THE IMPACTS OF CONNECTED AND AUTOMATED VEHICLE TECHNOLOGIES ON GOODS MOVEMENT AND DISTRIBUTION IN NORTH AMERICA

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1 Introduction

Though often overshadowed by passenger transportation in discussions of Connected and Automated Vehicle (CAV) technology, goods movement across North America is evolving rapidly to take advantage of efficiencies facilitated by new technologies and to keep up with changing consumer demand trends. CAV technology is nascent and its eventual impact on the industry is uncertain; many industry players remain skeptical of opportunities for industry reinvention, particularly in the short-term. However, there are early indications of this technology's safety, employment, financial, and land-use implications.

This paper examines the impacts that CAV technology will bring to goods movement operations over the next two decades, particularly in the context of increasing demand for fast, frequent home delivery. Specifically, this paper focuses on truck-based freight with respect to long-distance hauling, and both trucks and automated off-road vehicles (such as drones and sidewalk-based unmanned delivery vehicles) for the purposes of last-mile solutions. Beyond changes to vehicle technologies and operations, changes to distribution centre (DC) scaling, location, and operation are reviewed. Private and government initiatives are explored, as is the use of electricity as a fuel source for freight vehicles. This paper includes primary research gathered through interviews with several large retailers and freight transport/logistics firms to establish baseline use of CAV technology in freight operations, and the likely role of CAV technology over the next decade. Primary research is supplemented by a literature review.

2 Trends and Developments

This section explores recent developments in CAV freight technology and trends in the freight industry.

2.1 Connected and Automated Truck Technology

Many freight (carrier) firms, retailers, software and hardware manufacturers, vehicle Original Equipment Manufacturers (OEMs), government agencies, resource extraction firms, and other parties are actively researching, developing, and testing CAV truck technology. Some are industry incumbents, including Amazon, which operates its own truck fleet and was recently granted US Patent 9,547,986 (related to wireless communication of guidance information for direction-reversible lanes),[i] and Scania (Volkswagen) and Toyota, which are launching a three-year full-scale CAV freight truck platooning test in Sweden, Japan, and Singapore.[ii] (Platooning in this context consists of wirelessly coupling a chain of vehicles, with the lead vehicle providing instructions to enable simultaneous reaction, and thus short distance between vehicles. Truck platooning trials have taken place across Asia, Europe, and North America.) Others are new entrants, such as Peloton, a firm producing software for automating and platooning freight trucks with the goal of reducing collisions, fuel use, and labour costs; and Uber, who is looking to build its own fleet of driverless trucks on the back of its recent acquisition of Otto Truck (as distinct from Otto Motors). New entrants also include third-party logistics (3PL) industry startups such as Cargomatic and Convoy, who provide Uber-like apps linking customers who require on-demand goods movement with active and available carriers.[iii]

Government agencies are also testing CAV technology, often in the form of vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication equipment in various on- and off-road settings. For example, the Wyoming Department of Transportation (DOT) is running a connected vehicle (CV) pilot deployment program to develop applications using short-range V2V and V2I communication to broadcast travel guidance and roadside alerts to freight trucks, with the goal of reducing the number of wind-induced blow-over events and other weather incidents in order to improve safety and reduce delays.[iv]

2.2 UAVs (Drones) and Other Off-Road Delivery Vehicles

Numerous freight and courier firms are exploring the possibility of delivering goods using small unmanned aerial vehicles (UAVs, or drones). Flirtey, an Australian startup, uses drones to deliver mail, medicine, and other small-capacity packages quickly and cheaply. Matternet, a Californian logistics startup, builds drones for transport of lightweight items, and has partnered with Mercedes-Benz to pilot a combined van/drone delivery system to address last-mile challenges. In 2015, Amazon proposed a regulatory framework and standards for creating a multi-level airspace above cities, dedicating the space between ground level and 200ft for slow-moving drones, and 200ft-400ft above ground level for fast drone travel; drones could be used for goods movement, but also for monitoring air quality, distributing parking tickets, or other city services.[v] Dispatch, a freight startup piloting a small, driverless vehicle ("Carry") which delivers packages up to 45 kg, allows customers to retrieve packages from one of the vehicle's compartments using a mobile app. "Carry" operates on sidewalks and paths, avoiding road use and vehicle traffic altogether.

