Oversize/Overweight Vehicles: An Investigation into the Safety and Space Requirements for Alternative Energy Projects

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Paper prepared for presentation at the

Geometric Design Considerations to Accommodate Other Transportation Modes Session

of the 2011 Annual Conference of the Transportation Association of Canada,

Edmonton, Alberta.

ABSTRACT

The use of oversize/overweight vehicles for the transportation of components and equipment for alternative energy projects is on the increase in North America. As the demand and popularity of such projects increases, the road infrastructure is expected to accommodate a wide range of complex vehicle configurations. One of the few examples of a roadway network is the High Load Corridor in Alberta. A system of High Load corridors has been developed in response to requirements to move over-dimensional equipment machinery, and preassembled components form manufacturing centers in central and southern Alberta to the Oil sands plants in northern Alberta. The High Load corridor allows loads up to 9m high and widths up to 9m. For the wind energy sector as an example, wind turbine component transportation planning is carried out in a reactive manner where adjustments to road furniture are made during the transportation of the heavy or abnormal load. With very little information available and documented on the impact of such specialized vehicles to the road and existing infrastructure, route planning becomes an extremely complex exercise. There is a need to develop a proactive approach which allows planners and designers to effectively design road infrastructure with the manoeuvrability of specialized vehicles in mind.

This paper examines key safety and road geometry aspects (for interchanges and intersections) of the current wind turbine component transportation planning process e.g. initial route identification, identification of physical obstacles, headroom restrictions, horizontal and vertical curves on existing roads and infrastructure. It also describes other considerations for wind turbine transportation planning which would typically impact the normal usage of the road e.g. road closures and temporary relocation of signage or static objects. The paper suggests a framework for future research initiatives on oversize vehicles e.g. the gathering information on the typical oversize vehicle for wind turbine component transportation and studies on the vehicle's turning radius and swept path.

1. Background

The price of crude oil has been on the upward trend and we are constantly reminded of the impending dark forecasts for the world economy. The sustained increase in crude oil prices over the years has had many people considering alternative sources of fuel. For a number of years now, one of the hot topics has been the use of renewable energy from natural resources such as sunlight, wind, rain, tides etc for power generation, heating and transport. The construction of renewable energy projects requires the transportation of over dimensional loads such as pressure vessels, modules, tanks, heavy construction equipment, generators. It is no surprise that there has been an increase in large-scale projects related in the energy sector mostly well suited to rural and remote areas. Because of the sheer size and magnitude of such projects, the equipment and machinery used are very large. Most of these components are fabricated and manufactured offsite and in certain cases utilize different forms of transportation for delivery. Figure 1 below provides a graphical representation of the renewable energy share of global final energy consumption in 2008 (1).

