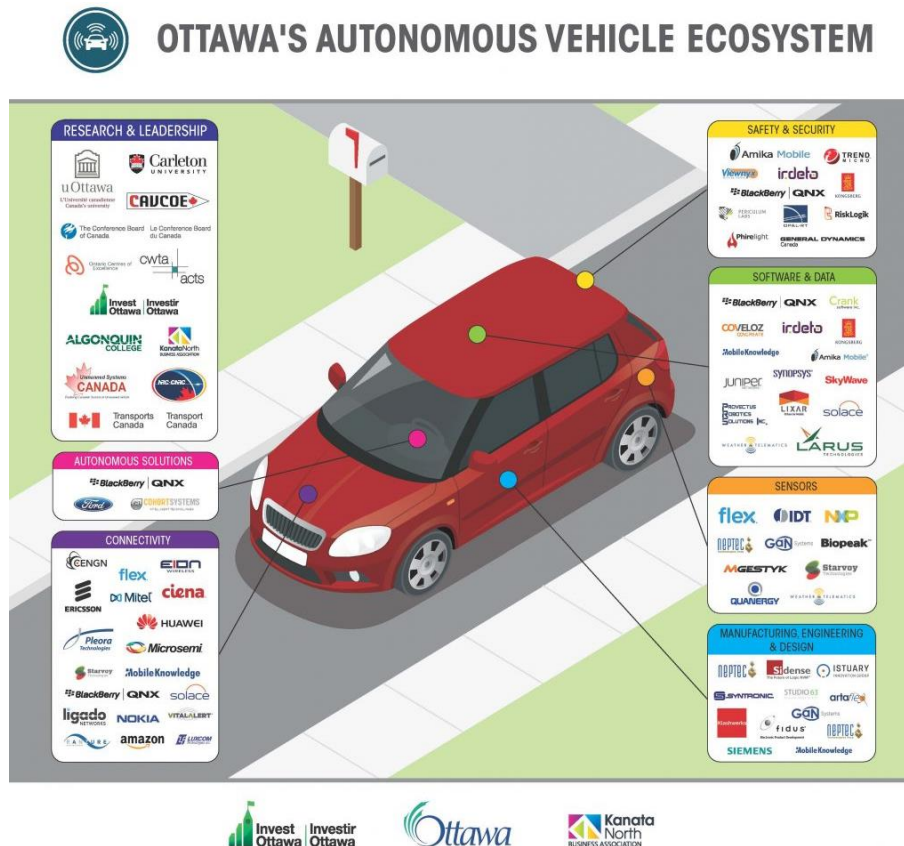

Figure 1: Ottawa has developed an AV R&D Cluster that wraps an on-street AV test route around a technology park that's home to more than fifty companies working on self-driving technology (Kanata North BIA, 2017)

Edmonton

Edmonton's primary focus has been on connected vehicle testing through the ACTIVE-AURORA program at the University of Alberta. Connected vehicles focus on the ability for vehicles to communicate with each other and roadside infrastructure. While connected vehicles are not AVs, the two technologies complement each other and are commonly referred to as connected-autonomous vehicles (CAVs). Edmonton has currently established three connected vehicle corridors which allows for a variety of testing.

Additionally, University of Alberta is establishing a testing ground for CAVs on the south campus lands. Work is underway to set up a route with connected infrastructure using the existing roads. Testing of AVs can be done at this location since the lands are considered private, and there is no public access to the testing area (the south campus area is mostly undeveloped / agricultural lands).

Figure 2: As part of the ACTIVE AURORA project, The City of Edmonton outfitted one of its buses with connected vehicle technology. The bus can receive audible message warnings that it is speeding, approaching a high collision intersection and if it is following too close (if the vehicle ahead is equipped with connected vehicle technology).

Case studies – United States of America

In September 2017, the US Department of Transportation (DOT) released voluntary guidance for the deployment and testing of self-driving cars. The guidance document gives a framework for states to develop procedures and conditions for AVs safe operation on public roadways, and clarifies and delineates Federal and State roles in the regulation of autonomous vehicles; The National Highway Traffic Safety Administration (NHTSA) will regulate vehicle safety and equipment, while states will be responsible for drivers and vehicle operation. This federal direction will accelerate autonomous vehicle deployment on U.S. roadways (US DOT, 2017)

Over 20 states currently have some legislation enabling the testing of AVs on public roads. The figure below illustrates the status of legislation in each state. The City of Calgary identified California (Contra Costa), Nevada, Michigan and Arizona as the leading jurisdictions in AV testing. Administration talked with officials from California and Nevada to learn about the details and success factors for their respective programs.

