

CONNECTED VEHICLES: AN EXECUTIVE OVERVIEW OF THE STATUS AND TRENDS

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Toyota Touch Life

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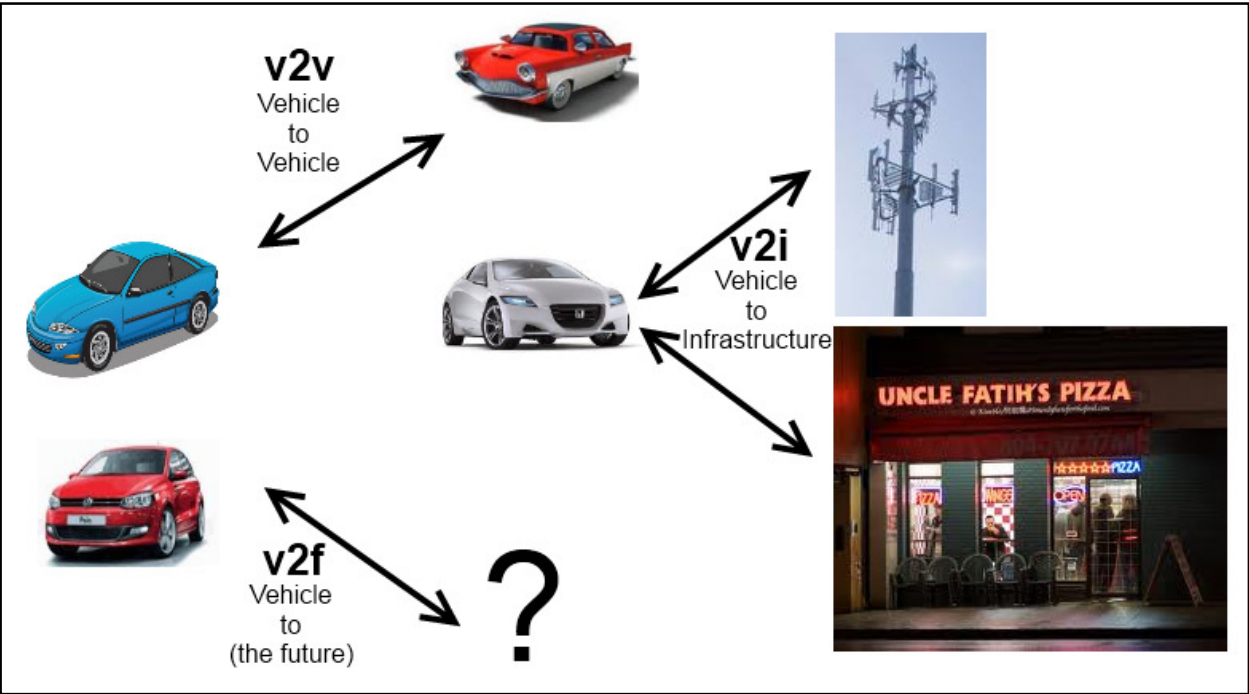
CONNECTED VEHICLES: AN EXECUTIVE OVERVIEW OF THE STATUS AND TRENDS

1.0 INTRODUCTION

Globis Consulting is pleased to provide this Executive Overview of connected vehicles¹.

Stanford University defines “connected vehicles” as:²
Vehicles that interact with each other (v2v), the roadside infrastructure (v2i), and beyond (v2x) via wireless communications.

Figure 1-1: Types of Connected Vehicles



¹ The terms *connected vehicles* and *networked vehicles* are both in common usage and are interchangeable. This report uses the term *connected vehicles*.

² <http://www.stanford.edu/class/me302/PreviousTerms/2011-05-03%20Vehicle%20Communications%20%28part%20I%29.pdf>

The applications that can be supported are wide-ranging including infotainment for the driver and passengers, safety, vehicle remote access, sending engine data to a service department, insurance on a pay-per-usage basis, and many others.

The technologies that are generally used are 3G/4G cellular, Wi-Fi, and 5.9 GHz Dedicated Short Range Communication (DSRC).

This document expands on these topics in the following sections:

- **Applications** describes both current and future ways in which connected vehicles will be used.
- **Connected Vehicle Ecosystem** lists some of the many organizations that are already active in this space.
- **System Design** shows some of the optional approaches to designing connected vehicle systems, together with the pros and cons.
- **Issues** addresses the key considerations involved in implementing and using connected vehicle systems.
- **Conclusions** summarizes the highlights from the above.

