AIRSHIP LOGISTICS CENTRES: THE 6TH MODE OF TRANSPORT

Blair Sherwood and Barry E. Prentice*

Introduction

Contrary to public perception, airship development did not terminate with the *Hindenburg* accident, some 83 years ago. Airships have operated continuously since that time, albeit in small numbers, and developers continue to invest in new materials, designs, propulsion and computerized control systems. The major investment gap of the airship industry is ground-based infrastructure. Many industrialized countries retain a legacy of military airship hangars, but Canada has no infrastructure to support the development of an airship industry. Ironically, the country that stands to gain the most from lighter-than-air technology is the least prepared to attract it.

Approximately 70 percent of Canada's surface area is inaccessible most of the year. All-season, low cost airships could open the Canadian hinterland to economic development. Moreover, airships could address growing concerns about Canadian sovereignty in the Arctic. Airships, which can fly anywhere with minimal infrastructure, are ideal for serving Canada's vast northern transportation needs.

Airships could also be valuable to Canada as a trading nation. As airships get larger, they become more competitive for long distance transport. Like ships of the ocean, airships enjoy increasing economies of size. A doubling of the airship's dimensions could quadruple its cargo capacity. Once airships are large enough to cross oceans economically, international trade will become their primary market (Prentice et al, 2005). At the risk of hyperbole, airships could

transform international air cargo trade, as much as containerships changed ocean freight[1].

Technological advances and evolving demand are pushing the airship industry towards a "tipping point" (Prentice and Russell, 2009). Professional engineers, logistical practitioners and academia are investing time and capital in the development of transport airships. The fifth *Airships to the Arctic* conference was held in Calgary, Alberta (October 2009) to track the growth and maturation of the airship industry. This conference was attended by over ten airship companies with delegates from a dozen different countries[2]. Within three years, the largest airship since the era of the giant Zeppelins is scheduled to begin testing[3]. Once business confidence catches up with the technology, a period of accelerating airship sales will begin.

The purpose of this paper is to explore the ground handling and cargo exchange needs of transport airships. Most airship bases were constructed to meet military objectives rather than commercial requirements. This paper presents the need for commercial airship bases and a brief history of airship hangar development worldwide. Subsequently, the paper considers the location, configuration and operations of civilian airship logistics centres. The last sections of the paper discuss the implications for intermodal co-ordination and the development of an airship industry in Canada.

Commercial Airship Bases

Logistics centres for organizing freight and arranging final delivery are important for all modes of transport. Infrastructure is required for refuelling, maintenance and cargo exchange. No literature exists in the public domain on the design or location of ground handling and cargo exchange centres for transport airships. Airship bases would resemble airports in terms of security, road access and management of airspace. An airship logistics centre would differ from airports in the mooring systems, apron development and hangar design.

At the heart of a future airship logistics centre is a hangar that can accommodate the dimensions of the biggest airships serving the location. Airship hangars fulfill the same role for an airship that dry-

docks provide for marine transport. Airships are safest and most productive when they are in the sky. The only time that an airship would normally use a hangar is for assembly or maintenance.

Although airships may not need to use a hangar often, this infrastructure is essential to their operations. Too many failed attempts to build airships without hangars prove the importance of shelter for assembly and testing of airships. Exposure to freak storms, rain and even vandalism impeded the efforts of several firms that tried to build airships outdoors[4]. Hangars are also necessary for airship maintenance. Each year an airship must undergo a weeklong safety inspection as part of air transport regulations. Airship assembly and maintenance is impossible without this critical infrastructure.

The lack of airship hangars in Canada presents a strategic industrial competitiveness problem. Unlike other developed countries that constructed airship hangars during the first half of the 20th century, Canada has no history or tradition of lighter-than-air transport. Canada can neither support cargo airship operations, nor undertake the construction of new generation transport airships without the appropriate infrastructure. A survey of airship hangars worldwide documents the competition.

A brief history of airship hangars

Count Zeppelin's first airship hangar was designed to float on Lake Constance, as pictured in Figure 1. The advantage of this innovation was that the entrance could be oriented relative to the prevailing winds to facilitate hangar entry and exit. In addition, Zeppelin did not need to acquire land to construct fixed facilities.

Once the Zeppelin Company became more established, they constructed larger land-based hangars. Figure 2 is a picture of the LZ127 *Graf Zeppelin* being led from its hangar in 1928. Their airship hangars were all destroyed during the Second World War.

