A Driverless Future
It's not Just About the Cars

Exploring the Urban Effects of Autonomous Vehicles and What Cities Can Do About Them

THINK BY IBI GROUP

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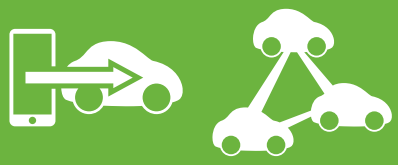
JANUARY 2017

What are connected and autonomous vehicles?

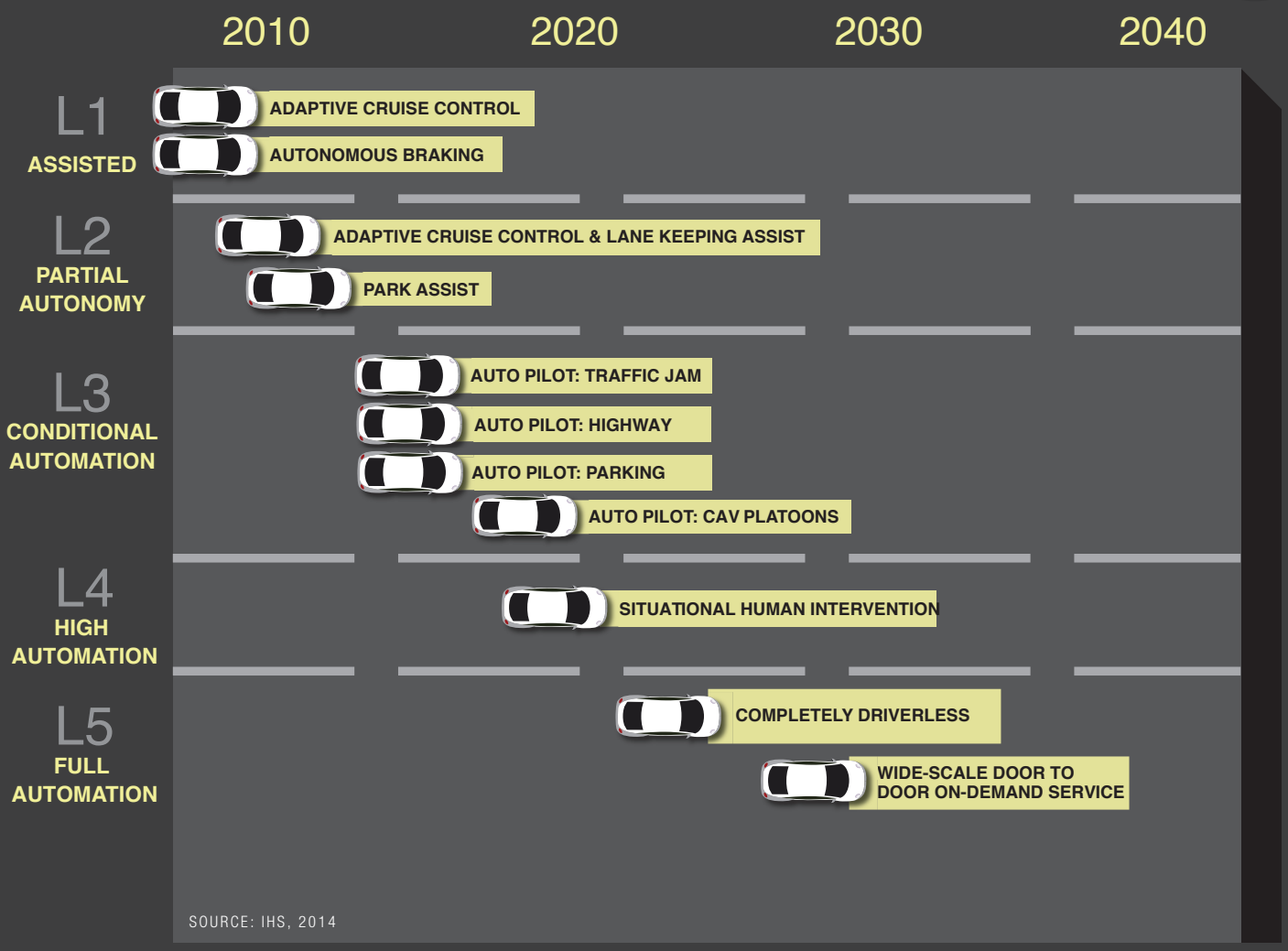
Connected Vehicles (CVs) are vehicles that are connected to infrastructure, mobile devices, and other CVs and are capable of sharing information with each other to optimize their function and performance.