This document is designed as an Executive Overview. In many cases, a single paragraph in this report could easily be expanded in considerably more depth.

The connected cars space is evolving very quickly and there will undoubtedly be further announcements and developments in the weeks and months following the publication of this report.

Please contact Globis Consulting if you have any questions. A profile of the company is provided in Appendix B; contact information is provided at the end of the Appendix.

2.0 APPLICATIONS

The introduction of connected vehicle systems and applications has started, but the scope of these will increase substantially in the next few years. The following sections describe these early applications and those that will be introduced in the years ahead.

Figure 2-1: GM's MyLink



2.1 Current Applications

Figure 2-2 lists the current applications for connected vehicles, including those in the 2012 model year. At this time, the features are generally available on selected models and will expand to more models in the next few years. Also, the range of features can vary between models from the same manufacturer.

Figure 2-2: Currently Available Connected Vehicle Applications

Company	Applications
Almost all car manufacturers	Integration of a cell-phone and the car's audio system using Bluetooth technology, including call management using a voice interface and/or using controls on the steering wheel. Europe has been a leader in this area for some years.
Audi	Audi Online Services does not require a smartphone to link the vehicle with the mobile phone network; instead, the car uses an embedded mobile phone module. Features of the system include the capability to perform a Google search, access to Wikipedia, etc.
BMW	BMW's ConnectedDrive system provides updates for Facebook and Twitter and the capability to conduct Google searches, all of which are integrated with the navigation system. Pandora ³ on the phone can also provide an audio feed to the vehicle's audio system.
Ford	Ford's Sync (powered by Microsoft) is an infotainment system that lets smartphone users listen to Internet radio stations and control apps through the car's display using an integrated voice engine and steering wheel controls.
GM	GM's MyLink / IntelliLink includes voice control over digital music selection, it allows a driver to see the application screen on the car's display, and to control various functions using the car's audio controls.
GM's OnStar division	Driver concierge services, emergency roadside assistance including after a crash, stolen vehicle immobilization and recovery, etc.
Hyundai	Hyundai has started equipping its cars with a package of telematics services from ATX Group. The Blue Link package includes safety and service features, infotainment, and web and smartphone interfaces.
Mercedes-Benz	<p>The Mercedes-Benz Mbrace supports features such as remote door unlocking, roadside assistance, and the ability to send destinations to the car's navigation system. It also includes a concierge service for driving directions, traffic updates, movie times and restaurant listings which are also sent directly to the navigation system.</p> <p>The company has also publicized a concept car with a telematics / infotainment system known as @yourCOMAND</p>

³ Pandora provides Internet radio service via apps for iPhone, Android, Blackberry and Windows devices.

Company	Applications
Mini	Mini's Connected app is only available for the iPhone. It supports Facebook, Twitter, Google search, a driving efficiency coach, music that changes its playlist depending on the driving style, and access to Internet radio stations.
Nissan	Nissan Carwings is an app that allows users to remotely control functions specific to electric cars, such as the schedule for charging the battery and starting the climate control system.
Smart Car	The Smart Car's Smart Drive system supports navigation, phone and music. The phone becomes a navigation device; an application allows the driver to see fuel prices at nearby gas stations. Currently, the system supports the iPhone only.
Toyota	<p>Toyota's "Touch" family of infotainment head units uses an AM/FM radio that is connected to a smartphone. Features include navigation, hands-free calling, and internet radio.</p> <p>Toyota has also announced its Entune app integration for some 2012 models. In addition to music, it includes Bing search, OpenTable restaurant reservations, and MovieTickets.com. Entune works on iPhone, Android, and BlackBerry devices.</p>
Volkswagen	Volkswagen Group of America has selected Hughes Telematics to deliver connected vehicle services starting in 2013.