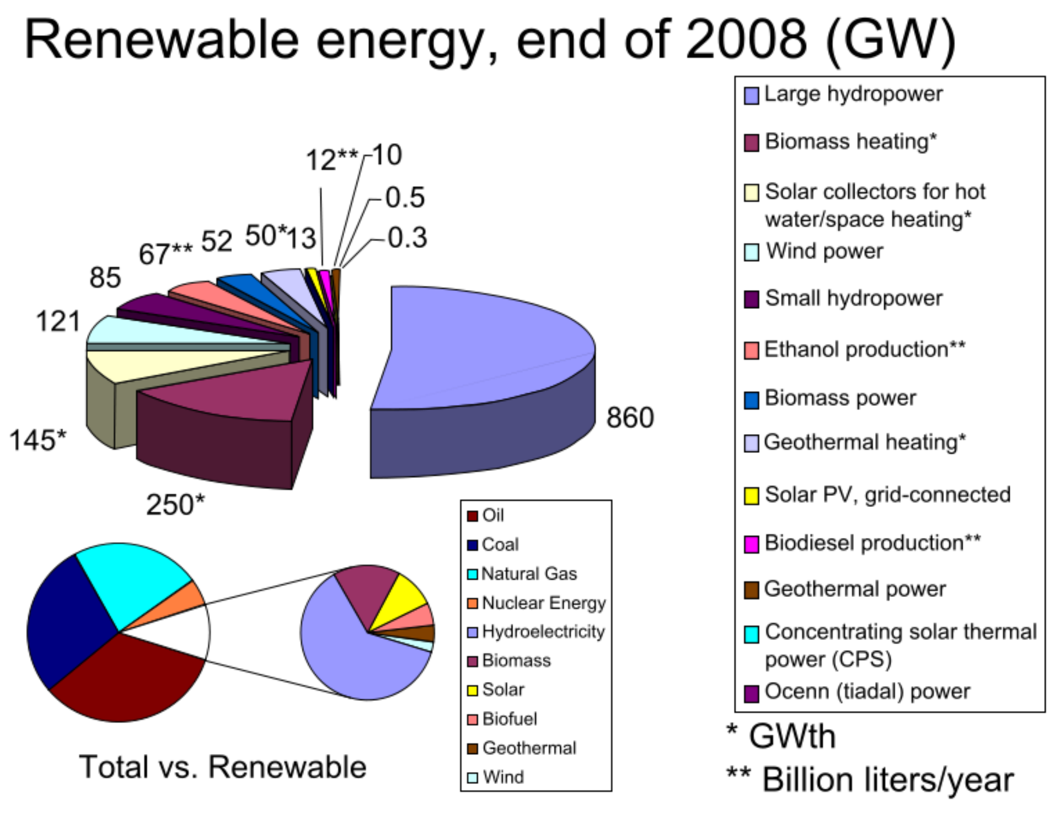

Figure 1: Renewable energy at the end of 2008

Figure 2 below show an image of a typical wind farm (2).

Figure 2: Wind Farm.

Figure 3 below shows an image of Grand Coulee Dam (3) on the Columbia River in the U.S. state of Washington built to produce hydroelectric power and provide irrigation.

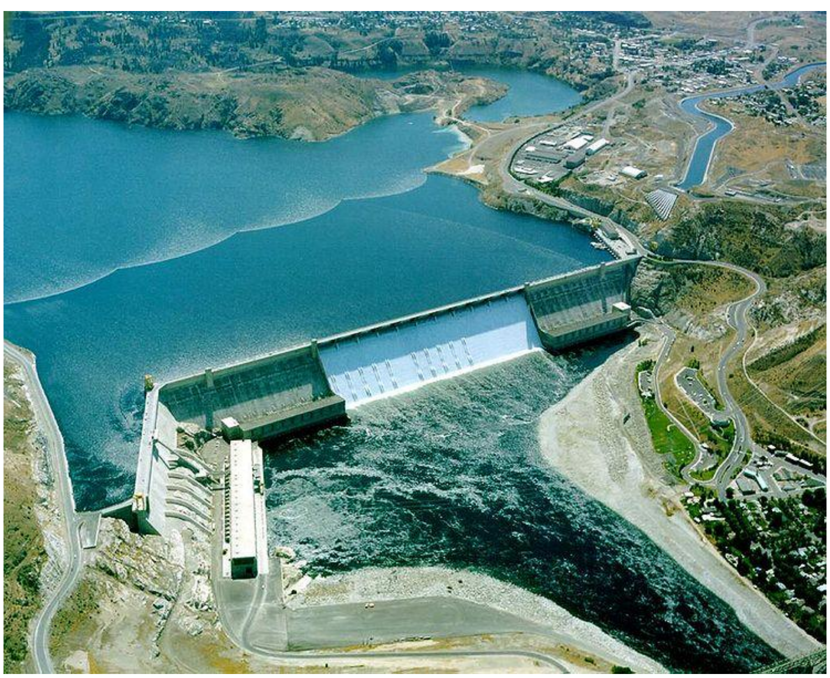

Figure 3: Grand Coulee Dam

2. Oversize/overweight Vehicles

The definition of oversize/overweight vehicles varies depending on region and jurisdiction. Generally, loads and vehicles are categorized based on height, width, length and weight (tonnes). For Ontario, for example, the Highway Traffic Act (HTA) and Regulations pertaining to Oversize/Overweight vehicles are available online.

Figure 4 shows a modular semi-trailer transporting a transformer platform.

Figure 4: Transformer platform

Shown below in Figure 5 is the 19-Axle High Tonnage Trailer which is capable of transporting loads in excess of 150 tonnes. The types of loads it can carry include mechanical presses (for automotive parts plants), gas turbines, tanks and wind turbine nacelle units. In terms of driving mechanics, it has the highway (rear movement is mechanically restrained but still allows for enough freedom for lane changing) and rear-steering modes (where a second operator mans the steering station at the rear, diesel generator is turned on to power steering hydraulics. Turning center is roughly at the longitudinal midpoint along the trailer assembly (typically at the midpoint of the load)

Figure 5: 19-Axle High Tonnage Trailer

Figures 6 and 7 below show the 30-Axle “Girder Frame” Trailer with capability of transporting payloads in the region of 370 tonnes. The dolly portions are comprised of SPMTs (self-propelled modular transporters). The units are typically a single axle set, but are assembled and slaved together to a master control which is used to steer.