Figure 3: Status of Autonomous Vehicle Legislation in the United States (NCSL, 2017)

Contra Costa, California

Overview

Contra Costa is a county situated in California with a population of approximately 1 million and is part of the broader San Francisco-Oakland region. The state of California was one of the first to pass legislation enabling the testing of AVs. The Costa County Transportation Authority (CCTA) undertook an initiative in 2012 to establish a testing facility using an inactive military base in the area. The site, called GoMentum Station, spans about 5,000 acres and has a variety of paved roads and buildings which allows for a variety of testing activities (Business Insider, 2015). The facility enjoys proximity to Silicon Valley companies, and also offers an element of isolation which allows for private testing. GoMentum converted to a non-profit so it did not have to disclose private information of its testers.

The projects aim is to partner with private sector companies by providing space for testing activities in exchange for public sector access to the technologies to inform policy, regulation and planning decisions. Their strategy is focused on three core principles: Creating jobs to increase the region's economic competitiveness; partnering with communities to improve safety, mobility and the environment, and creating a world-class test bed with active industry and government participation.

In discussions with staff from GoMentum, the approach was to start small with some initial activities, and grow use of the GoMentum site through word-of-mouth. This was done via attendance at conferences and other engagements. GoMentum has set up many partnerships, with vehicle manufactures, other jurisdictions and academia. This provides a method for sharing testing data obtained at GoMentum and elsewhere to inform policy, regulations and design. This also allows other jurisdictions to be involved in AV activities without needing to construct their own test track.

Legislation

In September 2016, a bill was passed that gave Contra Costa Transportation Authority, authority to conduct pilot projects for the testing of autonomous vehicles that do not have a driver seated in the driver's seat and are not equipped with a steering wheel, a brake pedal, or an accelerator (given a number of conditions).

Benefits

The test track is close to Silicon Valley, which is the epicentre of driverless vehicle research, and supports many of the companies there including Apple, Toyota, Mercedes-Benz and other major car and technology companies. Three Canadian startups have also used the facility for testing. Along with industry setting up offices in and close to Contra Costa, they also get corporate tourism from companies who are visiting to test at the facility. This tourism supports the hotel, restaurant and entertainment industry in Contra Costa.

Michigan

Overview

Much like Contra Costa County, the University of Michigan has developed a test track facility called Mcity in Ann Arbor, Michigan. Michigan is a natural fit for a test facility due to the proximity to many of the major auto manufacturers in the United States, and also allows for some cold weather testing to occur. Mcity cost $10 million to construct and opened in July of 2015. Unlike GoMentum, Mcity was built deliberately with the testing of AVs in mind. The test track allows vehicle manufacturers to put the vehicles in a variety of complex, urban situations. Another objective of Mcity is a living lab component, where concepts can be tested on public roads. There are over 1,500 connected vehicles travelling in Ann Arbor, and several trials of connected transport trucks (platoons) along Interstate 69 as part of the living lab. One main goal is "implementation of a working system of connected and automated vehicles in Ann Arbor by 2021." The vision of Mcity is similar to GoMentum in many ways. There is a focus on developing partnerships across a wide spectrum of disciplines to test concepts and share information with respect to autonomous and connected vehicles. The hope is that this will facilitate new business opportunities, create jobs and shape policy development.

Legislation

In addition to Mcity, Michigan has legislation in place that allows for on street testing and is one of the first states to allow vehicles to operate without a driver in the front seat and permits automakers to operate self-driving taxis.

Benefits

The Mcity facility has attracted more than $16 million in research funding with over 30 projects. Testers want to be near the test site as part of development, so the proximity of Mcity to major auto manufactures is advantageous. Michigan is attracting international investment in autonomous vehicle research. For example, in August 2017, Taiwanese electronics manufacturing company Foxconn announced it will be building a multibillion-dollar research and development facility for autonomous vehicle components in Michigan (CNBC, 2017).

Figure 4: Examples of winter testing in Michigan (Detroit News, 2016)

Nevada

Overview

Currently, there are around 100 vehicles licensed for operation in Nevada, and they are free to use all public roads.

Additionally, the City of Las Vegas has been piloting a Low Speed Autonomous Shuttle. The shuttle was deployed on a section of Freemont Street in the downtown initially as a trial for the Consumer Electronics Show (CES) in January of 2017. The shuttle ran successfully and generated significant interest from media, the public, and local officials. Las Vegas expanded its trial of the low speed shuttle service into mixed traffic in November 2017. The trial made headlines worldwide when on opening day, a human driven truck backed into the stationary autonomous vehicle.

Legislation

Nevada was one of the first state legislatures to pass legislation enabling AVs in 2011. The legislation essentially allows people or entities to simply apply at the motor vehicle office for an autonomous vehicle license, provided they have insurance and have 10 000 hours of testing completed. No driver is required in the vehicle and there are no specific vehicle requirements. Crashes must be reported, similar to regular vehicles. Due to Nevada's relaxed regulations, many companies who once tested in California have moved down to Nevada to test their vehicles.

Benefits

Speaking with Nevada, there has been a growing interest from auto companies, high tech start-ups and battery manufacturers looking to set up offices in the state. Las Vegas stated that their low speed trial has helped brand their city as a high tech hub, educated the public and has allowed for City staff to have a better understanding of how the technology works and how it can be integrated into short term and long term planning initiatives.