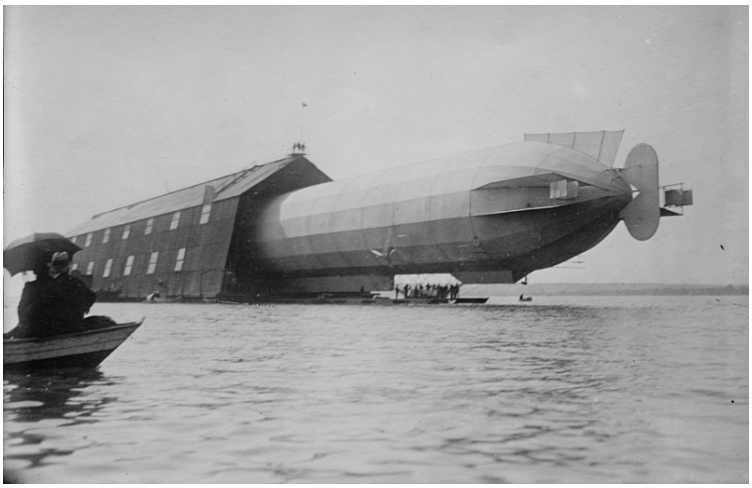
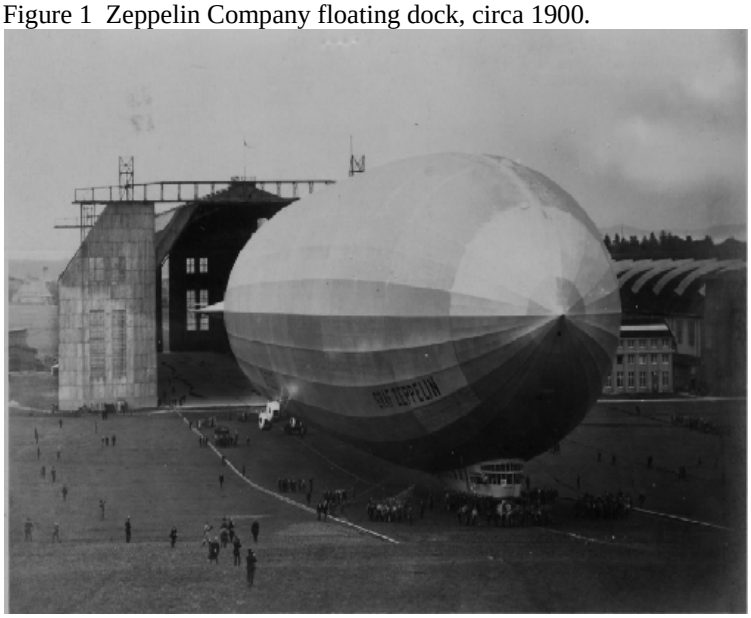


Figure 1 Zeppelin Company floating dock, circa 1900.



Source: http://www.airships.net/lz127-graf-zeppelin/history

Figure 2 LZ127 *Graf Zeppelin* being led from its hangar for and inaugural flight, September 18, 1928

Lighter-than-air technology has been used for many different applications since the early 1900s. The world's first commercial passenger airline was a German airship service that commenced in 1909[5]. Many military uses were explored during the same period. Zeppelins were used to bomb London in the First World War, and to deliver relief supplies to African colonies. Italy built a hangar at Augusta in 1917, which is still standing, to support airship patrols against German U-boat attacks. Many countries, including Britain and Russia, employed airships and tethered balloons as reconnaissance platforms.

The British Government decided in 1924 to establish a worldwide passenger airship service to connect the far reaches of its empire. Hangars were built at Howden and Cardington for the construction of two giant passenger airships, the *R100* and *R101*. A second hangar was added at Cardington in 1928. Figure 3 shows a picture of the Cardington Sheds.

Figure 3 Cardington Airship Sheds

The crash of the *R101* ended the British passenger airship program, but the "sheds" continue to be used to this day. These hangars were critical to the construction of the *SkyShip 600* airship series. Most recently, Hybrid Air Vehicles (SkyCat) have used the British airship hangars to develop and test their prototypes.