In Canada, Drone Delivery Canada is working with Staples and NAPA Auto Parts to deliver loads up to 4.5 kg, with their first commercial deliveries expected in 2017. Transport Canada has two active drone test sites, in Foremost, AB, and Alma, QC respectively, and is looking to update drone regulations in Spring 2017 to permit drone operation closer to built-up areas than is currently allowed. [vi]

2.3 Electricity as an Alternate Vehicle Fuel Source

Electricity appears to be the most common alternate fuel being tested for freight vehicles. Tesla's freight ambitions include "Tesla Semi", a fully electric truck intended to "deliver a substantial reduction in the cost of cargo transport, while increasing safety and making it really fun to operate."[vii] Mercedes is testing a prototype called the "Urban eTruck", a fully electric freight vehicle with a capacity of 26 metric tonnes and a range of 124 miles, clearly intended for short-distance hauling within urban areas.

Developments are also occurring with respect to electric vehicle infrastructure. In Sweden, Siemens and Scania are trialing a 1.2-mile stretch of highway with overhead wires to enable freight vehicles to operate under electric propulsion using a catenary, with vehicles reverting to an internal combustion engine when leaving the pilot area.[viii] In the UK, Highways England is testing under-road power (Dynamic Wireless Power Transfer, or DWPT) to enable electric vehicles to drive long distances without needing to recharge.[ix]

2.4 Fast and Frequent Home Delivery, and Off-Peak Delivery

Demand for fast delivery of everyday purchases is skyrocketing, with Amazon both driving and serving as the poster child for this trend: Amazon now offers free same-day delivery in 27 US cities; free one-hour delivery from Amazon Restaurants in 17 US cities; and two-hour delivery of chilled beer, wine, and cider in the UK, for instance. On-demand prepared-food delivery firms, such as UberEATS and Foodora, are also visibly fuelling this trend. Quite often, deliveries are small in terms of both quantity and value of goods.

Off-peak delivery typically involves last-mile delivery of goods during late evening or overnight, when road congestion is significantly lower than at peak hours. The Florida Department of Transportation is completing a three-phase CAV freight pilot, of which phases 1 and 2 consist of equipping freight vehicles and traffic signals with communications equipment to better understand vehicle progression through corridors, and phase 3 consists of off-peak signal priority for freight vehicles. The goal of the project is to reduce freight vehicle travel time, and travel time variability, with the aim of reducing congestion along major freight corridors. Several North American jurisdictions, including the City of New York and the Province of Ontario (in cooperation with the City of Toronto), have tested or are testing off-peak delivery, sometimes spurred in part due to special events such as the Pan-Am Games in Toronto in 2015.

2.5 Automation

Automation of physical tasks has been occurring progressively and on a large scale since the onset of the industrial revolution. There is a perception, rightly or wrongly, that automation is increasingly reducing industry demand for labour, with much of the attention focused on industries where automation was not perceived as realistic until recently. The goods movement industry is no exception: beyond up-and-coming self-driving and assisted driving functions of CAV truck technology, automation is happening across warehouses, manufacturing plants, and DCs. In 2012, Amazon purchased Kiva, a robotics firm, and has since put its robots to use in its fulfillment centres to assist with selecting and packaging goods for shipment. Doing so has cut costs by $22-million (USD) per fulfillment centre, or roughly 20%.[x]

In Canada, Hudson's Bay Co. has invested more than $60-million (CAD) to upgrade one of its Toronto DCs to keep up with competitors. The system can process roughly 4,200 customer orders per hour, uses a fleet of 300 automated robot delivery vehicles, and is 12-15 times faster than an equivalent manual order fulfilment process, and three times faster than DCs using the previous generation of automation equipment. The 750,000 square-foot distribution centre employs approximately 300 people.[xi] Otto Motors (a division of Clearpath Robotics, as distinct from Otto Truck, a startup recently purchased by Uber) is one example of a CAV vehicle manufacturer producing tools for the goods movement industry, with its vehicles transporting material around warehouses and other facilities. Otto's vehicles require no purpose-built infrastructure to enable operation, can be pre-programmed to conduct a series of tasks even if communication with the central control systems are lost, and are controllable via desktop or mobile apps.

3 Industry Response (Primary Research)

Interviews were conducted with 15 Ontario freight industry participants, including major retailers, carriers (goods distribution firms), manufacturers, warehousing and storing firms, and government agencies and crown corporations. Participants were questioned regarding the feasibility, value, and likely time-frame for introducing CAV technology. Questions were intended to establish baseline (i.e., current) use of CAV technology as well as anticipated use in the coming decade. Off-peak delivery, use of electricity as a fuel source for freight trucks, and distribution-related trends were also discussed where applicable.