Figure 5: (Left)Low Speed Autonomous Shuttle Operating on Freemont Street in Las Vegas (The Verge, 2017) (Right) You can get a licence for an autonomous vehicle at the DMV in Nevada (PC World, 2013)
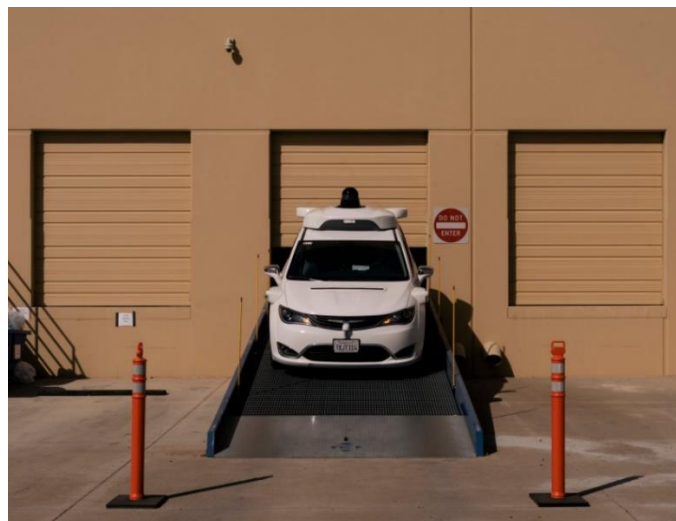
Arizona

Overview

Arizona is seen as one of the leading states when it comes to AV testing. It has attracted major testing programs from Google, Intel, Mobileye and Ford. There is interest in Arizona due to its close proximity to Silicon Valley (a 12-hour drive or two-hour flight); the weather and road conditions (no snow which is easier for on road testing) and most importantly it offers the "most permissive regulatory climate in the United States" (Wired, 2017). Much like Nevada, this regulatory environment has attracted companies from California where it is seen as more burdensome to test AVs.

Legislation

Arizona's Governor Doug Ducey signed an executive order in late August 2015 directing various agencies to "undertake any necessary steps to support the testing and operation of self-driving vehicles on public roads within Arizona." He also ordered the enabling of pilot programs at selected universities and developed rules to be followed by the programs. The order established a Self-Driving Vehicle Oversight Committee within the governor's office.

Benefits

The New York Times reported in a November 11th, 2017 Article titled "Where Self-Driving Cars Go to Learn" that as a result of the state turning itself into a live laboratory for self-driving vehicles, "the payoff for Arizona has been a tech boom, with dozens of autonomous vehicle companies flocking here to set up operations. Every day, Waymo, the driverless car business owned by Google's corporate parent Alphabet, as well as Uber, Lyft, General Motors and Intel now deploy hundreds of cars that drive themselves on the streets of Phoenix, a sprawling metropolis of 1.4 million people" (New York Times, 2017).

Figure 6: A Waymo test vehicle leaving the company's self-driving car test site in Chandler, Ariz. Over the last two years, Arizona has turned itself into a live laboratory for autonomous vehicles (New York Times, 2017) .

Summary of learnings from other jurisdictions

Throughout the interviews and research, several themes emerged as contributing to the success of testing programs. It is recommended that the Province of Alberta takes in to account these key factors when establishing regulation and/or a testing program for AVs.

1. Finding a niche within the industry offers the highest potential for success and economic return

Since so many places are vying to be a part of the AVs, a common piece of advice was that finding a niche issue would be the best way to provide new opportunities around autonomous systems and jobs. This was preferred to constructing a test track or other infrastructure and hoping that testing companies would arrive. It would also set Calgary apart from other jurisdictions with a legal framework for testing, and helps address the challenge that Calgary has not typically been a centre for the automotive industry.

2. Less regulation attracts testing, companies and investment

Jurisdictions are competing for autonomous vehicle testing and investment. While each jurisdiction has put in place a level of regulation that was felt to be appropriate to address safety and risks, the general trend has been to reduce regulations as much as possible. Minimal regulation is the starting point for some jurisdictions, while others have been reviewing initial regulations with an eye towards reduction. Jurisdictions with few regulations were quite comfortable with this approach and felt that testers were adequately addressing the safety aspects of their vehicles. Jurisdictions with fewer regulations and clearly defined rules were attracting testers away from places with more regulations. Some companies are moving away from California to states like Nevada, Michigan and Arizona due to a friendlier regulatory environment.

3. Companies tend to self-regulate when it comes to safety, though certain precautions such as a required amount of testing hours, paired with insurance are necessary before testing vehicles on public roadways

In general, jurisdictions allowing testing felt that preservation of the testers' reputation was a significant motivator for ensuring any vehicles on the road were unlikely to experience significant problems. Currently, any incidents involving AVs generate significant media interest. Thus, it is in the best interests of industry and the tester to prevent these issues from happening as much as possible. This is coupled with most jurisdictions' requirements for evidence of a minimum amount of testing (e.g. number of hours) and a large insurance policy (usually around $5 million) has generally ameliorated concerns about unsafe testing.

