A lesson from the Native Access to Engineering Programme

# Transportation

**transportation:** trans-pər-'tā-shən (noun) c.1540
1 : an act, process, or instance of transporting or being transported
3 a : means of conveyance or travel from one place to another b : public conveyance of passengers or goods especially as a commercial enterprise

Merriam-Webster On-line Dictionary
http://www.m-w.com/

## What is transportation?

As the definition implies, transportation is all about moving goods and people from one place to another.

*How many different types of transportation can you name?*

Sometimes getting from one place to another is easy, like when you transport yourself from home to school.

Other times, getting from one place to another is much harder. Transporting you from home to visit an Aborigine community in Australia would take lots of time and involve some combination of planes, trains and automobiles (and possibly even boats).

Even within Canada, transportation can be quite difficult. Our road network is concentrated in the south. Rural communities may have few roads. Remote communities may only be accessible by boat or plane.

*How do you think goods like orange juice, jeans and textbooks get to remote communities?*

## Natural transportation

All animals are equipped with some natural method of transportation adapted to what they move in, on or through:

- for animals that move mostly on land, including humans, it's generally feet;
- for animals that live in water, like fish, it's fins and flippers.
- for animals that fly through the air, like birds and many insects, it's wings;

Because creation is so diverse, there are exceptions in each of these categories. For instance, lobsters and crabs live in water, but they move around on legs.

*How else are animals adapted to move through their environments?*

Animals are amazing at moving from one place to another. Some Pacific humpback whales migrate the almost 6000 kilometers between Alaska and Hawaii twice a year. Some species of birds have been known to travel more than 15,000 kilometers (one way) in their migrations. But the most amazing travellers on the planet are us.

## Humans and transportation

A loaded travois being pulled by a horse.

Long before cars, snowmobiles and airplanes, humans had migrated to all over the Earth powered almost exclusively by their feet. Eventually, people got tired of walking around and carrying everything they needed on their backs. They started to use domesticated animals to carry goods. They also built machines and devices, like sleds and travois, to help them carry more. In some parts of the world, they began using the wheel and axle to build carts and carriages.

*How have your people traditionally transported goods and people from place to place?*

As people travelled back and forth, establishing trading routes, well-used paths became more and more permanent. These paths became the first roads. As time went on, people started to maintain the roads and look at ways in which they could be made easier to travel, these people were the first transportation engineers.

## Transportation engineering

Transportation engineering is a type of civil engineering which focuses on the infrastructure of transportation: all the elements which support the movement of goods and people. Transportation engineers design runways, build bridges, layout roads and plan docking facilities. They look at traffic patterns, determine when new transport facilities are needed and come up with better ways to get from point A to point B.

To build the infrastructure they have to consider:

- the geographic features of the construction area;
- the local climate;
- and local needs.

*What could a transportation engineer do in your community?*

Engineers must look at needs, climate and the area of construction both separately and together. Many Aboriginal communities are located in remote or rural areas which present unique challenges of climate and geography to building transportation infrastructure.

*Think about your community, what would some of the challenges be ?*

## Geography

One of the basic questions a transportation engineer must answer is, "Can I support the needed infrastructure in this place?"

*What geographical features might make the construction of transportation infrastructure difficult?*

If you were a transportation engineer, where would you draw a line on the mountains, so that the material removed from above the line, could be used to fill the valleys below the line?

Mountainous terrain may make laying roads or rail difficult or impractical; it may require blasting of passes and tunnels and the construction of bridges or filling of gaps over deep ravines. When planning roads through mountainous or hilly terrain, engineers try to plan the road so that material blasted from one area can be used to fill other areas.

Rocky exposed coastline requires stronger docking construction than sheltered coves. Saltwater ports require a different type of concrete than freshwater ports.

Roads and runways are pretty heavy all by themselves, when you put a large truck or airplane on them they get even heavier. In some places the land just can't support all that weight. For instance, in areas filled with boggy muskeg, roads are very difficult to build, they have to be raised above the ground so that they don't constantly crack or sink.

In other places geography may determine what kind of transportation can be used to reach a community. Large mountains or bodies of water may isolate a community so that it can only be reached by air or water (or sometimes overland only by foot). Having the facilities to receive planes or boats then becomes very important to the community.

In Nunavut, most communities are very isolated, especially in winter. Food brought in by plane, especially things like fresh milk and vegetables, becomes very, very expensive. To save money, many families will place an order for non-perishable food - and other supplies - in the south in the spring. Their goods are then shipped up north by boat or barge during the short summer when the waters in and around Hudson and James Bays are free of pack ice. Families must plan their needs carefully as there is usually only time for one sea shipment per year.