Autonomous Vehicles (AVs) interpret the world around them and navigate roads without human intervention. Driverless cars are fully autonomous vehicles.

Connected and Autonomous Vehicles (CAVs) are capable of synergizing the abilities of both the autonomous and connected components and will be the vehicles of the future.

When are they coming?



The prospect of Connected and Autonomous Vehicles (CAVs) represents a transformation in the way the world moves. CAVs will also be a significant disruptor to established practices across multiple industries. As potentially defining elements of integrated mobility systems in the cities of tomorrow, they are likely to have considerable influence on how we live, work, play, move, and interact.

AS ***PETER DRUCKER***, THE FOUNDER OF MODERN MANAGEMENT, ONCE SAID

> **The best way to predict the future is to create it.**

Where are CAVs being considered today?

USA
Many states have now legalized the testing of CAVs on their roads. In Pittsburgh and San Francisco, driver-present autonomous Uber vehicles have been introduced and can be requested by passengers.

Ontario
Since January 2016, Ontario has allowed CAVs to be tested on its roads. The University of Waterloo has begun testing AVs and is improving the technology to adapt to winter road conditions.

Helsinki
Plans to eliminate the need for car ownership by 2025 by promoting on-demand transit that is envisioned to eventually be a fully autonomous system. Driverless buses are currently operating along a fixed route.

Switzerland & Netherlands
Autonomous minibuses operate along a fixed route. Service began at the start of 2016.

Singapore
Currently operates driver-present autonomous taxis and will be rolling out driverless buses in 2017.

Japan
Robot taxis began testing on public roads in 2016. The goal is to have Robot Taxi in service for the 2020 Olympic games in Tokyo.

CAVs could have both positive and negative implications for many aspects of urban life

1. TRAFFIC SAFETY

90% of accidents

are caused by human error[1]

20% to 30% of all collisions

involve driver distraction[2]

33,147 annual motor vehicle fatalities

in Canada and the USA[3]

1 person killed every 25 sec

around the world (1.25M annually) due to a vehicle-related accident[4]

$10 billion annually

economic loses related to health care costs and lost productivity caused by traffic collisions in Canada[5]

Annual Traffic Fatalities in Canada and the USA[6]

5,172
Pedestrians

4,484
Motorcycle Drivers/ Passengers

22,694
Automobile Occupants

755
Cyclists

Potential Gains

\+ CAVs could eliminate or reduce the severity of 90% of traffic related fatalities.

Potential Pains

\− The transition period when both CAVs and non-CAVs are on the road could make matters worse before it makes them better. CAVs will also need to make morally complex decisions that will be controversial.

Potential Ways to Leverage the Gains

⊕ Design infrastructure to consider the operating parameters of CAVs.

⊕ Segregate of CAVs and non-CAVs in the early stages of infiltration.

1. STANFORD LAW SCHOOL, 2013 - HTTP://CYBERLAW.STANFORD.EDU/BLOG/2013/12/HUMAN-ERROR-CAUSE-VEHICLE-CRASHES
2. ALBERTA TRANSPORTATION, 2011 - HTTP://DISTRACTEDDRIVING.CAA.CA/EDUCATION/
3. TRANSPORT CANADA, 2014 - WWW.TC.GC.CA/MEDIA/DOCUMENTS/ROADSAFETY/CMVTCS2014_ENG.PDF
4. WORLD HEALTH ORGANIZATION, 2016 - WWW.WHO.INT/MEDIACENTRE/FACTSHEETS/FS358/EN/
5. WWW.CAA.CA/DISTRACTED-DRIVING/
6. IIHS - WWW.IIHS.ORG/IIHS/TOPICS/T/GENERAL-STATISTICS/FATALITYFACTS/STATE-BY-STATE-OVERVIEW

2. TRANSPORTATION EFFICIENCY

Congestion causes a 35% increase in travel time in Vancouver and 31% additional travel time in Toronto[1]

17.2% of Canadian commuters take 45 mins or more to get to work[2]

The average Canadian commuter lost 79 hrs in 2014 due to traffic delays[3]

Conventional transit service is inefficient in low-density areas

Potential Gains

+ Commute time could be used more effectively (working, sleeping, entertainment, socializing).
+ CAVs could improve public transportation services and decrease auto ownership by enabling more efficient, user-friendly, and low cost on-demand transportation services, even in low demand areas.
+ CAVs can platoon and become more space efficient which can increase traffic throughput and road capacity by up to 30% and reduce travel times.