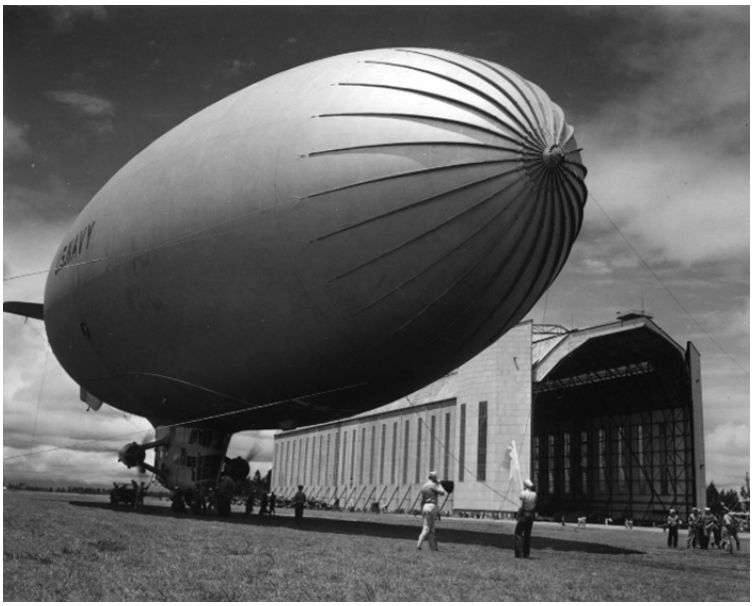
The United States built their first airship hangar in 1921 at Lakehurst, New Jersey. The picture in Figure 4 shows the *Los Angeles* outside the Lakehurst Hangar, circa 1924. In addition to the *Los Angeles* and most other airships of the era, the Lakehurst hangar was used by the trans-Atlantic Zeppelin passenger service, including the *Hindenburg*.

Figure 4 Hangar No. 1 Lakehurst Naval Station and LZ 126 *Los Angeles*, circa 1924

Additional hangars were built at Akron, Ohio and Sunnyvale, California for the construction of experimental flying aircraft carriers (*Macon* and *Akron*). During WWII, the US built over 300 blimps for anti-submarine defence, and additional hangars on both the east and west coasts. Approximately 12 large airship hangers remain available in the United States to support their expanding airship industry that is mostly located near these facilities.

The airship hangar at Akron, Ohio is being used by Lockheed-Martin for the construction of a very large experimental airship, *ISIS* (Boyd, 2007). This airship is designed to operate robotically in the stratosphere. The airship is 320m long and 100m in diameter. These dimensions, which are larger than the *Hindenburg*, occupy a space of 1.4 million cubic metres within the Akron Airdock[6].

The only large airship hangar in the southern hemisphere was inaugurated in 1936 at Santa Cruz, Brazil to support Zeppelin passenger services. This building is 53.5m high by 50m wide and 270m long. This hangar is pictured in the background in Figure 5. The airship is a US Navy K-84 that was stationed at Santa Cruz during the Second World War. This former Zeppelin hangar is still in use today serving as a hangar for the Brazilian Air Force.



Source: http://www.uboatarchive.net/U-134AirshipPhotos.htm

Figure 5 Airship Hangar with US Navy K-ship, Santa Cruz, Brazil

Figure 6 CargoLifter Hangar, Brandt, Germany, circa 2005

The world's newest and largest airship hangar was completed in November 2000 for the German company, CargoLifter. Following the bankruptcy of this venture, this hangar was converted into a

tropical amusement park. A photograph of the current CargoLifter hangar is presented in Figure 6. This structure is 106m high, 220m across the base and over 360m long. The "clam-shell" doors open at either end. Whether this structure will ever be returned to its original intended use is uncertain, but it exists as a potential airship-manufacturing centre for airships larger than the *ISIS*.

Civilian Airship Centres

The infrastructure needs of airships are less than for all other transport modes. An airship hangar is huge, but this building is also the manufacturing site, the logistical support centre, and the maintenance depot. By comparison, fixed wing aircraft need an assembly factory, extensive airport aprons and runways to take off and land, as well as hangars for overhaul and maintenance. The only other critical infrastructure needs for airships are anchoring systems and gas supply.

An airship cargo facility is similar to most cargo buildings; only the exchange of cargo between the airship and the ground handling equipment needs to be considered. Depending on the design, the airship may need a ballasting and a mooring system. Airships may also require some gas to top up their lifting cells and the aircraft needs to be refuelled.