Figure 2-3: BMW's ConnectedDrive



2.2 Future Applications

Other applications are also currently being developed, including:

- Using the navigation capability of smartphones instead of the embedded navigation systems that are common today. TeleNav has demonstrated a prototype of a smartphone-based navigation solution running on a low cost automotive head unit.
- Although traffic and weather information in cars is now common, a future connected car or truck could continually and automatically scan the web for information on the road and traffic ahead and alert the driver if there is a problem due to weather, an accident, high traffic volume, or a long line-up at a border crossing. The same platform could also recommend an alternative route.
- Web browsing using a combination of a smartphone, the car's built-in display, voice controls and/or the existing steering wheel controls. (See the later section on driver distraction.)
- There is interest and ongoing work in implementing car insurance based (in part) on where you drive and the distance travelled. This is sometimes called Pay As You Drive (PAYD) insurance or Usage Based Insurance (UBI). In 2010, the State of California's Department of Insurance allowed insurance companies to charge customers based on the distance driven; the early feedback has been positive. With connected vehicles, the vehicle's locations and odometer readings would be uploaded to the insurance company's server.
- Toyota and Salesforce are developing a private social network approach called "Toyota Friend" that allows drivers to make your car your friend (or a vehicle belonging to your spouse or other family member). Your car can then send you updates just like a human friend.
- Many transportation authorities use wire loops that are embedded in the highways to measure traffic volume, density and speed. Connected cars with links to road-side terminals could provide the same information. Privacy is, of course, a key issue. The current loop systems are metal detectors which are inherently anonymous; any system that replaces loops should also be anonymous.
- Cars will be able to provide parking lot / parking garage operators with their position and therefore allow the operators to determine which spaces are occupied and which are empty. The information could be delivered to either the operator or directly to vehicle displays.

- Although after-market remote starting systems are common nowadays, connected vehicles can support a wider range of remote functionality, including setting the heating / air conditioning controls before drivers get into their cars. Most drivers are expected to take their smartphones with them when they leave their vehicles, so one implication of this is the requirement for an embedded mobile phone module in the vehicle.
- There is significant interest in capturing and uploading engine and vehicle data, especially if there is a malfunction. The data could be used to send an alert to the driver, and detailed engine data could also be sent to the manufacturer and/or the dealer's service department.
- Fleet management systems are very common today. The connected vehicles of the future provide much of the platform that is required for fleet management, so we can expect an integration of these platforms and a corresponding reduction in the dedicated equipment needed for fleet management.
- Car sharing is a growing business and it works better when you have connected cars. Connectivity allows users to locate the nearest available car, access information on traffic and parking availability, and leave the car anywhere. The fleet operator can monitor the health of each vehicle, including battery status, receive failure reports and maintenance alerts, and perform remote locking or unlocking.
- Looking further into the future, it is likely that the development of connected vehicles will lead to an important and long-sought objective: the fully automated roadway.
- Linked to autonomous vehicles, but somewhat separate, is the deployment of "road-trains" or "platooning" in which a single vehicle leads a convoy of other vehicles with wireless connectivity between them, instead of a physical tow-bar. The lead car could be driven by a human or a computer.

3.0 CONNECTED VEHICLE ECOSYSTEM

The connected vehicle ecosystem is widespread and comprises eight main stakeholder groups:

1. As can be seen from Section 2.1, many **car manufacturers** are already strongly committed to connected vehicles.
2. **Technology companies** are equally interested in the opportunities, including Hughes, Microsoft, Intel, LG Electronics, Nokia, and Samsung.
3. The car manufacturers and technology companies are working closely together in this ecosystem. One example is the **Car Connectivity Consortium (CCC)** that was launched by Daimler, General Motors, Honda, Hyundai Motor Company, Toyota, and Volkswagen; system suppliers Alpine and Panasonic; and consumer electronics makers LG Electronics, Nokia and Samsung. So far, there are 31 members that represent approximately 60% of the global market share in automotive and smartphone industries⁴. It is anticipated that further leading industry players will join the consortium over the coming months.

The objective is to drive global innovation for in-vehicle connectivity, including the CCC's MirrorLink standard (previously known as "Terminal Mode").

The CCC will focus on further developing this interface standard, address certification and branding, and start looking at new promising opportunities for the automotive environment, including Near Field Communications (NFC) and wireless charging.

Another example of the synergy between car manufacturers and technology companies is Intel and Toyota. The companies have announced that they are working together to define next-generation in-vehicle infotainment (IVI) systems that will enable new usage models for mobile device connectivity in the car.