Figure 6: 30-Axle “Girder Frame” Trailer

Figure 7: 30-Axle “Girder Frame” Trailer

Figure 8 shows a 9-Axle Schnable with Steerable Dolly with the ability to carry 70 tonne loads. These are primarily used to move wind turbine tower sections in North America and have the highway (rear movement is mechanically restrained but still allows for enough freedom for lane changing) and rear-steering (handheld remote used to steer rear, only the front 3 axles of the rear dolly do) modes of driving the steering.

Figure 8: 9-Axle Schnable with Steerable Dolly

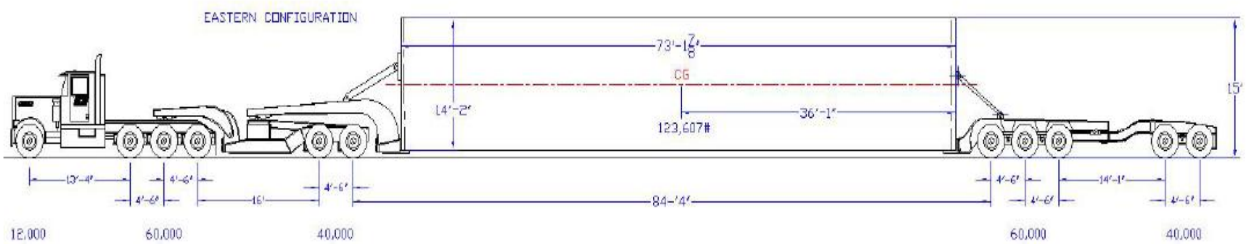

Figure 9: Typical dimensions of a Schnable trailer

Figure 10 shows a SPMT (Self-Propelled Modular Transporter) Assembly. In 2004, Sheuerle Transporters moved an oil and gas drilling platform with total weight of 14,350 tonnes (5). These kinds of oversize/overweight vehicles carry plant and refinery assemblies and components, boats and ship modules including handling heavy loads in port logistics. The module units are typically a single axle set, but can be assembled into traditional trailer configurations or more exotic bed/platform layouts. The units are then slaved together to a master control which is used to steer. They can be powered by either push/pull tractors or by modular power units, or both.

Figure 10: SPMT (Self-Propelled Modular Transporter)

3. Alberta High Load Corridor

The use of oversize/overweight vehicles for the transportation of components and equipment for alternative energy projects is on the increase in North America. As the demand and popularity of such projects increases, the road infrastructure is expected to accommodate a wide range of complex vehicle configurations. In the wind energy sector for example, the sizes of wind turbine blades keep increasing in order to capture greater wind forces. The sheer size of these components has resulted into new challenges to the heavy haul industry and transportation professionals involved in route planning. Since the loads traverse many province and state boundaries, it is noted that some jurisdictions are more prepared than others. This is no different here in Canada.

There are examples of proactive measures taken in anticipation of the increased activity in the transportation of over-dimensional cargo. One of the few examples of a roadway network is the High Load Corridor in Alberta. The initial corridor construction was funded by the Alberta Transportation (6) and the intent is to recover the cost from the users of the corridor in the form of permit fees. This system of High Load corridors has been developed in response to requirements to move over-dimensional equipment and machinery, and preassembled components from manufacturing centers in central and southern Alberta to the Oil Sands plants in northern Alberta. The High Load corridor allows loads up to 9m high and widths up to 9m. Transport weights allowed in the corridor range from 122 tonnes in the summer to 177 tonnes in the winter. Weights as high as 380 tonnes may be conveyed providing size and spacing requirements of undercarriage wheel assemblies are met for critical bridge structures. A system of truck turnouts has been developed to facilitate the movement of very large slow-moving vehicles (9).