4. A seamless process and a central point of contact are critical

Leading jurisdictions had dedicated team who could quickly facilitate requests for testing or enable permits. This made it easy for testers to talk directly with staff who could facilitate specific testing requirements and ensure any coordinated response from government was addressed (e.g. police, roads, etc). For test track sites, staff would facilitate detailed requests to adapt the test track to suit particular testing conditions.

How the City of Calgary can support the economic development of the AV sector

On-street AV testing is the responsibility of the Provincial government. Administration explored off-street testing and how best to support the AV industry from the municipal side using the lessons learned from other jurisdictions.

Finding a niche

The City of Calgary worked with the University of Calgary, Calgary Economic Development and industry in order to understand what Calgary's niche was in relation to the autonomous vehicle industry.

Calgary niche in the autonomous vehicle industry is autonomous systems.

Autonomous systems is an umbrella term that encapsulates technologies that relate to the automation process. These systems include: sensing the environment (sensing), making a decision (cognition) and implementing the decision (actuation).

Autonomous Systems		
Sensing (Geomatics, mapping, data collection)	**Cognition** (Artifical Intelligence, situational awareness, decision making)	**Actuation** (performing the task)

The following sections explaining Calgary's strength in the autonomous systems sector are produced by the University of Calgary, and Calgary Economic Development. The University of Calgary has a world renowned specialty in geomatics, mapping and sensor technology. Industry in Calgary has a specialty in: Computer systems design and related services; data processing, hosting, and related services; and surveying and mapping.

In our conversations with Nevada and Contra Costa, both jurisdictions brought up that geomatics expertise was a highly sought after skill set within the autonomous vehicle industry. Geomatics is defined as the branch of science that deals with the collection, analysis, and interpretation of data relating to the earth's surface.

Academic Strengths – Section contents from the University of Calgary

The University of Calgary (UCalgary) is active in several research areas for autonomous mobile systems (such as vehicles, drones and robots) and related technology (sensors, sensor fusion, software). Autonomous vehicle research includes control and navigation systems, V2V/V2I (vehicle to vehicle / vehicle to infrastructure) technology, and intelligent transportation modeling and design. UCalgary has achieved global recognition for its research excellence in related areas over the past 30 years and continues to lead such technology development and commercialization. Relevant researchers across multiple departments and faculties have collectively trained over 400 graduate students and published 40 patents, 800 journal papers, and approximately 1000 conference papers. Many are internationally recognized in their respective fields with a proven track record of training, research excellence, technology transfer and product commercialization.

Research Excellence

With four national and provincial research chairs, and the largest undergraduate and graduate training programs in Canada, UCalgary is an established leader in geomatics engineering and related technology development for autonomous mobile systems. Research productivity, scholarly impact and international collaborations are the highest of any institution in Canada. This capacity and excellence has generated thousands of highly skilled personnel and high-impact commercialization via innovation, contributing substantially to Calgary's (and Alberta's) global leadership in geomatics. UCalgary geomatics has generated more than $15M research revenue, 12 software licenses, and six spin-off companies in the last decade alone (e.g. 4FrontRobotics, Ventus Geospatial, Trusted Positioning Inc., SensorUP Inc., Nexteq Navigation Corp., and Profound Positioning Inc.). In 2009, UCalgary led development of the first national Centre of Excellence for Commercialization of Research ($40M federal and provincial investment) in the area of geomatics technology, TECTERRA Inc., which has supported over 100 Alberta-based SMEs and generated $200M economic impact to date.
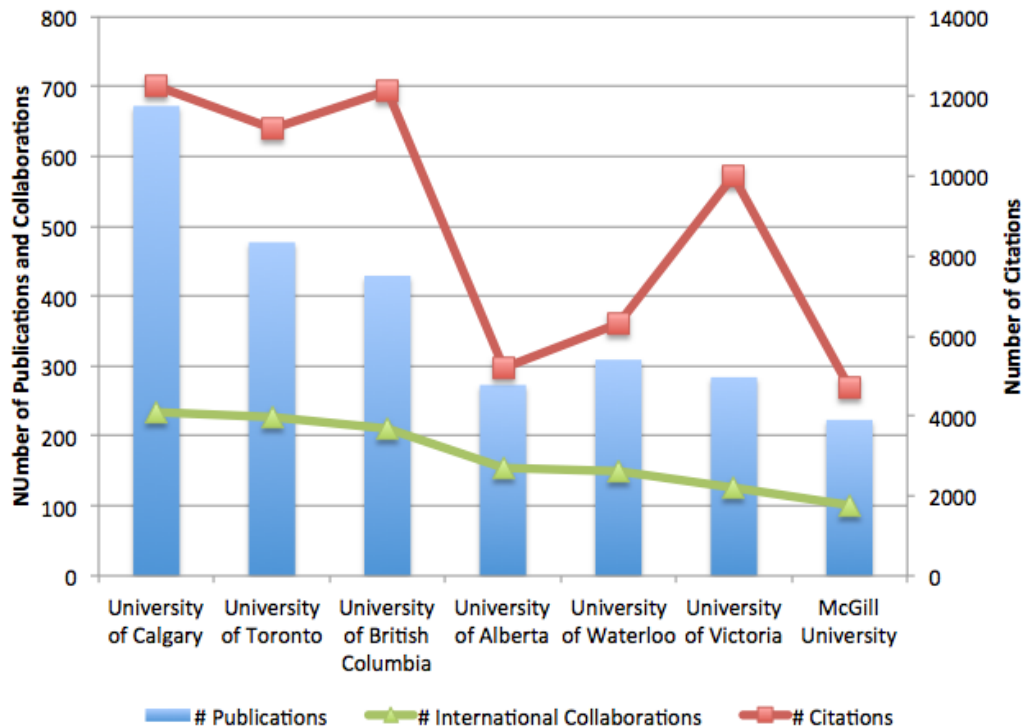
Figure 7 :Geomatics engineering research productivity in Canada 1980-2017 (Thomson Reuters InCites, 2017).