3.1 Baseline Use of CAV Technology and Other Trends

A variety of on-road connected vehicle technologies are being used by freight industry participants. These include onboard GPS devices to track vehicle idling, speeding, braking and acceleration patterns, cameras for monitoring collisions and other incidents, and software related to monitoring of vehicle operations. No participants described use of V2V or V2I technologies in existing operations or pilot programs. No industry participants interviewed are currently making use of on-road automated vehicle technologies, nor are any conducting pilot programs. Carriers, retailers, manufacturers, and warehousing firms conveyed that the technology is in its infancy and not ready for wide-scale deployment. Little work has been put into incorporating or testing automated vehicle technologies into operations.

Carriers interviewed consider use of electricity as a fuel source for on-road trucks to be feasible and attractive. Use of electricity would contribute to reduction of emissions (and elimination of emissions locally) and would be quieter to operate. One vehicle parts manufacturer interviewed stated that Ontario is a candidate location for manufacturer of new technologies, including electric vehicles, owing to its reputation for high-quality manufacturing. Though automation of DCs was only briefly discussed during interviews with industry participants, it was clear that some DCs have become fully automated, and the trend appears likely to accelerate moving forwards as more traditional DCs seek to remain competitive.

One manufacturer interviewed provides direct-to-store distribution, and a carrier noted the trend towards using smaller and more numerous DCs to accommodate omni-channel delivery (i.e., to enable a range of delivery options/vehicles to maximise customer base and ability to serve all needs). This is particularly true in dense urban areas, where smaller retail facilities with limited shelf space are common, necessitating more frequent deliveries. However, the carrier also noted that small DCs will not supplant need to maintain large, highly efficient distribution centres served by large vehicles. In particular, some participants observed that Canadian DC operations are very centralized out of necessity due to Canada's low population density.

Two primary barriers to off-peak delivery were cited by industry participants: the willingness of customers to have goods delivered during off hours (this is particularly true for small retailers who do not otherwise employ off-peak staff), and noise (truck) restrictions in neighbourhoods and specific streets during off-peak hours. Some carriers have found a way around the first restriction, by having customers use code-based locks and security systems, enabling carriers to deliver goods without a need for retailer staff to be present. Changes to zoning bylaws is considered necessary for addressing the second challenge.

3.2 Future Use of CAV Technology and Other Trends

Industry participants interviewed revealed a perception that CAV technology is a long way from being operational, and that the most likely near-term technology would be early-stage CAV technology such as adaptive cruise control and automatic braking. Vehicles equipped with these features would still require a truck operator. Safety and liability were cited as the most attractive aspects of future use of on-road CAV technologies. Many participants cited the need for loading, unloading, and accounting at either end of a delivery as major impediments to full-scale automation of vehicles; some believe that full automation of vehicles is unrealistic, at least for Class 8 (e.g., tractor-trailer) vehicles.

One carrier noted that electric trucks appear more likely in the short-term than use of CAV technology. Use of electric vehicles may help to solve off-peak truck noise concerns; however, while truck noise is somewhat addressable through the use of electric vehicles, noise-based restrictions will continue to prove challenging for deliveries that require refrigeration units as these are notoriously loud.

None of the industry participants interviewed revealed plans to operate CAV technology pilot programs in the foreseeable future. In short, the industry appears focussed on day-to-day operations and immediate trends – such as conversion to automated DCs and frequency of low-volume consumer deliveries – more than CAV technology, which is still seen as futuristic and hypothetical, with limited and uncertain benefits.

4 Implications

This section discusses implications for the freight industry of CAV technology and other trends.

4.1 Impacts on Safety

Virtually all literature discussing CAV technology touches on the potential for improving safety by reducing or eliminating human error, and thus reducing collision rates. The US National Highway Traffic Safety Administration (NHTSA) estimated in 2011 that "human causes" are the primary factor responsible in 93% of collisions.[xii] In the United States in 2014, there were approximately 110,000 injuries and 4,000 fatalities caused by collisions involving large trucks.[xiii]

Collision reduction has huge potential for reducing freight industry costs given that collisions cause not only vehicle damage and human injury, but also lost productivity, damaged goods, insurance premiums, and corporate liability. While driverless vehicles offer the best long-term potential for collision reduction, automatic braking, driver attention and drowsiness warning, impaired driver detection, and other technologies have potential to reduce significant numbers of collisions using technology that exists today. Eventually, CAV technology will make increased speed limits on highways relatively safe and therefore feasible, increasing freight vehicle productivity. Highways England has suggested that DWPT (under-road power) could be installed with loops and/or sensors, enabling vehicles to stay within lanes even in snow or conditions with poor visibility.[xiv] Reducing collisions will also serve to reduce congestion: according to the US Federal Highway Administration, one eighth of all congestion is caused by collisions.[xv]

The overarching goal of the Wyoming DOT CV pilot is to provide real-time information to vehicles and drivers to reduce weather-related incidents and minimize associated delays. Though some industry participants and observers are skeptical of the feasibility of on-road freight vehicle automation, if the Wyoming pilot is successful, it will provide concrete evidence that CV technology – which already exists in many forms – is feasible and impactful.