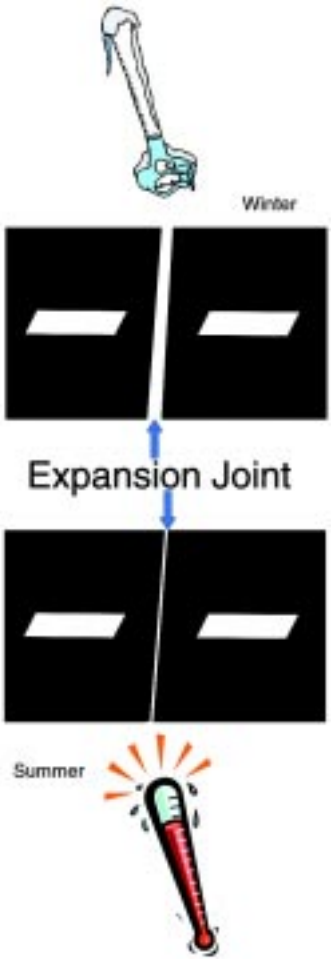
*What would happen if these communities didn't have the transportation infrastructure to receive such shipments?*

Sometimes the need for transportation infrastructure outweighs the challenges of construction. During the early settlement of Prince Edward Island in the 1700s, the only people who would venture across the dangerous ice of the Northumberland Strait in midwinter were the Mi'kmaq. Reliable links with the mainland did not exist until 1912 when a year round ferry service was established. Still, ferries meant that Islanders had to live by the ferry schedule. In 1997, the Confederation Bridge opened providing a permanent and constant access route between PEI and New Brunswick. Engineers had to consider the winter ice in design and construction. Each bridge support is surrounded by an ice shield which forces the ice up and breaks it apart rather than allowing it to impact or solidify around the bridge supports.

The Confederation Bridge.

## Climate and weather

In Canada and the northern United States climate and weather also play a large role in transportation. We all know that winter conditions can make travel more difficult because of poor visibility, high winds and extreme low temperatures. The weather affects how fast people and goods move and even if they move at all.




Temperature also has a large impact on transportation infrastructure. Shifts between heat and cold have to be considered when building any kind of transportation infrastructure. High temperatures cause materials to expand while cold temperatures cause them to contract. Bridges, railway tracks and roadways are built with expansion joints which give the materials room to expand and contract.

*What would happen if roads didn't have expansion joints?*

On the plus side, what geography takes away may sometimes be returned by climate - at least temporarily. In areas where the winter freeze is deep and long, roads and bridges are often constructed on the ice, linking communities which are much harder to link in the summer months.

In summer, the Dempster Highway runs north from Dawson City, YK to Inuvik, NT. Travellers on the highway must take ferries across the Peel and Mackenzie rivers; those who wish to travel onto Tuktoyaktuk or Aklavik must fly or take a boat. In the winter the road gets extended by the climate. From mid-November until the beginning of May, ice bridges cross both rivers and an ice highway connects Inuvik to the more northern communities.


The dog doesn't weigh enough to break the ice, but cars might.

## A little more about ice

Because of our climate, ice bridges and roads are used all over Canada and the northern United States in the winter. While they make it easier for people to travel and receive goods, ice roads and bridges have to be monitored carefully: when the temperature warms and ice begins to thaw, driving on ice becomes dangerous.

Engineers have studied ice to know when it is safe to travel over with cars and trucks. Over time, they have developed a formula which provides a good estimate of the minimum safe thickness of ice needed to hold a given weight,

$$h = 4\sqrt{P}$$

where h = thickness of ice in inches, and
P = total weight of the vehicle and its load in tons.

When ice is at the minimum thickness for a given weight, it is recommended that vehicles are separated by at least 100 times the thickness of the ice. If the ice is thicker than the minimum for the weight, vehicles may travel closer together, but caution is recommended at all times.

*How thick should ice be to support a 2 ton truck with a 1 ton load?*

## Making things work together

In our daily lives we may walk to school, or drive to the co-op or take an ATV or boat to go out with our friends. But when we're travelling or moving goods over long distances, we often need to use more than one type of transportation to get from one place to another. So, transportation engineers also study ways of getting different kinds of transportation to work together: this involves considering what kind of facilities are needed to move from one type of transportation to another and lots and lots of scheduling.

A good example of making different types of transportation work together is the shipping of wheat. Canada is one of the largest producers of wheat in the world. Much of the wheat is exported to countries which cannot grow their own grains or as much grain as they need.

*How does wheat get from the Canadian Prairies to China?*

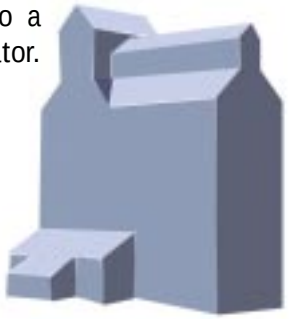
The wheat grown on a farm in Saskatchewan is harvested ...