It is by no means clear that future airships will burn current aviation fuels. Alternative gaseous fuels are more desirable because they have lower greenhouse gas emissions. The size of an airship enables low-pressure gas storage to be incorporated into the hull. Blau gas, a blend of methane, hydrogen and air, was used successfully by the *Graf Zeppelin* to fly around the world. Blau gas, which is about the same weight as air, has the ability to store more energy than kerosene and avoids the burnt-fuel ballasting problem. In order to use gaseous fuels, ground based storage facilities and re-fuelling procedures need to be developed.

A cargo origination centre is logically located near the airship hangar. The destination does not necessarily need as much infrastructure. An open area is required for the landing and loading/unloading of freight.

Cargo can be carried as sling loads, pods, and in the interior of a heavy-lift airship. The vertical take-off and landing (VTOL) abilities of new airships eliminate the need for large ground handling crews.

Facility Location

The location of an airship logistics centre should have three important components: labour, connecting roads/rail and airport infrastructure and a market area to be served. It will be easier to recruit personnel if the airship hangar is located in an established aerospace centre. The CargoLifter Company found it difficult to establish their workforce at a former East German military air base because qualified engineers were not living in the vicinity. Human resource needs suggest that an airship facility should be located within an hour's drive of a major aerospace centre.

In addition to the workforce commute times, freight has to be economically transported to and from the facility. An airship facility would be preferable if it were close to an international airport, to help with the transfer of needed parts and personnel. Fixed wing aircraft and airships can operate in the same air space, as demonstrated by the *Zeppelin NT* that is based at the Friedrichshafen International Airport.

Finally, the logistics centre location must have some natural transportation transhipment advantage. A strategic location in Canada would have road, rail and airport access to major industrial cities and be a gateway to the remote northern communities.

Four cities in Canada that meet these criteria are Edmonton, Winnipeg, Toronto and Montreal. The latter three cities are largest centres of aerospace manufacturing in Canada. Montreal and Winnipeg are well located to serve the Canadian Shield and the eastern Arctic; Edmonton is ideally positioned to serve the western Arctic. Mooring facilities will require approximately one kilometre in diameter for each airship. Land in Toronto and Montreal is much more expensive than in the cities of western Canada. Winnipeg and Edmonton may be the most attractive locations for an airship logistics centre, but several locations in Canada will likely vie to be the first

airship cargo gateway. Following the success of the initial facility, several airship logistics centres are expected to emerge.

Facility Design and Operations

The general shape and design of airship hangars is reasonably well established based on the experience of the mid-20th century. Techniques were developed to move airships safely in and out of hangars, and to provide mooring. Chale (2009) suggests some new approaches that could be considered for construction of the walls and interior facilities such as in-floor heating, fire suppression and lighting considerations. New materials may also permit technological advances in the construction of more robust coverings and the fabrication of lighter doors.[7]

The dimensions of the hangar facility should be large enough to accommodate the construction of the first generation of commercial transport airships. The initial transport airships are likely to lift between 10 and 50 tonnes of cargo. The approximate hangar dimensions for these airships would be 30m high by 60m wide by 120m to 200m in length. A longer hangar would permit two large airships to be located end to end inside the hangar, while two smaller airships might be fitted side by side in a shorter hangar.

Assembly of non-rigid airships begins with envelope inflation, and then all the "hard" pieces, like engines, fins, gondola, etc. are attached. Rigid airship assembly begins with the construction of the shell and the gas cells are inflated subsequently. Two strategically placed 10-ton lift cranes would be sufficient to move components into place. A dual-chamber hangar would permit two airships to be assembled simultaneously, or one bay could be used for assembly and the other for airship maintenance. Initially, the hangar would likely operate in the manufacturing mode, until the number of operating airships became large enough to dedicate space for ongoing maintenance.

A components fabrication facility for the manufacture, repair and storage of parts would be attached to one side of the airship hangar.

It could be approximately 10m high by 50m wide by 50m in length, with a large door to bring components into the hangar for assembly.

An office complex for management and engineering staff could be built into the side of the hangar. The boardrooms and offices would be augmented with bathroom, locker facilities for the production and aircrew personnel. A lunchroom and grounds-crew office could be other ancillary space requirements.