Infrastructure and Facilities

Established and new laboratory resources are available at UCalgary for autonomous mobile systems research and training. These include two labs in the Calgary Centre for Innovative Technology: the Multi-Sensor Lab with over $1M investment in multi-sensor navigation software, low-cost through high-grade inertial systems, design platforms, and sensor calibration and testing equipment; and the Position, Location, and Navigation lab with $2M of multi-constellation multi-frequency Global Navigation Software System (GNSS) hardware and software receivers, antenna test range, hardware and software simulators, and RF front-end data acquisition systems. Much of the infrastructure available is mobile and can be installed on various platforms for field-testing. Lab capacity can accommodate large teams of collaborative researchers.

Relevant Partnerships

Relevant partnerships include the industrial sector: e.g. InvenSense, Modern DSP Technologies, Smart Sensing, NovAtel Inc., and Applanix. The nature of industrial collaboration ranges from industry-hosted student internships to supporting visiting industry researchers in UCalgary facilities and joint research projects. Relevant international academic partnerships are well-established with Ohio State University (United States), EPFL (Swiss Federal Institute of Technology in Lausanne), Wuhan University (China), National Cheng Kung University (Taiwan), and the Hong Kong Polytechnic University (China). Opportunities are under development to formalize shared graduate program curriculum with Wuhan University and Hong Kong Polytechnic.

Training Programs – New Opportunities

There is an urgent need for well-trained professionals who are capable of developing multi-sensor technologies to meet the demands of mapping, navigation and localization applications. The multi-sensor industry is increasing rapidly in Canada and across the world. However, the Canadian (and international) multi-sensor systems workforce faces a significant void in experienced and highly knowledgeable personnel for navigation and mapping engineers and scientists.

To address this need, UCalgary recently developed a new collaborative training program in "Multi-Sensor Systems for Navigation and Mapping - Technology, Applications and Analytics." With federal funding of $1.65M over six years, this program will support more than 100 new undergraduate, MSc and PhD students. This is the largest coordinated training program in geomatics ever hosted at UCalgary. With ten academic collaborators and five industry partners, the program will focus on developing the next generation of skilled personnel in multi-sensor systems for geospatial applications (including autonomous navigation and control), and facilitating their transition to careers in the emerging industry and related sectors. The program combines advanced training and interdisciplinary engagement, currently not offered at Canadian universities, with professional development and practical experience (with the industry partners and other external groups). Trainees will develop systems that integrate various positioning (e.g., Global Navigation Satellite Systems), navigation (e.g. inertial navigation sensors), remote sensing (e.g. imaging and laser scanners), and wireless (e.g. wireless sensors networks) technologies to deliver more reliable, accurate and enhanced information for autonomous mobile systems, among many other applications. Training themes include acquisition and sensing platforms, sensor integration, human interaction and analytics, and applications.

Availability of an autonomous vehicle test platform and testbed would provide major advantage to this program – in terms of skills training, ability to attract further industry and academic partnerships, and commercialization potential.

Industry Strengths - Section contents from Calgary Economic Development

Strengths and Opportunities in Autonomous Systems Cluster

To get a baseline understanding of Autonomous Systems, Calgary Economic Development identified various industry sectors that are either directly related or have components that are associated with Autonomous Systems. All these industries form a cluster, which are groups of similar and related firms in a defined geographic area that share common markets, technologies, worker skill needs, and which are often linked by buyer-seller relationships. The industries were broken down by the North American Industry Classification System, which allowed us to identify the number of companies, and the level of employment for the Autonomous Systems cluster.