Potential Pains

− CAVs could increase vehicle kilometres travelled (VKT) as people could tolerate longer commutes, live further from their workplace (exurban sprawl), and travel more often.
− Short trips by on-demand CAV services could replace trips made by active transportation and public transit.
− High rates of personal CAV ownership could perpetuate the status quo in parking, ownership, and land use patterns.

Potential Ways to Leverage the Gains

⊕ Create synergies by integrating CAV technology, emerging on-demand transportation services, public transit, and other shared mobility options.
⊕ Leverage CAVs to improve public transportation service before they become widely available and affordable as personal automobiles.
⊕ Develop infrastructure and invest in the development of an integrated mobility system.

1. TOMTOM, 2014 - WWW.TOMTOM.COM/EN_CA/TRAFFICINDEX/?PID=7969333#%2F
2. STATISTICS CANADA, 2011 - WWW12.STATCAN.GC.CA/NHS-ENM/2011/AS-SA/99-012-X/99-012-X2011003_1-ENG.PDF
3. TOMTOM, 2014 - WWW.TOMTOM.COM/EN_CA/TRAFFICINDEX/?PID=7969333#%2F

3. LAND USE EFFICIENCY

It is estimated that there are between 4 and 8 parking spots or up to 1,300 square feet of parking for every automobile in North America. On average, automobiles are parked 95% of the time.[1]

In auto-oriented cities, up to 50% of land surface can be dedicated to transportation compared to 10% in pedestrian oriented cities. Dedicating land to transportation carries significant financial and environmental burdens.[2]

Potential Gains

- CAVs that are providing on-demand transportation services will contribute to a decrease in vehicle ownership. This will reduce the total number of cars in urban areas that are sitting idle, resulting in a reduced demand for parking space.
- Land that was previously used for parking could be re-purposed for other uses (housing, retail, recreational, etc.).

Potential Pains

- Personal CAV ownership could further promote urban sprawl.
- While parking space may be reduced, there may be an increased need for curb-side street space.

Potential Ways to Leverage the Gains

- Land use policy can include restricting access to newly converted on-street parking space by allocating it to specified commercial or recreational uses, such as delivery bays, enlarged footpaths, or bicycle tracks.
- Freed-up space in off-street parking could be used for urban logistics purposes, such as distribution and charging centres, or for recreation, affordable housing or urban agriculture.
- New suburban neighbourhoods need to be designed with sustainability principles - co-working, on-site flood prevention, on-site power generation and agriculture, social networks, and on-demand mobility.

1. WWW.NRDC.ORG/EXPERTS/DAVID-B-GOLDSTEIN/DOES-EVERY-CAR-NEED-8-PARKING-SPACES-RIDE-SHARING-CAN-SAVE-EMISSIONS
2. WWW.VTPI.ORG/LAND

4. INFRASTRUCTURE AND TRANSIT SPENDING

$123B
Infrastructure Deficit

Given the challenging financial situations experienced at all levels of government, Canadian cities and communities are challenged by this deficit[1]

79%

On average, more than 79% of the useful life of the currently available public infrastructure has been exausted[2]

Billions
of dollars in transit investment

Canadian cities are expecting to invest billions of dollars into transportation infrastructure in the coming years to increase their transportation network capacity. A significant portion of this funding will come from the federal and provincial governments.

0.41 : 1

The average ratio of revenues to operating expenses from 49 of the largest transit agencies across North America[3]

Potential Gains

- \+ CAVs will require less road space per vehicle, thus increasing the capacity of existing roads and highways.
- \+ Publicly regulated demand-responsive CAV services will be able to provide a lower price point and better service to dramatically improve transit in areas with low transit demand.
- \+ Demand-responsive CAVs could reduce the need for car ownership and promote alternative transportation modes.