... and transported by truck ...

... to a local grain elevator. Here it may be sorted for quality.

It will then either be put in a truck or railroad boxcar ...

... and brought to a terminal grain elevator.



Grain from the terminal elevator then fills up huge transport crates which are carried by train...

... to the port of Vancouver ...

... where they are loaded and stored on ocean freighters.


The ships cross the Pacific to ports in China where the process is reversed and the wheat is eventually delivered by truck or rail to processing plants.

Without the transportation network of road, rail and sea this process would be impossible.

## Transportation networks

In big cities like Montreal, Toronto and Vancouver, transportation infrastructure is everywhere: there are highways, shipping ports, railway lines and air terminals. Each of these systems - road, rail, air and water - is part of a large network which connects the cities with other communities (both larger and smaller) in other parts of the country and all over the world.

*Why do you think the Internet is sometimes referred to as the Information Highway?*

Interlinking or networking of transportation sounds relatively new but it has existed for a long time. Many ancient peoples all over the world built networks of roads for travel and trade.

Remnants of the Inca road network and cities remain throughout the Andes.

In what is now South America, the Inca built a road system that ran from Equador through Chile. At the peak of its use, this network had more than 22,000 km of road. It consisted of two main roads - one running north-south along the coast, the other running north-south through the Andes Mountains - and many smaller roads. Building through the Andes was a serious feat of engineering. Deep ravines had to be filled with rock to support the road. Suspension bridges had to be built over wide rivers. On really steep parts, big steps were cut into the road to make climbing easier.

*What does the use of steps imply about the Incan road network?*

Other kinds of transportation networks also existed. The river systems of Turtle Island were used extensively for trade and travel. Access to major waterways became the wealth of the Nation, the tribe, the clan and the family. Routes from one place to another were well-known and sometimes heavily travelled. They were often marked with pictographs or other markings which acted like road signs and gave travellers information about navigation and conditions further up or down the river.

## References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## Math Problems

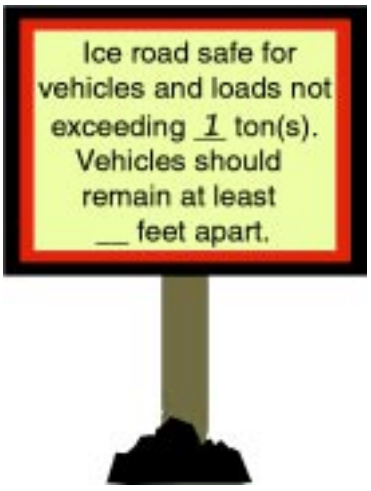
1. Your community is on an island only 3km from the mainland. While there are quite a few businesses and an elementary school in town, the bank, big grocery store and high school are located in the town which borders the shore of the mainland. In spring, summer and fall, a ferry runs between the two communities every half hour. In the winter the ferry is replaced by an ice road over the lake.

   As the town's Director of Public works, it is your job to determine when it is safe for people to travel over the ice. You measure the thickness of ice everyday and post signs at the water's edge telling people how much weight can safely be carried over the ice.

   The table shows your Monday morning measurements for ice thickness from November through April.

| Date | Ice thickness (inches) | Date | Ice thickness (inches) |
|---|---|---|---|
| November 3 | 0.25 | February 2 | 16 |
| November 10 | 0.5 | February 9 | 17 |
| November 17 | 0.5 | February 16 | 18 |
| November 24 | 0.75 | February 23 | 20 |
| December 1 | 1 | March 2 | 17 |
| December 8 | 2 | March 9 | 14.5 |
| December 15 | 3.5 | March 16 | 12 |
| December 22 | 4 | March 23 | 10 |
| December 29 | 5 | March 30 | 7.5 |
| January 5 | 6.75 | April 6 | 3 |
| January 12 | 8 | April 13 | 1 |
| January 19 | 10 | April 20 | 0.5 |
| January 26 | 13.5 | April 27 | 0 |

   a) From the values in the table, graph the ice thickness from November 3 to April 27.




   b) Every day you post a sign so peole know how much weight the ice can take. When do you post the sign which says, "Ice road safe for vehicles and loads not exceeding 1 ton(s)"?

   c) Your sign also says, "Vehicles should remain at least ____ feet apart." How many feet do you write on your sign, on the day that the ice can hold 1 ton weights?

   d) When the ice is at its thickest, how much weight can it hold?

   e) Pretty much all of the traffic using the road is 1 ton or less. When do you close the ice road for the season?

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