VISIONS OF THE FUTURE: LESSONS FROM SUSTAINABLE TRANSPORTATION LEADERS

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Introduction

The trucking industry has tremendous social, environmental and economic impact in North America. In the United States, nearly nine million people, or one in every 15 civilian workers, are employed in trucking or trucking-related jobs. Trucks move about 11 billion tons of freight each year and deliver 70 percent of all freight tonnage. In Canada, trucking is a $65 billion industry that employs over 260,000 drivers. Trucking also burns about 54 billion gallons of fuel each year in the U.S. (Schulz 2011), and accounts for 20% of transportation greenhouse gas (GHG) and criteria air contaminant (CAC) emissions (Davies and Facanha 2007). The purpose of this paper is to discuss challenges and opportunities in sustainable trucking, drawing on the literature and an elite panel of sustainable transportation leaders.

The paper is organized into three more sections. First, there is a brief review of literature on green trucking. The lack of published work in the academic journals is astonishing. Second, the paper presents some lessons from an elite group of four sustainable transportation leaders. These experts were speakers at the February 2010 Future of Trucking Symposium in Winnipeg. Third, the paper closes with conclusions, including a research agenda moving forward.

Literature

Despite the importance of the North American trucking industry, the billions of gallons of fuel it consumes and its environmental impact in terms of CO^2 emissions, there appears to be little academic literature on green or sustainable trucking. A search of ABI/INFORM's Global Business database, for articles with "trucking" and "sustainable" or

"green" in the citation or abstract, and limited to *scholarly journals, including peer-reviewed*, yielded only five hits. While two of these were published in 1982-1983, another two were published in 2001 and 2003.

Pieces on green trucking are much more likely to be found in trade journals, on association web-sites, or in the form of think tank papers and government reports.

Zuckerman (2010) reports the following estimates: 28 percent of GHG emissions are produced by the transportation sector, and every gallon of gas burned puts 22.2 pounds of carbon dioxide (CO^2) into the air. She also observes that truckers can become greener and more efficient by making a few relatively basic changes in operations, such as installing auxiliary power units (APUs) and tire inflation systems, along with incentives for drivers to conserve fuel and limit idling (McCue 2010).

In Canada, SDTC (2009) estimates that 12 percent of fuel consumed by long-haul trucks is burned when engines are idling—and trucks are not moving. SDTC also argues that driver skill has a tremendous impact on fuel consumption, with fuel savings of 15 up to 25 percent possible through improved driving practices.

A number of other easy changes are among the American Trucking Associations' (ATA) six recommendations to reduce CO^2 emissions. ATA recommends limiting truck speeds to 65 miles per hour (mph). At 75 mph rather than 65 mph, trucks consume 27 percent more fuel. Going further, Schneider National saves an estimated 3.75 million gallons of fuel per year by keeping its fleet speed at 60 mph (Gelinas 2010). ATA also recommends reducing *discretionary idling* (e.g. idling to keep the cab reasonably warm or cool during rest periods) by using APUs.

Another ATA recommendation is for shippers and carriers to join the U.S. Environmental Protection Agency (EPA) SmartWay Transport Partnership Program. Gelinas (2010) reports impressive results for the program. Since its 2004 launch, SmartWay partners have saved about

1.5 billion gallons of diesel fuel and avoided emissions of over 14.7 million metric tons of carbon dioxide and other harmful pollutants.

Empty backhauls or deadhead miles are another contributor to fuel waste and harmful emissions. Sowinski (2010) suggests that load optimization tools and freight-matching software can fill trucks and get deadhead ratios down to as low as 3 to 5 percent. She credits the California Air Resources Board (CARB) with igniting the move to install trailer skirts and low-rolling resistance tires. At a cost of less than $2,000, trailer skirts reduce fuel consumption up to 7 percent.

SDTC (2009) notes that empty backhauling is a frequent occurrence in Canada; roughly one out of three heavy trucks on major Canadian highways runs empty, and more than 50 percent carry freight below capacity. A fully loaded truck is 84 to 110 percent more fuel efficient than an empty truck. They also note that restrictions against foreign carriers moving domestic freight (e.g. Canadian trucks doing point-to-point moves within the U.S.) contribute to the empty backhaul problem. Even within Canada, a lack of regulatory harmonization limits opportunities for load optimization.

Ogburn et al. (2008) describe the potential of vehicle technologies (e.g. aerodynamic retrofits and low-rolling-resistance tires), combined with long combination vehicles (LCVs). These innovations could lift ton-mile efficiency of long-haul trucks by a factor of 2.5, and reduce fuel consumed to move freight by 64 percent. In the United States, this could save the Class 8 truck fleet about four billion gallons of diesel fuel and reduce CO^2 emissions by 45 million tonnes per year.