Potential Pains

- − More vehicle kilometres travelled (VKT).
- − More expensive connected infrastructure is required to support CAVs and non-CAVs.
- − Labour shortages and union/public backlash against job automation.

Potential Ways to Leverage the Gains

- ⊕ Incorporate CAVs into strategic assessments for capital investments in infrastructure. Consider new ways of utilizing existing infrastructure based on CAV specs and requirements.
- ⊕ Re-purpose infrastructure that becomes underused for more green space, parks, or other uses.
- ⊕ Ensure that the projects built today will not be made redundant by the advent of CAVs in the near term.

1. WWW.ACEC.CA/FILES/ADVOCACY/VI/PUBLIC%20INFRASTRUCTURE%20UNDERINVESTMENT%20-%20THE%20RISK%20TO%20CANADA%E2%80%99S%20ECONOMIC%20GROWTH_2010.PDF
2. WWW.RCCAO.COM/RESEARCH/FILES/RCCAO_INFRAFUNDDEFICIT-JUN06.PDF
3. FAREBOX RATIOS AROUND THE WORLD" WIKIPEDIA, 2016

Leveraging the gains while avoiding the potential pains

Cities need to address how the technology integrates into the broader mobility ecosystem. The rise of driverless cars is happening in parallel with three important urban mobility developments: a transit renaissance, the rise of shared mobility, and the emergence of on-demand technologies.

On their own:

Driverless Cars

= More Suburban Sprawl

Rapid Transit

= More Traditional Transit

Shared Vehicles

= More Ridesharing

On-Demand

= More Hail Services

Reduced or negative impact on:

- Pollution
- Congestion
- Cost
- Convenience
- Space Use

Combined:

Driverless Cars + **Rapid Transit** + **Shared Vehicles** + **On-Demand**

=

More Sustainable + Resilient Urban Ecosystem

Reduction or improvement in:

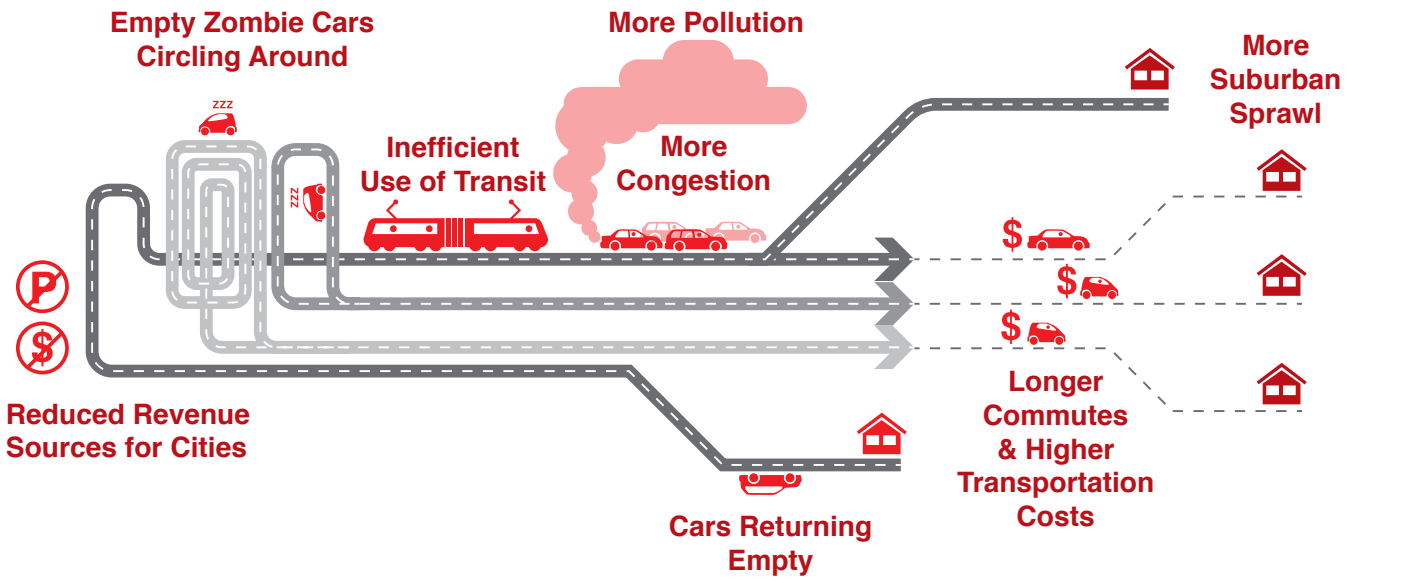
- Pollution
- Congestion
- Cost
- Convenience
- Space Use