4.2 Impacts on Land Use and Facilities

There is much talk surrounding the potential for CAV technology to shift land-use patterns. Perhaps the most commonly cited example is a potential relocation and vast reduction in capacity of parking facilities. However, as highlighted in the interviews with industry participants, the freight industry is likely to experience other land-use changes, including a shift in the size, number, and location of DCs. As consumers order increasing volumes of goods online, including staple goods such as groceries and clothing, the frequency of small-scale deliveries will continue to increase, necessitating an increase in the number and distribution of DCs. Many of these are likely to be small, automated facilities spread across urban areas.

DCs and other freight facilities will also be affected by CAV technology, and automation trends generally. Facility layout and organization may change to accommodate new loading mechanisms, new sizes and shapes of both road and in-facility vehicles, and reorientation of labour and other non-automated tasks.[xvi] Full automation of DCs and other facilities will enable better use of space, particularly vertical space, potentially leading to more efficient (i.e., reduced) land use for such facilities. Some DCs may become mobile: for example, there is speculation that refrigerated trucks toting groceries may drive to a neighbourhood, park, and use small delivery vehicles to complete local deliveries.[xvii] Such a model would fuel the habit of consumers ordering a few small items at a time as it becomes cheap and fast to do so. However, as noted during industry interviews, small shipments are less efficient and more costly on a unit basis. Yet it is conceivable that the premium for small-scale delivery may eventually become negligible.

4.3 Impacts on Operations, Routing, and Road Networks

CAV technology will impact both urban and long-haul freight operations. As vehicles become safer, more fuel efficient, and capable of platooning, there is likely to be a progressive shift, of unknown magnitude, away from rail-based freight to truck freight for firms, industries, and/or goods best suited or able to capitalize. Given the perception that driverless technology will be ready for use on highways long before use on urban roads, there is speculation that truck freight could evolve to have drivers sleep, relax, or attend paperwork while on the highway, taking active control of the vehicle only when traveling to and from the highway on urban roads. Another option, posited by one of Otto Truck's founders, would use driverless highway technology to convert truck freight to local employment: a driver in Calgary could ferry a truck from a factory to the Trans-Canada Highway, put the truck in driverless mode, and head home, while another driver could meet the truck on the highway in Winnipeg, and complete the last-mile journey.[xviii]

With the introduction of vehicles such as Daimler's Freightliner Inspiration Truck, the first licensed automated commercial truck operating on public US highways, freight and logistics firms may choose to rent or lease vehicles rather than maintain an ownership model.

Delivery routing will transform as CAV technology develops. With use of different vehicle sizes and types (potentially including drones or other off-road vehicles for last-mile solutions), modified routing algorithms, potential for increased off-peak delivery, changes to traffic patterns, and, eventually, evolution of the size and shape of road networks, freight delivery will have both the opportunity and need to adapt accordingly. Beyond the need for new or different infrastructure, seemingly mundane infrastructure standards will need to be considered in a new light: for example, roads may require thicker pavements to handle the wear of freight platooning.[xix]

Changes to road networks and airspace are already being proposed. The Central North American Trade Corridor Association stated in 2015 that its members were already engaged in designing a driverless truck corridor from Mexico to Manitoba along US Route 83 which would expedite travel and border crossings.[xx] Given the flexibility and scalability of electric motors, inasmuch as electricity becomes a feasible fuel source for freight vehicles, this will enable a move to smaller vehicles, alternate vehicle forms (including drones and other off-road vehicles), and small-scale deliveries.[xxi] Amazon's proposal for a regulatory framework for airspace dedicated to drones reinforces is an indication of the breadth of ideas being considered for reinventing freight operations.

Columbus, Ohio – the winner of the United States DOT Smart Cities Challenge – has a mandate to provide real-time traffic information to improve truck routing through and around the city. This sort of information sharing is already common in rudimentary form (e.g., variable message signs, websites, and news reports) across North America, but is becoming increasingly available in real-time and on an individualized basis via mobile applications and other technologies.