We then performed a location quotient (LQ) analysis on industries associated with this cluster, which quantifies how concentrated the employment of a particular industry or cluster is in a region as compared to the nation. It can reveal what makes a particular region "unique" in comparison to the national average. For example, a LQ of 2 for a given industry means that the employment is two times more concentrated in the region than the national average. It is commonly accepted that a LQ >1.2 for a specific sector or cluster shows a strength for that region.

Table 1 shows the analysis performed on the Autonomous Systems Cluster.

Table 1. Analysis of Autonomous Systems Cluster of Industries

NAICS	Industry	2017 Establishments	Calgary Employment	Specialization (Location Quotient)
334220	Radio and television broadcasting and wireless communications equipment manufacturing	4	98	0.39
334290	Other communications equipment manufacturing	3	22	0.14
334511	Navigational and guidance instruments manufacturing	3	7	0.04
336110	Automobile and light-duty motor vehicle manufacturing	0	0	0.00
518210	Data processing, hosting, and related services	57	2,157	**2.27**
541370	Surveying and mapping (except geophysical) services	81	1,671	**3.31**

541514	Computer systems design and related services (except video game design and development)	2,103	12,264	**1.19**
541710	Research and development in the physical, engineering and life sciences	90	998	0.50
	TOTAL	**2,341**	**17,216**	**0.98**

Source: Statistics Canada June 2017

As of June 2017, there were 2,341 establishments with about 17,200 employees in the industries related to the Autonomous Systems Cluster in Calgary.

The key takeaway from this table is that it shows the Calgary region has a high specialization in high end services associated with the Autonomous Systems cluster. This includes having a concentration of companies involved with custom software development, surveying & mapping (Geomatics), data storage, data analysis (GIS), and synthesizing of data. Amongst the three, Computer Systems Design has the largest employment at 12,264 and includes companies such as General Dynamics and Veerum, which have developed custom software for controlling vehicles or manage infrastructure in a cost effective and efficient manner. The other two industries, Surveying and Mapping and Data Processing, have lower employment as compares to Computer Systems Design, but have over 2 times employment specialization in Calgary as compared to the national average.

Another important area highlighted in the table above is that the Calgary region does not specialize in manufacturing sectors associated with Autonomous Systems Cluster. As can be seen from Table, all manufacturing sectors have Specialization much lower than 1, which means Calgary's employment concentration in these sectors is lower than the national average.

Industry Perspective

CED interviewed several organizations involved with Autonomous Systems for their perspective. Since technology and innovation are a vital component of Calgary's growth and diversification strategy, the purpose of this Industry Scan is to get a private sector perspective on the Industry Strengths of testing and development Autonomous Systems in Calgary. Below are the overall findings.

There is a crossover of strong expertise in Calgary that are applied to Autonomous Systems Industry.

Calgary has a base of established multinational companies that are developing leading edge technologies with GPS, GIS, telecommunications equipment, and drones. From Unmanned Systems testing facility (CCUVS) near Foremost AB and Defence and Aerospace (QinetiQ) in Medicine Hat, to aircraft manufacturing (Viking Air), UAV control systems (Lockheed Martin CDL Systems, General Dynamics), and miniaturized GPS components for UAS (NovaTel) in the city, Calgary has a variety of industrial developments that are directly related to the Autonomous Systems Cluster. In terms of support organizations, The Western Canadian Defence Industries Association, headquartered in Calgary, manages the Unmanned Vehicle Systems Canada Conference each year. Calgary also has a Post Secondary Education System that provides R&D into Machine Learning. With a growing entrepreneurial system that is adapting and developing away from agriculture and natural resources, Calgary companies are getting more and more involved in developing tools and technologies that are essential for autonomous systems.

Calgary has talent and software development expertise directly related to Autonomous Systems, however there is a need to attract, enhance, and retain more talent and software assets.

As companies in the autonomous systems Industry move more and more towards automation, there are two main automation paths. One of them is System Integration - being able to connect together various hardware and software components within a larger system. The other is Artificial Intelligence/Machine Learning/Deep Learning. Calgary has the potential for spurring Innovation for Autonomous Systems Industry. Having amongst the best engineering and geomatics talent in Canada, Calgary's industries see emerging trends in components of Systems Integration and Artificial Intelligence that are essential for functioning of Unmanned Autonomous Systems. Calgary's industries have knowledge of Industrial Internet of Things, LiDAR Systems, and softwares such as JAVA, NODE-JS, PYTHON, and C++. However, to adapt to the growing trend of Autonomous Systems, Calgary will have to enhance in software knowledge and development as well as human resource talent that includes Data Scientists, Programmers, Technologists, Software Developers, Computer Visioning Experts, Research Academia, and generally technologically creative individuals that maintain their presence in Calgary.

Calgary makes for an excellent on-road Testing Ground for Autonomous Vehicles.