Combining the disruptive potential of driverless cars with improved public transit, access to shared mobility and on-demand technology can have a positive, long-lasting effect on our cities.

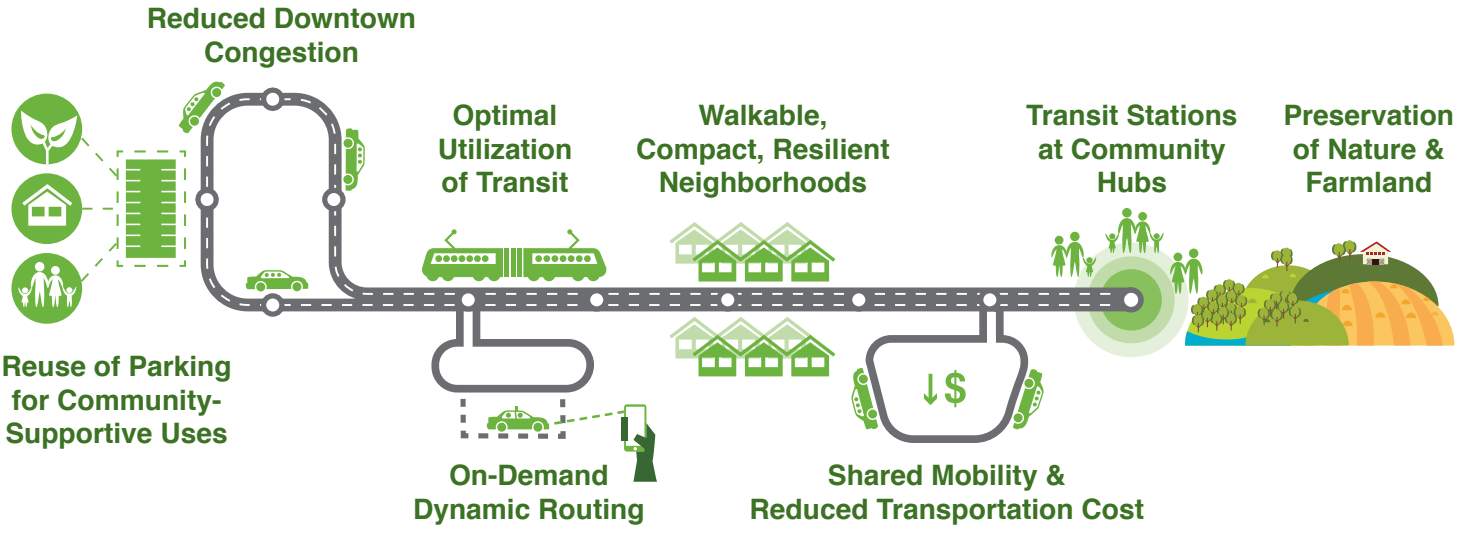
Results: safer, cleaner, faster, cheaper, more convenient, and less land needed for highways and parking.

Positive scenarios of a combined urban ecosystem

Driverless Cars On Their Own:



A Healthy Urban Ecosystem



Rapid Transit:
Shared driverless cars could bring people to transit stations and then pick up new passengers for the ride home, reducing the demand for parking at the station or your destination, and reducing congestion on highways.

Shared Mobility:
Driverless cars could be shared by many instead of owned by a single household, reducing the cost of ownership, the number of cars on the road, pollution etc.

On-Demand Technology:
Apps that allow for real-time pickup with pricing that's integrated into your transit ticket. Instead of monitoring how bad traffic is or how much your taxi fare is going to be, you know that you always have mobility at your fingertips.