An all weather tarmac would surround the facility to ensure EMS recovery/fire safety work, efficient ground handling, and snow removal. The ramp area would be of sufficient size to store service vehicles. Depending on the size of the airship centre, several mooring masts could be located for waiting airships. The mooring area does not need a prepared surface, except for paved access roads.

An operations centre would be installed outside of the main facility, complete with the storage of EMS/Fire safety equipment. The communications centre and tower would also be housed in this facility. Co-ordination with local officials could include the use of EMS/Fire coverage for surrounding areas in case of an emergency.

The logistical support centre is likely to be a separate cross-dock warehouse located near the hangar. Freight would be marshalled in this warehouse to load the airships, and freight unloaded from airships would be sorted in the warehouse for delivery to consignees. The warehouse operations, cargo handling and paperwork filing would be managed separately from the airship hangar.

The operation of the airship hangar is a business in itself. The hangar management team would be responsible for leasing floor space to the different owners, manufacturers and leasers of the airships. The proper use of the equipment, safety, and operations of the airspace would also fall within the purview of the hangar management.

At least one airship hanger in each region could be required to serve an airship fleet for northern Canada and for future use in international trade. If airships carry only a fraction of the tonnage needed for the

future projects that await the north, a market could exist for as many as 300 airships. With the need for weeklong, annual safety inspections, one hangar would be needed for every 50 airships, depending on scheduling. With this volume of activity, five or six airship hangars would be required.

The Next Ten Years

The reality of change is that people have a difficult time accepting its implications. Often the participants fear the worst outcome. Transport airships should complement most modes of transport more than compete with them for freight. The lowest cost logistics is generally an intermodal solution because each mode of transport has unique attributes. Transport airships will dominate where no existing infrastructure exists for truck and rail transport, as is the case in Northern Canada.

Low value, non-perishable freight, like fuel or building materials, could be moved to the northern extremes of the existing road and rail networks before transhipment to airships. It is reasonable to envision satellite airship transhipment centres at locations such as Hay River, NWT, Thompson, Manitoba, Long Lac, Ontario, or Val-d'Or, Quebec. These locations would not necessarily have hangars, but they would have mooring masts and cleared locations for freight handling.

If gentle handling and speed are more important than cost, the freight could be transhipped at the airship logistics centre for movement directly to the destination. The location of an airship logistics centre within an inland port could be synergistic for truck and rail cargo exchange. Unlike fixed-wing aircraft, in which the fuselage shape and the door size limit the cargo dimensions, transport airships are only constrained by weight. Freight that moves at less than 80 kilometres per hour (kph) by road or rail is very suitable to an airship that would cruise at 130 kph. It is realistic to envision over-dimensional, and eventually over-weight, loads transhipped from truck or rail to airships at an inland port.

These are exciting times for the airship industry, although most of the action has yet to attract much public attention. The advent of large airships returning to the skies will happen by 2012, providing the US military contract terms are met (Pincus, 2010). A hybrid airship with the footprint of a soccer field is scheduled to make trial flights within 12 months and for delivery within 18 months. Several airship companies are ready to build 10-ton lift capable transport airships, and the Boeing-SkyHook vehicle has a 40-ton lift hybrid airship-helicopter design that is expected to begin testing in 2013.

The demand for airships should increase if trends in climate change persist. The end of the ice roads that now serve remote communities seems as inevitable as the melting of the Polar Ice Cap[8]. Airships are a viable solution to ice roads, and an environmentally friendly alternative to all-weather roads or fixed-wing aircraft to access resources in the North.

Conclusion

The elements exist to build a strong business case for an airship logistics centre. Regions that invest in the construction of airship hangar facilities can obtain significant economic benefits in the form of jobs and investment. The manufacture of airships and the operations of these vehicles would have positive spin-off effects on input supply businesses, logistics providers, financial services and other skilled workers.

A transport airship system will also create opportunities for the towns and villages in remote areas. Year round construction of houses and light manufacturing could be established. Lower cost, reliable airship transport could eliminate the “remoteness” of communities that have no all-weather road connections. Better transportation could lead to improvements in chronic social problems, such as bad diets, health problems (diabetes and tuberculosis) and inadequate public services.

Businesses would also be created at intermediate transhipment points. For example, transport airships could supply inputs to mining operations and transport mineral concentrates back to outside markets.