4.4 Impacts on Labour Requirements and Productivity

There is much speculation that CAV and related technology will lead to a loss of employment and/or employment quality in the freight industry. The industry employs roughly 3.5 million Americans as truck drivers, with truck driving being the most common profession in many states. A report by the Mowat Centre estimated that 1.6 to 7.5 million jobs in Canada are at risk of being replaced, or downgraded in terms of security or permanence, by automation in the coming decade; repetitive-task jobs are at greatest risk, [xxii] and many observers put driving jobs of all types, including freight, into this category.

Estimates of cost-saving implications of CAV technology for the freight industry vary widely. In the long term, former General Motors executive Larry Burns anticipates freight industry costs to drop by as much as 40% as a direct result of driverless CAV technology.[xxiii] Others phrase savings using different measures: roughly 34% of truck freight operational costs are due to labour, and savings have been estimated at up to 168 billion USD annually ($70 billion labour, $35 billion fuel efficiency, $27 billion productivity, $36 billion collision reduction).[xxiv] Still others shy away from making pronouncements: new entrants such as Peloton emphasise the fuel-savings and collision-reduction benefits of CAV technology, which are uncontroversial and near-universally celebrated, and shying away from figures related to job losses and labour savings, though these are surely anticipated and intended.

Other types of employment in the freight industry may also be at risk of significant labour churn, particularly in urban settings. For example, entities providing automated 3PL services pairing shippers with carriers will compete directly with existing freight-industry brokers, who charge significant premiums to provide pairing services. This will drive down brokerage costs and reduce employment opportunities.

Though such efficiency gains will take years or decades to fully realize, significant savings will begin to accrue sooner and should be taken into consideration. Depending on how much human labour is supplanted by CAV technology, labour (union) disputes are likely to arise. This is particularly true if trucking becomes an increasingly attractive job – for instance, if vehicles become driverless on highways, limiting the nomadic nature of the freight industry and enabling trucking to become a local job.

Yet a handful of trends may limit employment losses. The freight industry currently suffers from a massive labour shortage across North America, with a predicted shortfall of 240,000 drivers in the United States alone by 2022.[xxv] CAV technology has the potential to fill some or all of this shortage by enabling driverless operation in the long-term (possibly leading to a scenario where workers shift from operating vehicles to managing and loading goods at DCs and other locations), and by enabling platooning, or driverless highway operation, in the short-to-medium term.

An increase in the number of deliveries generally will create employment in the freight industry. For example, UberEats, Foodora, and similar services offer goods delivery (typically food) for restaurants and other commercial entities which previously did not offer delivery services. Many of these deliveries are performed by cycle. Even where transport is completed by powered vehicle, collection and delivery of the package currently requires a human, in much the way that warehouse to DC operations require loading, unloading, and paperwork at either end of a trip. In the short-to-medium term, near-self-driving vehicles may not have a significant impact on employment, as drivers will still need to be present and paying attention to mitigate industry liability associated with distracted or absent vehicle operators.

In the longer term, labour force participation may provide a partial solution. One estimate suggests that the US government is predicting a 5% reduction in the US labour force participation rate by 2040, primarily due to an aging population; Statistics Canada has similar projections.[xxvi] A reduction in labour force participation will mitigate the effects of employment lost due to automation.

5 Conclusion: Industry Threats and Opportunities

The freight industry is at the cusp of significant change across all realms of its business. Uncertainty and anticipation abound, and reasonably so – there is substantial evidence to suggest that things will change rapidly in the coming decades, but there is very little concrete evidence to indicate specifically how, when, and to what degree this change will take place.

Given the direction that technology is moving, a few broad trends appear likely in the next 20 years:

- Increased safety and reduced costs of CAV truck-based freight may cause some rail-based freight activities to shift to trucks, and will reduce injuries, loss of life, and associated costs;
- Decentralization of goods movement, such as direct supplier-to-consumer shipments, a trend towards having a large number of small DCs located across an urban area in place of a single large DC, and electric vehicles will lead to land-use changes and possible changes to off-peak delivery and other zoning restrictions;
- Increased last-mile deliveries may contribute to road congestion unless off-road vehicles take on a meaningful share of these deliveries; and,
- Reduced labour requirements, in particular for long-haul shipments, will help to address the current truck driver labour shortage, but may also cause loss of employment, and/or reduced employment quality and security.

Opinions vary greatly on where this technology is heading and how deeply the freight industry will be affected. As always, time will tell.

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