Compared to other cities in Canada, there is more stability in Calgary's infrastructure and less congestion, which makes for an excellent first stage testing ground. In addition, Calgary has all types of weather conditions that vehicles should be tested on such as snow, ice, and fog which will help companies boost innovation as they attempt to tackle these issues.

Having an innovative tech talent coupled with a strong Geomatics Industry in Calgary, The City of Calgary can help companies infuse that strength into autonomous systems.

Suggestions from the industry highlight areas that City of Calgary may consider for further developing the Autonomous Systems Industry. Following are some of the considerations for City of Calgary from the Industry:

- Easing regulations:
  Loosened regulations that allow for testing of AVs in warehouses as well city streets. This involves loosening protocols and policies, facilitating transport Canada approvals, and overall creating highly efficient facilities that help companies move through the regulatory process. Industry believes that more flexible regulations would induce development and innovation of this technology in Calgary.

- Real time Support:
  Industry aspires real time support that is more at the Business speed. This real time support can include creating a simple process for Autonomous Systems development and testing to support Industry, making sure that The Council listens to recommendations, and reinforcing that industry desire is met with collaboration.

- Testing Tracks:
  For the Province of Alberta, one measure can be amending the Highway Traffic Act to allow testing of Autonomous systems. Within Calgary, Autonomous systems need to be tested in complex environments in "Canyoned" areas like downtown where GPS signals are variable. Having a virtual "test track" setup on a number of streets in downtown Calgary between Midnight and 6am is a recommendation by Industry. Creation of a downtown Calgary AV test track would be the next step from testing in parking lots.

- Facilitating Start-ups:
  The City of Calgary can help in reducing risks and costs associated with technological projects. This included facilitation Start-ups by creating industry collaboration Incubators and accelerators that serve as physical space, capital, coaching, common services, and networking connections for Start-ups.

- Communication is Key:
  Communication can involve The City of Calgary connecting start-ups and community in the form of events, publications, and modes that allow people to tap into local happenings in the startup autonomous systems world. Constant communication from The City and from Calgary Economic Development is also necessary in terms of the resources that are available to SMEs and large companies. A consideration is that CED can host an

Autonomous Systems Group that includes Universities and Technical Colleges, as well as local and regional Small, Medium and Large companies.

- Performance standards:
Performance standards include safety regulations necessary to ensure the safe operation of those vehicles. The City of Calgary can set performance standards in areas such as level of autonomy, insurance coverage, operational and safety requirements, and public participation.

- Fostering Innovation:
To promote Agile Software Development, the City can help tech talent adapt, learn, and champion the ideas around Autonomous Systems in Calgary. They can also encourage R&D and testing of AVs by promoting a friendly business environment to attract additional companies in Calgary. This initiative can start with projects that provide grants for startups and tax incentives for incumbent companies.

Additionally, The City can contribute to advance education by encouraging more options for students in Postsecondary Institutions and motivating local SMEs to hire local talent. This will not only give employers incentives to hire students after internship, but also foster loyalty to Calgary by recent graduates and companies.

What The City of Calgary can do to support Industry and Academia in the autonomous systems industry

A reoccurring theme in conversation with industry and academia is that they are looking places to test autonomous systems technology. The technology tested could range from an autonomous vehicle, to a sensor. One of the strengths The City has is that it has a number of different assets where testing could occur. Below is a list of assets that industry complied; this list represents a sample of the different assets industry and academia are looking to utilize:

- Roadways & City personnel

- Parkades & personnel supporting the parkade

- Traffic lights/signals staff and equipment

- Parking lots

- Public Parks (Open Space tests wireless communication systems)

- Fleet vehicles maintenance personnel & operators & equipment

- Vehicle operators & maintenance staff

- Police & Fire Department personnel & training facilities

Administration then investigated ways that The City could give access to assets to industry and academia.

Establishing an Intake Process

Currently, there is no formal process for industry to use a City asset like a parking lot to conduct testing[3]. Transportation worked with CED and Law to understand what processes would be suitable for in taking industry and academia's request for using City assets. Using the learning from other jurisdictions that <u>a seamless process and a central point of contact are critical</u> in establishing a testing program, we came to the conclusion that the existing CED film intake process was very similar to the intake process being contemplated.

Overview of Film Process

The following is an overview of the process for filming in Calgary-

1. An individual or company wants to film a scene
2. They then fill out the relevant online forms including:

    a) A Mandatory Film Production Information Form - This form provides basic information about the production and the production company; a brief outline of all planned activities; the initial shooting schedule; and approximate number of cast and crew members.
    b) A Mandatory Acceptance of Terms and Conditions Form – This form serves to "indemnify and save harmless The City of Calgary and Calgary Economic Development from and against any and all claims, actions, damages, injuries, costs, expenses or losses of any kind which may be brought against or suffered by The City of Calgary, Calgary Economic Development or their personnel or agents as a result of or in connection with the Applicant's filming and other related activities at the Location(s) unless those claims, actions, damages, injuries, costs, expenses or losses are caused solely by the gross negligence and willful misconduct of The City of Calgary or Calgary Economic Development".