In an earlier study, Ogburn et al. (2007) estimate the impact of the Canadian Class 8 fleet of 294,000 trucks adopting a package of green technologies, including tractor/trailer fairings and skirts, low rolling-resistance tires, APUs, etc. Truck owners and operators would save 4.1 billion litres of fuel and reduce emissions by 11.5 million tonnes of GHG each year. It would be like taking 64,000 trucks off the road, in terms of fuel use and emissions.

Van Amburg and Hall (2010) focus on several "co-benefits" of improved truck efficiency: reduction of GHG and nitrogen oxide (NOx) emissions, and enhanced energy security via fuel economy. Interestingly, from 1990-2006, Canadian CAC emissions declined, but fuel use and GHG emissions increased (SDTC 2009). While technology is available to capture CAC emissions, the only way to limit GHG emissions is by reducing fuel consumption.

CALSTART makes the case that fuel economy and emission control standards are not sufficient to drive needed change. Barriers to more efficient trucking include: high costs of producing and purchasing the latest technologies, availability of appropriate solutions, and lack of information on performance, reliability, durability and maintenance of these technologies. Their public policy recommendations to overcome these barriers include the following: vouchers for purchasing new technologies, public funding for research and development, and government grants to manufacturers of efficient trucking technology (Van Amburg and Hall 2010).

The Future of Trucking Symposium

The Future of Trucking Symposium took place in Winnipeg, from February 17-19, 2010. The event featured 27 expert speakers and an audience of 161 trucking industry enthusiasts. The three authors were involved in organizing the Symposium from the start and moderated several of the sessions at the symposium.

This section reports and interprets lessons from four of the speakers on February 18. The first sustainable transportation leader is Hiroko Kawai, a Principal with the Rocky Mountain Institute. Her topic was "transformational trucking." The other three experts were grouped in a panel titled "Visions of the Trucking Industry: New technologies; shifting demographics." They are: Antonio Benecchi, a Partner with Roland Berger Strategy Consultants; Bill Van Amburg, Senior Vice President, CALSTART; and Rick Whittaker, Vice President, Investments and Chief Technology Officer, Sustainable Development Technology Canada.

The speeches were audio recorded and transcribed. All four speeches were also supported by PowerPoint presentations. The authors studied the transcripts and slides to summarize and interpret lessons from the speakers, as shown below.

Hiroko Kawai, Rocky Mountain Institute

Hiroko focused largely on the following three themes: opportunities for improvement in fuel economy; the role and position of truckers; and coordination/collaboration as the key to innovation.

Almost everything in our lives relies on trucking and efficient freight movement. The backbone of the economy, American trucks burned nearly 44 billion gallons of diesel fuel in 2008. While fuel efficiency is critical for carriers, technology investments are high and payback periods are uncertain. Thus, truckers find it challenging to invest in the latest fuel efficient technologies.

The Rocky Mountain Institute (RMI) concept of "double efficiency – transformational trucking" was inspired by John Woodruff's three axes of transport system optimization: minimization of vehicle fuel consumption, number of vehicles on the road, and travel distance. RMI starts by looking at what's possible using existing technology. Assume a truck runs at 6.5 miles per gallon and 130 ton miles per gallon. By installing devices and tires to reduce aerodynamic drag by 50 percent and rolling resistance by 30 percent, and also to increase engine thermal efficiency by 6 percent, an improvement to 12.5 miles per gallon and 275 ton miles per gallon can be achieved. In addition, permitting turnpike doubles or long combination vehicles (LCVs) on highways – increasing vehicle weight from 80,000 pounds on five axles to 120,000 pounds on nine axles – would enable improvement to 8.7 miles per gallon and 335 ton miles per gallon. Further gains are possible via hybrid vehicles and auxiliary power units (APUs).

Hiroko noted that over the road truckers make money by moving the freight; not by sitting idle loading, unloading, waiting at the border, being broken down or stuck in traffic, etc.

The Owner Operators Independent Drivers Association (OOIDA) has 158,000 members representing more than 200,000 trucks. They have 26,000 company drivers, and 3,500 fleet owners, usually with six or less trucks, i.e. "mom and pop" operations (http://www.ooida.com). Owner operators and independent drivers are aware of issues such as global warming and peak oil. However, when a small trucking firm is struggling to cover an insurance premium or a monthly payment on a truck, technologies to reduce fuel consumption or GHG emissions fall off the radar screen.