Transport airships and their logistical support are complementary to all forms of transport, with the exception of large cargo airplanes. Initially, the first generation of commercial airships in Canada would only serve domestic markets. The materials and plans already exist however, to build larger transport airships that can easily cross oceans. Canada is well located to take advantage of trans-polar routes to move freight between Asia, Europe and North America. Transport airships could open up airfreight trade routes that now carry only high value goods.

It has often been observed that the airship industry faces a "chicken and egg" problem, or what is sometimes called the "innovator's dilemma". Until the market for airships can be proven, it is difficult to justify the investment in the construction of a vehicle to prove the market. This might also seem to apply to airship hangars, but this is not the case. "You cannot hatch an egg, without an incubator". The construction of airship hangars must precede the development of commercial operations. The absence of airship infrastructure is an impediment to progress. This infrastructure gap must be resolved before Canada can establish a manufacturing industry or utilize airships to move cargo to remote communities.

The airship industry is near the "tipping point" of commercial development. Transport airships are ready to serve the needs of the 21st century with environmentally friendly, affordable and flexible delivery of cargo. A first mover advantage exists for regions that have the courage and foresight to grasp the leadership of this 6th mode of freight transport. The first step is to start planning and building the needed infrastructure of airship hangars and logistics support systems.

References

Boyd, Robert. "Delivering Value with Buoyant Aircraft." 4th Airships to the Arctic Conference, Winnipeg, MB: presentation, October, 2007. Forthcoming at: www.isopolar.ca.

Chale, Rick. "Building Large Airships in Canada - Engineering Considerations". 5th Airships to the Arctic Conference, Calgary,

AB: presentation, October, 2009. Available at: www.airshipstothearctic.com.

Pincus, Walter. "Military seeks an intelligence-gathering airship" *Washington Post*. Tuesday, February 16, 2010.

Prentice, Barry E., et al. "The Rebirth of Airships" *Journal of the Transportation Research Forum*. Vol. 44. No. 1 (2005): 173-190.

Prentice, Barry E. and Stuart Russell. "Competing Technologies And Economic Opportunities For Northern Logistics: The Airship Solution" *Canadian Transportation Research Forum*. Proceedings Issue: 44th Annual Meeting (2009): 685-698.

---

* The authors are:
Blair Sherwood, President, BNS Environmental Logistics Corp.
Barry E. Prentice, Professor, I.H. Asper School of Business, Transport Institute, University of Manitoba. Dr. Prentice is the founder and President of ISO Polar.

[1] Containers succeeded principally because they greatly reduced the terminal costs of ocean shipping. Airships would not have much impact on terminal costs, but they would greatly reduce the linehaul costs of transport relative to fixed-wing aircraft.

[2] Proceedings of the latest Airships to the Arctic conference can be found at www.airshipstothearctic.com

[3] The Boeing-SkyHook project is scheduled to assemble and test a 40-ton lift airship in 2013. www.airshipstothearctic.com

[4] Thomas Slate's first attempt to build an all metal airship in Glendale, California was destroyed by high winds in 1927. He subsequently built a hangar. Hokan Colting, 21st Century Airships, lost his airship in the summer of 2007 at Newmarket, Ontario during assembly on a field. The unprotected airship was hit by a microburst during a thunder storm. Subsequently, he sold his firm to a US company that operates out of Atlanta. Alan Handley, Varialift, at Birmingham, England had his partially assembled airship destroyed by vandals in 2009. Even airship companies with small hangars have suffered damage when the hangars failed. Both Ohio Airships and the Canadian Airship Manufacturing Company experience hangar failures the set back their efforts.

[5] Count Zeppelin founded world's first commercial airline, DELAG, or the German Airship Transportation Company in November 1909.

[6] The *Hindenburg* was 247m long and 42m in diameter.

[7] ISO Polar Airships, www.isopolar.ca, is leading an industry consortium in the analysis of airship hangar developments in Canada.

[8] "The Ice Road season in Manitoba is ending prematurely in 2010. Our drivers are fighting the mud more than the snow, and are restricted now to "night time only" travel for the last couple of days. We still have many loads to go. We had some great loads to the Ontario First Nations, but could never get there, because the road was in such terrible shape and damaging our trucks. When going up hill, the truck ahead had to pull the truck behind, slowing down the whole convoy. There were drivers who turned around and refused to deliver. It is not just about how long the winter roads last, but whether they are maintained well enough to be used at all."
Personal communication: Lucie Reid, VP Express, March 10, 2010.