4. A key beneficiary of connected vehicles is the **mobile carrier industry**. Clearly, data volumes will increase significantly as connected vehicle systems and driver applications are deployed worldwide. Web browsing, search engine utilization, vehicle data, etc will all drive significant increases in data volume.
5. There is a significant opportunity for **app developers** to jump into this market. However, a key issue is the extent to which the connected vehicle ecosystem will support third-party apps. Some connected vehicle OEMs will use the open standards approach and support and encourage independent apps, while others

⁴ Source: *Telematics Update*

will focus on proprietary standards. A critical issue is the risk of a third-party app interfering with the safe operation of the vehicle.

6. **Content providers** are also a key part of this ecosystem. In addition to traditional content for drivers and passengers, such as traffic information, weather, music, and news, almost anything on the web will be accessible in the future, such as the location of restaurants, hotels, service stations, bank machines, retail stores, etc. We can expect to see new web sites and portals targeted to drivers and passengers. Search engine providers will also play an important role here.
7. Drivers and passengers will also be able to use their favourite **Social networking sites**. Text-to-voice and voice-to-text engines will play an important role in keeping everybody safe.
8. **Universities** are doing essential research in this area. One example is a research network led by the University of Ottawa (Canada) which is developing network protocols and applications for vehicular ad hoc and sensor networks (VANets). This will allow high-speed communication among vehicles and the ground-based infrastructure.

Another example is Dong-Eui University in Busan, Republic of Korea. Researchers are developing a vehicle diagnosis program linked to the navigation system that can diagnose and manage different kinds of vehicle malfunctions and transmit diagnosis data to the navigation system using Bluetooth.

In addition to the above, there are industry associations that help develop the synergy required for advancement in this space. Two examples are:

1. There are Intelligent Transportation Systems (ITS) organizations in many countries around the world, as well as an annual ITS World Congress. With the theme “Smarter on the Way, the 2012 ITS World Congress in Vienna will focus on innovative systems for the improvement of mobility.
2. The Integrated Transport Mobility Alliance (ITMA) was founded recently and is a collaboration of public and private sector organizations focused on improving transport mobility – and the associated economic and social prosperity benefits – in a denser more mobile world.

4.0 SYSTEM DESIGN

Note: This section assumes some technical knowledge, so not all technical terms are defined.

The development and deployment of connected vehicles requires a robust architecture with a combination of technologies, interfaces, and processes. The result must be a system that meets four key requirements: safe, reliable, upgradeable, and able to work with multiple brands of smartphones.

It is expected that most future connected vehicle platforms will use a combination of users' smartphones, embedded functionality in the vehicle, mobile phone networks, and cloud-based servers. There are multiple approaches to achieve this; the following highlights the key ones and some of the tradeoffs.

Communications Options

There are a range of technologies to link vehicles to the Internet:

- Consumer-owned smartphones
- Mobile phone modules that are embedded in cars⁵
- Broadcast radio (AM, FM)
- Satellite radio
- Wi-Fi
- WiMax (a technology for wirelessly delivering high-speed Internet service to large geographical areas).
- Digital Short Range Communications (DSRC)
- A combination of two or more of the above

There are trade-offs to be considered. For example, there is an active debate over the choice between an embedded mobile phone module, a link to a smartphone, or a combination of both:

- An embedded mobile phone module provides the ability to communicate with a car even when the driver has left the vehicle with the smartphone. According to AT&T⁶, the current work to connect smartphones to car radios is just an interim step. The real goal is building 3G or 4G right into the radio, without the need for a connected smartphone. AT&T predicts that in 3-4 years all cars will offer embedded wireless.

⁵ Embedded mobile phone modules are available from many companies, including Cinterion in France, and Sierra Wireless in Canada.

⁶ Source: CE Outlook.

- The counter arguments are that a) an embedded module requires an extra phone plan, and b) the life of a car can be 10 years or more and there can be several generations of mobile phones and networks in that time. For example, the older 2G networks (which OnStar uses) will be retired soon and the existing embedded modules will have to be replaced.

Standards

As in many other areas, there are companies that are promoting the idea of open standards so that in an ideal world, any smartphone can work with any connected vehicle. On the other hand, some companies are more interested in proprietary standards to try and gain a competitive advantage.

The Car Connectivity Consortium, mentioned above, is active in the area of open standards and has developed MirrorLink.