Finally, Hiroko discussed the need for collaboration to move things forward. For instance, collaboration across state, provincial and federal jurisdictions is needed to harmonize weight and size rules and regulations—and enable LCVs to move more freight across North America.

Collaboration is needed to create a credible source of information on the various strategies and technologies, including their impact on fuel efficiency and emissions. This collaboration could involve truck manufacturers, the technology providers, trucking firms, owner operators, government agencies and university research institutes.

RMI spearheaded creation of the North American Council for Freight Efficiency (NACFE), a collaboration involving businesses and other organizations such as CALSTART, FP Innovations, Roland Berger, Navistar, J.B. Hunt, Wal-Mart, Volvo, and University of Michigan Transportation Research Institute (UMTRI). NACFE's vision is: *a rapidly evolving, more profitable, efficient, and safe freight industry that ensures the environmental sustainability of North American goods movement* (http://nacfe.org).

Hiroko summarized by stating: "We've got to work together." Based on the IBM Trucking 2020 Report, she called for a transformative strategy and collaboration among private, public and academic units. The University of Manitoba Transport Institute (UMTI) is a good example of this role, bridging the gap between government, industry and academia. There is much work to be done in the areas of vehicle technologies, regulations, research and development, market adoption

incentives (e.g. Manitoba's GrEEEn Trucking program; and similar programs in Alberta, BC and Ontario) and funding for infrastructure, including highways and intelligent transportation systems (ITS).

Antonio Benecchi, Roland Berger Strategy Consultants

Mr. Benecchi described population growth and predominant urban location of people as primary contributors to increased energy use and traffic congestion. To ease these problems, along with GHG emissions, he anticipates advances in trucking and transportation technology, as well as developments in government regulations.

In Canada and elsewhere, the population is growing and growing older, on average. This is highly relevant, as demand for transportation is derived, i.e. largely based on the mobility and material needs of people. Population is determined in part by *natural growth*, the difference between births and deaths. In Canada, natural growth is forecast to reach zero and start declining by 2030. However, this decline will be more than overcome by net immigration, which is the difference between numbers of people coming to Canada and leaving Canada.

Urbanization is another ongoing trend; the growing population is increasingly concentrated in big cities and major metropolitan areas. This defines where people will be, where businesses will be, and thus, where transportation infrastructure and services will be located. With urbanization comes congestion. Traffic congestion impacts mobility; it brings slower delivery of goods, longer commutes, increasing fuel consumption and GHG emissions. Benecchi anticipates regulations to counter congestion, and more regulations on pollution and emissions.

Along with population and urbanization, energy consumption is going up; the dependency on fossil fuels continues to grow. Long term spot oil prices and oil price volatility will also increase. Despite the greater effort to develop renewable sources of energy, these sources will not eliminate the dependency on oil in the next twenty years.

Canada will see stricter policies and stronger demands to limit GHG emissions. Last summer, G7 countries made commitments to limit climate change and to implement regulations and policies to limit global warming to up to 2 degrees centigrade.

What must be done to achieve a 2 degrees centigrade limit on global warming? Since the two main contributors CO^2 emissions are power generation and transportation, a lot of attention is being paid to those industries. In manufacturing regions of the world, emission standards are progressing towards a convergence. This is good news, as having harmonized regulations across different regions decreases supply chain complexity and cost.

In the U.S., the Environmental Protection Agency (EPA) is working on CO^2 emission standards. The plan is to provide guidelines for the reduction of CO^2 emissions, and to release these standards by 2013 for enforcement commencing in 2016. Over the next two decades, Benecchi foresees strict regulations in all the major markets to limit CO^2 emissions, which will affect the trucking industry profoundly.

Like Hiroko Kawai, Antonio Benecchi notes there are a variety of technologies available and being developed to help trucking fleets adhere to new regulations, achieve greater fuel efficiency and reduce carbon emissions. Some examples are vehicle design improvements focused on aerodynamics, development of lighter weight materials for truck bodies, and power train innovations, improving the efficiency of internal combustion engines. There are also innovations in alternative propulsion systems, including hybrid-electric, full electric and fuel cell powered vehicles. Depending on oil prices, incentives and rollout of required infrastructure, Benecchi expects hybrid vehicles may gain a significant share of the U.S. medium duty trucking market by 2020.

Benecchi is also a believer in ITS, both intelligent infrastructure and intelligent vehicles, to enhance efficiency, security, and the seamless crossing of international borders.

In summary, there will be more of us, we will be living longer, many of us in big cities—and we will be very hungry for energy. As fuel

prices increase we will become keen on conserving energy. Drivers will become more informed and economical. Vehicles will become more efficient and more intelligent in their ability to communicate with each other and with the transportation system infrastructure.