Sample policies that could contribute to a healthy urban ecosystem

This positive scenario will only happen if correct policies, initiatives, and incentives are put in place by the public sector. Actions like:

- Revamping parking regulations, including eliminating minimum parking standards and provisions to futureproof new parking investments
- Overlaying zoning and incentives for the redevelopment of parking structures and surface parking into community-supportive uses, such as micro-housing, urban agriculture and neighbourhood facilities
- Developing strategies for the reuse of street parking and excess road space, such as priority boarding areas on sidewalks for shared, on-demand services, pop-up open spaces, and alternative modes of transportation
- Implementing congestion pricing on major highways and in major shopping/employment areas targeted primarily at no occupancy and single occupancy driverless car trips
- Implementing progressive taxation by commute distance for single occupancy, single ownership driverless cars as a gradual move away from gas taxation
- Converting park-and-ride facilities to a higher and best use, such as compact housing and mixed-use community hubs with direct transfers between shared driverless services and rapid transit
- Integrating function and fare of private sector transit on-demand services with public transit, including incentives for provision of driverless carsharing as first-last mile provider

How can CAVs be leveraged to help achieve city building objectives?

Identify the opportunities and risks that CAVs pose for current strategic directions and city building objectives

Closely monitor the applications of this technology and develop metrics for evaluating performance and solution potential

Develop a framework and implementation strategy for how to leverage CAVs

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There are many possible directions that a city could take to prepare for this technology, from effective policy and proactive design, to complete avoidance. But one thing is for certain: CAVs are coming and they will transform the urban landscape in the near future.

Recognizing both the pains and the gains that this transformation presents, city builders have the opportunity to identify and maximize the benefits, while mitigating the risks. The only way to achieve this is through thoughtful design, sound policy development, proactive planning, and effective governance.

Internal Review: Phase 1 - Survey

IBI conducted an internal review of its service sectors to evaluate our capacity to capitalize on the opportunities that are emerging from the rapid progress of Connected and Autonomous Vehicle (CAV) technology and its wide ranging implications. In the first phase of the internal review of IBI's sector leads and office leads, 54 people responded. The responses represented the geographic and professional diversity of the firm.

87%
strongly or somewhat agree that CAVs will have a considerable impact on their existing clients.

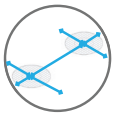
70%
strongly or somewhat agree that CAVs will have a considerable impact on their work.

58%
strongly or somewhat agree that consulting opportunities in the CAV arena exist today.

28%
strongly or somewhat agree that their department is ready for the opportunities.

The survey results suggest that CAV's present existing and emerging business opportunities but that there is much we need to do to prepare for these opportunities.

CAV Implications/Opportunities

	Region	City	Buildings/Street
			
INTELLIGENCE			
Traffic Management	✓	✓	✓
Transit Management	✓	✓	✓
Traveller Information	✓	✓	✓
Tolling and Revenues	✓	✓	
Information and Comm. Tech.	✓	✓	✓
BUILDINGS			
Residential Buildings			✓
Health Care Buildings			✓
Educational Buildings			✓
Civic/Industrial - Buildings			✓
Transit Station Design	✓	✓	✓
Maintenance Facility Design			✓
Transit Terminal Buildings	✓	✓	✓
Parking Structures	✓	✓	✓
Office Buildings			✓
Justice Buildings			✓
Hospitality Buildings			✓
Retail Buildings			✓
Greenfield Development		✓	✓
Brownfield Development		✓	✓
Intensification		✓	✓
INFRASTRUCTURE			
Regional Planning	✓		
Neighbourhood Planning		✓	✓
Site Planning		✓	✓
TOD		✓	✓
Real Estate, Economics	✓	✓	✓
Transit Infrastructure	✓	✓	✓
Transit Planning	✓	✓	✓
Highways	✓	✓	
Active Transportation		✓	✓
Transportation Planning	✓	✓	✓
Water Resources			✓

Internal Review: Phase 2 - Internal Consultation

The second phase of the review involved in-depth discussions with the survey's most involved respondents across the firm's three primary sectors - Intelligence, Buildings, and Infrastructure.