The International Standards Organization (ISO) is also active in the standards area. Technical Committee TC 204 is responsible for the overall system and infrastructure aspects of intelligent transport systems (ITS), including telematics⁷.

An important workshop took place in Germany in 2011. Representatives from U.S., European and Japanese vehicle manufacturers and government officials met to discuss cooperation on connected vehicle technology standards.

The Research and Innovative Technology Administration within the US Department of Transportation has a project called the *Connected Vehicle Core System*. The objectives are improvements in safety, mobility, and sustainability. The focus is on wireless communications with and between mobile elements including vehicles (of all types), pedestrians, cyclists, and other transportation users, and between mobile elements and the roadway infrastructure.

A sub-issue of this topic is ensuring that applications developed by third parties cannot negatively affect the operation of the vehicle. Crashing an on-board processor can lead to disastrous consequences. Approaches to address this include firewalls and an approval process for third-party apps.

One group pushing for standardisation in data formats will be the insurance industry. They will want to see standards for usage data as an input to their servers for Pay As You Drive insurance in addition to their vested interest in vehicle safety.

⁷ Barrie Kirk of Globis Consulting is a member of the Canadian Advisory Committee for ISO / TC204.

Software Development

Another active debate is whether smartphones should use native apps or browser-based access to information sites. (This discussion, of course, only applies to software that is not used in the basic operation of the vehicle.) A recent report by PriceWaterhouseCoopers concluded that consumers will embrace native apps over browser-based access because they make smartphone functionality quicker, easier, and better

However, some companies are promoting web-based access using HTML5, an evolution of the well-known HTML language; it includes elements of HTML, XML, CSS3 (for style sheets), etc. The language is being promoted for use in automotive systems for connected vehicles, although it can also be used in cars on a standalone basis for the driver / car interface, more generically known as the Human Machine Interface (HMI).

Cloud

Cloud storage and computing will play an essential role in connected vehicles for the same reasons as in other areas: cost savings and reliability. Ford's newest concept car, the Evos, was introduced recently at the Frankfurt Motor Show and will store data and retrieve it from the cloud.

With data storage in the cloud, a car could become a highly customized personal assistant connected to the driver's home, smartphone, and computer.

5.0 ISSUES

There are a number of key issues that must be addressed in the rollout of connected vehicles. Some of these are technical issues and were mentioned above; other issues include:

- The business case for providing connected vehicle content and other services. The options include:
 - free basic services with the expectation that some percentage of users will see the benefits and upgrade to the full-featured subscription version;
 - free introductory period for a full-featured subscription service; and
 - blending content provision with the sale of handsets.
- Driver load and driver distraction are recognized as major issues. Significant work is going on to leverage the voice interface – including support for natural speech – and using the existing controls on the steering wheel.
- Hackers can be expected to create problems in this space, whether their motives are financial, to prove that weaknesses exist in the system and/or apps, or simply because they think it is fun. *“Most people would rather have malicious software running on their laptop than inside their car braking system. Thus, incorporating strong security solutions will give manufacturers a competitive advantage.”*⁸ There have not been any reports of significant attacks by hackers on vehicles so far, although there are an increasing number of network elements that make this scenario likely in the future.
- Many wireless carriers charge significantly higher rates when the mobile phone is outside the home territory. This obviously creates issues for people who drive moderate or long distances. For example, Globis is based in Ottawa, Canada approximately one hour from the US border. Once across the border, much higher roaming rates apply. Smartphones generally allow the user to disable data roaming, but this deprives the user of key information and other services when they are far from home.
- Connected vehicles will lead to higher data volumes, and this can create issues for both the users and the carriers. A vehicle tethered to a smartphone (either through Bluetooth or a USB cable) will result in higher data volumes for the user, which may result in a need to upgrade to a higher-level data plan. This is good news for the wireless carriers, but the carriers will need to factor the higher data volumes into their network planning.

⁸ Professor Christof Paar, University of Bochum, Germany.