Bill Van Amburg, CALSTART

CALSTART is a non-profit, member-based organization offering programs and services to support and expand the growth of a clean transportation industry that will create high-quality jobs, clean the air, reduce dependence on foreign oil, and reduce emissions. CALSTART works with fleets to facilitate implementation of clean technology and fuel. They also work toward policy development and building broad support, as solutions are required to address three inter-related needs: energy security; air quality; and climate change.

Mr. Van Amburg argues there is no single "magic bullet" in terms of alternative fuels (e.g. natural gas) or technologies that will save us from depleting fuel supplies, rising oil prices, and increasing climate change issues. Rather, a lot of different solutions need to be in play.

He also observed significant reductions in emissions due to the 2010 rules, but also large increases in costs. Fuel economy was on the back burner in the trucking industry, partly because of the need for after treatment and cleaning up the vehicles. However, now there is a big new push towards greater fuel efficiency, inspired by high oil prices, fuel price shocks, and concerns about energy security.

CALSTART is bullish on hybrid trucks, including plug-in hybrid electric vehicles, hydraulic hybrids, and all-electric battery vehicles. Many of these vehicles are already in low-volume production by the major North American truck makers. A *hybrid* is simply a technology that can use two different sources of stored energy and capture energy for re-use back into the power train. Hybrid trucks may be especially suitable for urban environments.

Hybrid technology can greatly enhance fuel economy in stop and go duty cycles. In a variety of applications, hybrid vehicles have been

proven out to reduce energy consumption by 20 to 50 percent. More broadly, hybrid technology can increase North American energy security, while reducing harmful emissions. The benefits span the "triple bottom line," from economic to social to environmental.

Mr. Van Amburg also described CALSTART's Hybrid Truck Users Forum (HTUF). Ten years ago, the U. S. Army and CALSTART collaboratively launched the HTUF initiative, to promote hybrid and high-efficiency dual-use technologies for commercial and military trucking applications. The U. S. Army has a large stake in energy efficiency; it spends $2-3 billion per year for fuel, and lower fuel use means fewer convoys—and less danger for soldiers (HTUF 2010).

The purpose of this HTUF partnership is to assess commercial value of hybridization, and find ways to drive volumes up and costs down. Van Amburg noted that action follows from consistency, persistence, and aligned incentives and regulations. While it is critical to show net benefits over the life cycle of an initiative; some risks, e.g. extreme escalation of fuel prices, are often not considered.

Recently, the California Air Resources Board (CARB) invested $20 million in a hybrid truck incentive program. The program is being administered by CALSTART, which quickly received requests to fund 300 vehicles for about $8.5 million. This makes California the North American leader in adoption and use of hybrid trucks.

CALSTART also recently launched the California Hybrid, Efficient and Advanced Truck (CalHEAT) Research Center. The center is sponsored by the California Energy Commission, to be a resource for research, development, demonstration and commercialization of efficient truck technologies and systems. Its activities include conducting a market barrier analysis on the combination of alternative fuels and hybrid truck technology and demonstration of a high efficiency Class 8 truck in an application such as port drayage or urban delivery.

In summary, Van Amburg and CALSTART advocate partnerships, among commercial firms, government agencies and not-for-profits, as

a critical path to help fleets, truckers and manufacturers overcome the financial and cultural barriers to producing, purchasing and using advanced technology. They also argue for movement forward on multiple technological solutions, and for the high-level objectives to incorporate fuel efficiency and emission control.

Rick Whittaker, Sustainable Development Technology Canada

Mr. Whittaker focused on how Canada fits into the overall equation, given its existing market orientation and geographic dispersion of population centres, and their impact on transportation. Canada is similar to California in terms of total population, but very different geographically. In Canada, industrial transportation is the fastest-growing source of emissions.

These factors yield questions about how to utilize technologies and how to operate fleets. Sustainable Development Technology Canada (SDTC) is an arms-length, not-for-profit entity; established in 2001, funded by the Federal Government. Its focus is on pre-commercial emerging technologies which have yet to make it onto the market. SDTC bridges the transition between invention by scientists and movement into the market, with related financing risks. Investments are determined through a business case approach, which focuses on the impacts of resource utilization caused by the movement of freight in the industrial transportation sector. This approach aims to identify direct and enabling technologies that can help create more sustainable operations within and across all freight transportation sub-sectors. It also identifies Canadian policy priorities that will facilitate timely diffusion of these technologies into the market. SDTC's engagement process strives to understand what the vision in the freight industry is in connection to sustainability, fuel efficiency, meeting air emission standards, various other environmental components and economic growth.