    The form also requires that the applicant will: have insurance; obtain necessary permits; adhere to the law; pay costs identified or incurred by The City of Calgary; adhere to The City of Calgary's Guidelines for Filming; and settle disputes in in accordance with The Arbitration Act.

    c) Other commonly used forms including: Parking/street use permit application; Parks use permit application; Burn permit application; Transport explosives permit application; and Explosive use permit application.

3. Staff from CED's *Film, Television and Creative Industries* contacts the individual or company and there is a discussion about site selection, timing and other aspects of the shoot.
4. CED staff contacts the relevant City of Calgary Departments in order to facilitate filming and obtain permits on behalf of the applicant. There are specific point people within each City of Calgary business units who deal with film applications.

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[3] There are existing City processes like the Street Use Permit and Park Rentals where individuals can lease space, however these processes do not explicitly account for testing and the potential added complexities

5. City of Calgary agrees (or disagrees) with the filming proposal. If they disagree, alternatives are explored.
6. If the City agrees, CED notifies the filming applicant and they pay the relevant permitting charges and fees.
7. City of Calgary does the necessary work (e.g. closing a roadway)
8. Filming takes place

Depending on the complexity of the shoot, this process can take a week or a month.

Success of Film Intake Process

The film process has been a main contributor to the success of the film and television industry in Calgary since being established in 2009. There have been over 400 submissions in 2017 alone, and the process regularly receives positive feedback for its simplicity and helpfulness (relative to other cities in Canada). The film office has three staff that facilitate the process. This effort supports roughly 10,000 industry jobs in Calgary.

Overview of Potential Intake Process

The City of Calgary envisions a similar process for testing autonomous systems technologies. Given the need for a point of contact to facilitate a successful testing process, it was realized that the film process has several parallels to autonomous systems testing. These are that:

- Both activities are focused on a specific location, with unique opportunities and issues
- Both activities can involve unconventional activities, which can involve a level of risk
- Both activities use similar City assets (roads, parks, police services, etc.)
- Facilitation of both activities is to fulfill broader economic objectives (diversity of industry, creation of jobs, etc.)

The benefits to using this intake process is that:

- The requirements for filming and testing are similar
- The process can handle complexity and a variety of different technologies and scenarios
- There are minimal operating cost impacts as The City is reimbursed for costs, though it does not make a profit
- It is an existing process that works. City Staff and CED are used to this process.

The benefits of mirroring the film permit process are that:

- It creates a single intake point between industry and The City (via CED)
- CED has the most exposure to local businesses which facilitates contact
- Insurance, indemnification and other requirements are addressed up front as part of the submission
- It takes into account the unique nature of each request (location, details of work, etc.)
- The existing process has proven successful in the film industry and is highly regarded
- The application is very simple and straightforward, at only two pages.

As a result, Administration is recommending moving forward with establishing an intake process for autonomous systems testing that would be modelled after the film permit process. This would allow for a fair and consistent approach for handling such requests, with the aim that testing will support existing companies and potentially attract new ones. The process would expect that applicants would cover any costs incurred by The City and CED. While establishing the process can be done with minimal cost, the potential for a staff resource has been identified by CED to facilitate the intake process and position it to be successful.

Conclusion

The intake process proposed utilizes the lessons learned from other jurisdictions of utilizing our niche, setting up a streamlined process with as little red tape as possible, and putting the onus of safety on the tester.

There are over 20 states in the USA and one province in Canada currently allowing for autonomous vehicle testing in order to compete for jobs in this sector. In order for Calgary and Alberta to be competitive, we need to have regulations favourable to industry and a niche that attracts industry.

However, if the goal of testing is to attract investment, a car or tech company doing a few autonomous roadway tests does not have major economic benefits. In order for testing to benefit the economy, there needs to be companies investing in Calgary and creating jobs. The best way to do this is too build upon an existing niche / strength. In Ontario and Michigan, they are using their existing position as major auto manufacturers to further the automotive industry, and in Contra Costa they are building upon their existing tech strength in order to grow. In Calgary, we should utilize our strength in the autonomous systems sector in order to attract and grow industry. For example, the Alberta Centre for Advanced MNT Products (ACAMP) recently completed a number of autonomous systems tests including: developing an autonomous All Terrain Vehicle (ATV) for the Edmonton Airport; siren detection for vehicles; and a traffic signal detection device that adds wireless communication from traffic signals to assist vehicle operation. Through these tests ACAMP hired number of international and local employees in order to develop the product and conduct the testing. It is expected that most of the testing of autonomous systems technology will not utilize an autonomous vehicle, but will test the systems that are essential for the operation and development of the technology.

The combination of promoting regulations that support on street testing and the development of a program that will allow industry and academia access to City assets in order to develop the autonomous systems in Calgary, will put Calgary in a better place to grow our economy and create jobs in this sector.

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