- There are many privacy-related issues. Whenever user information is uploaded to corporations or government agencies, anonymity is preferred, and if not, then privacy is vitally important. One example, mentioned above, is the use of vehicle data to replace data from loops embedded in the highway. Another example is what happens when the car is sold? Will there be a way to erase all personal information, including account information for any embedded wireless module?
- Most experts expect voice-based interfaces to play a major role, but the wide array of languages and dialects around the world is an issue.
- There is one issue that is specific to the US and yet has major ramifications. As part of the International Traffic in Arms Regulations (ITAR), the U.S. State Department is proposing to control unmanned ground vehicles (UGV) in a comprehensive way. This could have a major impact on the deployment of autonomous vehicles in the US.
- If, as is expected, connected vehicles lead to autonomous vehicles, there are operational and legal issues that must be addressed. For example, if a computer is driving the car, who is responsible if there is an accident: the driver, the car manufacturer, or the computer supplier? Currently, the driver is generally responsible, even if the computer is driving the vehicle, so new legislation may be needed.

6.0 CONCLUSIONS

“The world is in the early stages of a far-reaching transformation in mobility.

On the vehicle side, the explosive growth in cellular connectivity and, more recently, smartphones has fundamentally changed expectations regarding how consumers communicate and use information.

More exciting, it's likely that these options simply represent the early market manifestations of a gradual shift towards the long-imagined holy grail of a fully automated roadway.”⁹

Vehicles are the last major market for connectivity, now that homes and businesses are linked to the Internet. The initial products and services are already on the market; many more will be launched in the next few years. We will also likely see a convergence of technologies between the smart homes of the future and connected vehicles.

This ecosystem is growing rapidly and announcements are being made every week. Many companies and institutions large and small are investing in this space; many of them are already part of this ecosystem and others plan to be part of it.

There are many benefits for drivers and passengers, many opportunities for businesses, and government agencies that own highways will be able to manage traffic more efficiently.

As always, there are issues and some of these will be easier to solve than others.

The next generation of connected vehicles will be exciting for drivers, passengers, and the industry.

⁹ Dan Garretson, Peter Shoemaker, *Thinking Highways* magazine, Sept/Oct 2011

APPENDICES

Appendix A: Acronyms

2G/3G/4G	Versions of cellular / mobile communications networks
CCC	Car Connectivity Consortium
DSRC	Dedicated Short Range Communication
HMI	Human Machine Interface
HTML	Hyper-Text Markup Language
ISO	International Standards Organization
ITMA	Integrated Transport Mobility Alliance
ITS	Intelligent Transportation Systems
IVI	In-vehicle infotainment
NFC	Near Field Communications, a wireless communications system with a range that is typically a few centimetres
PAYD	Pay As You Drive – refers to linking car insurance rates to the distance driven and to the geographic area
UBI	Usage Based Insurance
UGV	Unmanned Ground Vehicle
V2v	Vehicles that interact with other vehicles
V2i	Vehicles that interact with the roadside infrastructure
V2x	Vehicles that interact beyond the roadside infrastructure via wireless communications networks
VANets	Vehicular ad hoc and sensor networks
Wi-Fi	A system for connecting electronic devices over short distances. "Wi-Fi" is a trademark of the Wi-Fi Alliance and the brand name for products using the IEEE 802.11 family of standards
WiMAX	Worldwide Interoperability for Microwave Access

Appendix B: Globis Consulting

Globis specializes in the management, technical, regulatory and economic aspects of information and communications technology and broadcasting. The company's services are marketed to the telecommunications, broadcasting, cable TV, transportation and related industries, as well as all levels of governments. Globis Consulting Inc. has on staff or via our associates, considerable expertise in many areas dealing with the delivery of solutions to clients.

Globis Consulting Inc. was incorporated in 1997 and has over those years provided a variety of technical and management services.

The company is located in Ottawa, Canada and draws on the combined experience of its Partners and Senior Associates to address the short-term needs of its considerable list of clients. Being located in Canada's capital allows Globis to apply its wealth of experience from dealing with the Federal Government and the technology industry, to the unique requirements of clients in those sectors. In addition, the extensive technical knowledge of the Partners and Senior Associates enables Globis to meet the challenges of a wide range of technical and management projects.

Our resident experience includes but is not limited to:

- Connected vehicles
- Vehicle usage and traffic studies
- Driver information systems
- Telecommunications network design
- Radio and TV broadcast technologies
- Public Alerting
- Satellite communications
- Due diligence for investment in technology companies
- Delivery of broadband communications to remote communities
- Economic evaluations
- Broadcast policy
- Internet solutions

Contact Information

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- To download this report, go to www.globisconsulting.ca and click on the "downloads" button.

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