A four-tiered process, SDTC STAR™, is implemented by SDTC to create a picture of the market and address requirements of the key stakeholders, e.g. logistics providers, equipment manufacturers and regulatory bodies. The process starts with information input, then

moves on to needs assessment, focused on technological, economic, political and social forces. This is followed by a detailed analysis of economic and environmental criteria. The outcome of the process is an investment report.

The STAR™ process has been instrumental in visioning the needs of the Canadian industrial transport sub-sector. Occasionally, outcomes have policy implications. Though not a "policy shop," SDTC makes an effort to talk to policy-makers and understand their needs.

A look at Canada's 2010 budget anticipates a scarcity of resources for research and program implementation, i.e. a "no new money year." Therefore, policy pieces are going to be critical, since technology investments will be on a priority basis requiring decisions about leveraging strengths and focusing on areas of need. In this context, the vision resulting from SDTC's countrywide consultation process anticipates that absolute energy consumption and GHG emissions in on-road trucking will be reduced by 50 percent by the year 2030.

Transportation in Canada is responsible for about 37 per cent of total energy related to GHG emissions. The trucking sector is one of the largest contributors of emissions, it is very energy intensive, and its consumption of energy is growing. Of course, transportation is critical to the economy; in terms of employment, mobility, freight movement, and value added to gross domestic product (GDP). In terms of maintaining food supply alone, disruptions can have very severe repercussions.

SDTC considers technical and non-technical needs in sustainable transportation. The technical needs include diesel engine design, alternative fuels, integrated aerodynamics and light-weighting in vehicle design, load optimization systems, etc. Non-technical needs include monetization of emission reductions, fuel economy standards, incentive programs, harmonization of vehicle weight and dimension regulations and operator training. In summary, the SDTC vision can be achieved through development of new technologies, adoption of suitable public policies and regulations, and creation of sophisticated risk management techniques for investors.

SDTC estimates about $1.5 billion is needed to fully commercialize the new technologies in its portfolio of high assay projects, to reach the goal of 50 percent reduction in fuel consumption and emissions. In addition, a government instrument of about $500 million is needed to "de-risk" project development and demonstration.

Conclusions

Even with the widespread uptake of more efficient technologies and driver skills, what is the future of trucking in this rapidly changing world? Rising fuel prices and further emission regulations will likely inspire more efficient multi-modal innovation, diffusion of advanced telematics and ITS in the trucking industry—and possibly a shift towards rail. Trucking must re-invent itself to be competitive and prosper in sectors and lanes where it can deliver benefits. Higher oil prices and socio-economic changes may bring lower demand, shorter supply chains, and the leveraging of regional or local (as opposed to global) models of economic development.

Fuel price is a primary driver of the adoption of fuel economy and emission reduction technology. Long-term price rises, rather than temporary spikes, are the key determinants of investment decisions, which tend to be based on measured assessments of risk and return.

SDTC's goal of absolute reduction of 50% in fuel use and emissions in Canada is laudable. However, it may be more useful to consider reductions in fuel use and emissions on a tonne-kilometre basis. In a future of constrained fuel and emissions, achieving an efficient and sustainable service model may be the difference between growth and survival in long-haul trucking. The relative efficiency of the railroad, coupled with new technology and infrastructure investments, may be a formidable challenge to trucking.

What emerges from the panel of sustainable transportation leaders and the literature is that technological change is a critical force behind sustainability and competitiveness. But, how does change occur in an industry with low margins and high demand/supply uncertainties,

which constrain investment behaviour? Diffusion of technology can be enhanced by public support for research and development through to commercialization. There are many examples of such support.

A coordinated approach and comprehensive framework is needed to move forward, involving industry, academia, government agencies, and non-governmental organizations (NGOs). Collaboration among these actors is critical for innovation. Rather than relying on market forces, tools such as taxation, rebate incentives, and regulations can facilitate sustainability.

A better understanding of socio-economic and technological trends is needed to support strategies and policies that will deliver the greatest benefits, and to make the right infrastructure decisions. If electrified rail is the optimal approach in a given space, then building billions of dollars of highway would be an enormous mistake with long-lasting consequences.

Demand for freight transportation is derived from the demand for the freight, which is in turn determined by complex and changing socio-economic factors. Ultimately, the future of trucking will be decided by consumers and tax-payers—and their representatives in the public and private sectors.

Our future research is focused on the drivers of change in trucking, along with barriers, facilitators, costs and benefits of regulatory, operational and technological change in the trucking industry. Our plans include a survey of transportation users, providers and other stakeholders. In addition, we are developing several plausible future freight transportation scenarios, to be assessed for their impacts on prosperity, mobility and sustainability in Canada.

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