The purpose of these discussions was to identify the Strengths, Weaknesses, Opportunities, and Threats (SWOT) that CAVs pose to IBI Group. Strategic action items were also identified. These discussions are summarized below.

Strengths

Intelligence:
IBI has a working relationship with existing network operators and an understanding of how our clients operate road networks.

Buildings:
IBI is one of the world's largest Architecture firms and has expansive expertise and experience in adaptive building design and building retrofit projects.

Infrastructure:
IBI is a leader in infrastructure planning, transportation planning, urban design, and land use planning.

Weaknesses

Intelligence:
IBI does not own big data, develop mapping, or operate transportation services.

Buildings:
Existing clients have limited funding and ability to fund innovative design. The P3 process also limits design creativity .

Infrastructure:
IBI does not currently have a working relationship or connections with auto manufacturers, tech giants (eg. Google, Apple), or private transportation network companies, such as Lyft or Uber.

Opportunities

Intelligence:
Assisting with business models as they become more complex and helping clients understand the interface between transportation choice and technology.

Buildings:
Parking garage retrofits and adaptive building design. Also, Designing the interiors of autonomous micro-transit as there will be more of a focus on user experience and comfort.

Infrastructure:
The planning and testing of multi-modal transportation networks, the development of visions and design concepts for the integration of CAVs into neighbourdhood design, designing sustainable suburbs, designing pick-up/drop-off areas, vehicle circulation, street design, and re-purposing land uses.

Threats

Intelligence:
Not adapting to shifts in the market, not understanding the full context, and losing out on opportunities. Technology evolves faster than anticipated and all communications are V2V, eliminating the need for ITS and an intermediary between vehicles, infrastructure, and road users.

Buildings:
Rushing to enter the market before the future unfolds and seeming overly presumptuous.

Infrastructure:
Planning expertise becomes replaced by data companies and on-demand transportation services eliminate the need for an intermediary between the user and the service.

Actions

Intelligence: Market overview and further identification of opportunities

Buildings: Inform clients about CAVs and the importance of adaptive building design

Infrastructure: Develop content on the the impact of CAVs on infrastructure and land use trends and the need for proactive planning.

Opportunities for IBI Group as the age of CAVs emerges

Urban Design

» Redefining the Streetscape (street retrofits)
» Land repurposing
» Sustainable Suburbs

Transportation Planning

» Traffic Impact Studies
» Transportation Master Plans (with consideration for AVs)
» Macro-Modelling inclusive of on-demand AV services
» Demand Responsive AV transit systems in rural areas
» Parking Standards Updates
» Station Access Strategies leveraging AVs
» Pedestrian/Cyclist Interaction with AVs

Architecture

» Mobility Hubs and inclusion of first/last mile AV drop off areas
» Repurposing Parking Garages
» Adaptive Building Design

Land Use Planning

» Suburban Sustainability
» Driverless neighbourhood design
» Land Use and zoning by-law updates
» Land Repurposing

Transit

» Transit Master Plans (with consideration for AVs)
» Transit Infrastructure
» Preliminary Design
» Localized neighbourhood level transit
» First/Last Mile solutions with CAVs

Traffic Operations

» Circulation
» Curbside Drop-offs
» Road Safety
» Charging Stations
» Signalization

ITS and Civil Design

» AV road design
» Charging stations
» Signalization
» Connected infrastructure
» Data Collection
» Business Models

Interiors

» Vehicle Interiors – Less focus on safety, more focus on user experience and comfort
» Repurposing Parking Garages

For more information, please contact:

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IBI Group Inc.

IBI Group Inc. (TSX:IBG) is a globally integrated architecture, planning, engineering, and technology firm with over 2,500 professionals around the world. For more than 40 years, its dedicated professionals have helped clients create livable, sustainable, and advanced urban environments. IBI Group believes that cities must be designed with intelligent systems, sustainable buildings, efficient infrastructure, and a human touch.

TH!NK

THiNK is IBI Group's in-house research and development group. Unlike traditional R&D units however, TH!NK works as a decentralized knowledge network that leverages the intellectual capital of IBI employees across disciplines and geographies. TH!NK's role is to connect people, enable innovation and share knowledge through initiatives, platforms and partnerships – both internally and externally. This includes TH!NK's Pocket R&D program, a micro-research program conducted by our staff.