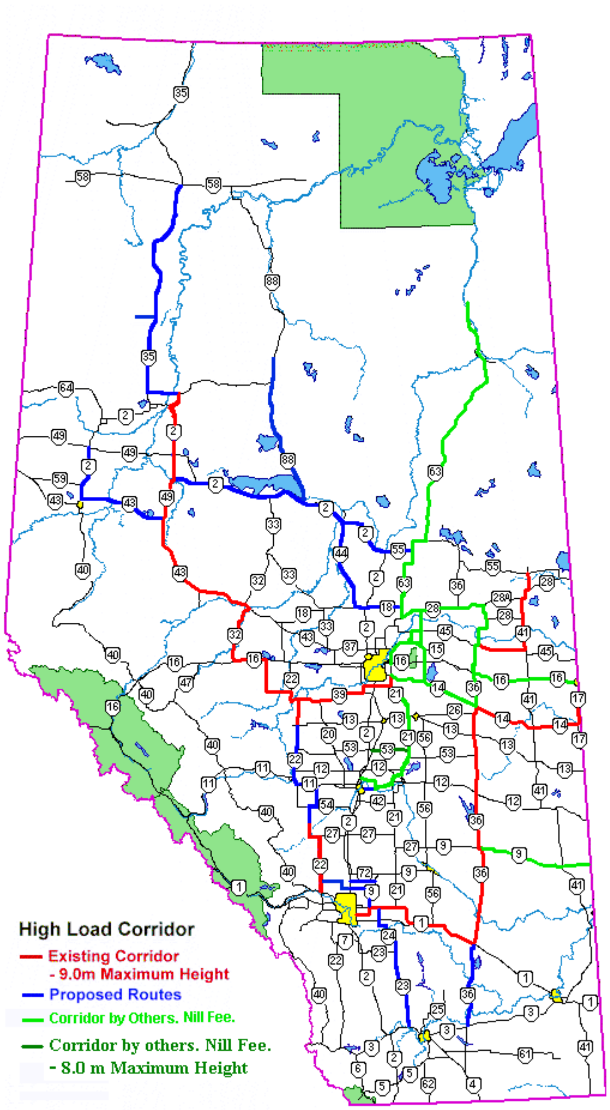

Figure 11: Alberta High Load Corridor (7)

4. Problem Definition

For the wind energy sector as an example, wind turbine component transportation planning is carried out in a reactive manner where adjustments to road furniture are made during the transportation of the heavy or abnormal load.

The importance of understanding the impact of the transportation of over-dimensional loads was highlighted recently in the Kearl Oil Sands Project. This project owned by ExxonMobil consists of an oil sands mine located in the Athabasca Oil Sands region at the Kearl Lake area. Developed in three phases, it is expected to begin production in late 2012.

In the course of the project, problems have arose where large modules stalled in the US because the highways cannot accommodate the oversize units. In April 29, 2011, it was reported by the Vancouver Sun (8) that the Kearl Oil Sands project remained on track despite legal challenges in the U.S. that threaten to hold up the delivery of more than 200 process modules from South Korea to the mine site near Fort McMurray.

The above case outlines the many challenges that such specialized projects face. This is compounded by the fact that very little information available and documented on the impact of such specialized vehicles to the road and existing infrastructure and as such, route planning becomes an extremely complex exercise. While vehicle and trailer manufacturers have responded by incorporating mechanical modifications to their trailers, transportation engineers have to do their part by understanding how these oversize vehicles and trailers manoeuvre and the impact of the pay load to existing infrastructure. The interaction of these complex vehicles with the road infrastructure has not been widely discussed either. For example, in the wind farm component transportation, Schnabel trailers are used to transport the tower section, blade trailers for the blades section and several different variations of trailers for the nacelle section.

Based on the problems outlined above, there is a need to develop a proactive approach which allows planners and designers to effectively design road infrastructure with the manoeuvrability of specialized vehicles in mind. In order to examine key safety and road geometry aspects (for interchanges and intersections) of the current wind turbine component transportation planning process (which includes initial route identification, identification of physical obstacles, headroom restrictions, horizontal and vertical curves on existing roads and infrastructure), it is important to consider the following:

a. Load specification

i. How are the loads and vehicles categorized?
ii. What does height, width, length and weight (tonnes) play in the categorization?
iii. How are permits applied for and issued and whose responsibility is it to ensure that all the relevant information is provided?
iv. Is the transportation of these loads or a particular type of load seasonal? It has been observed that the busy season is generally from April through October which is when construction increases and large equipment is needed more often.

b. Transport equipment required

i. Is there a good source of data detailing the height, length and weight restrictions?
ii. Size and weight limits may exist but will vary by bridge and roadway and season. In certain cases, higher weights can be moved when the ground is frozen.

c. Turning radius and swept path

i. Is there a good source of information pertaining to vehicle configuration or turning characteristics? This requires collaboration between the transporters, vehicle manufacturers, road designers and developers of vehicle swept path software such as AutoTURN (10).
ii. Are designated high load corridors available and what are they based on?
iii. How does the need to avoid downtown or congested areas affect the final route?

d. Road geometric constraints

i. Effect of road vertical alignment (e.g. k value at crests)?
ii. Are the bridge restrictions mostly permanent or and are lifted when the bridge has been improved or replaced?
iii. Are road restrictions derived from construction projects that temporarily restrict the horizontal width or height of a load until the project is over?
iv. Are areas that are undergoing construction known e.g. posted on websites which is available to customers in determining routing?

e. Logistics considerations

i. What are the proactive measures which can be taken to reduce vehicle/load/infrastructure conflicts?
ii. Can planners be encouraged when developing projects to paint medians in lieu of raised medians, using mountable curbs instead of right angle curbs, placing signage to minimize interfere with an oversize load, and using slimmer low profile foliage etc?
iii. Utilize a routing system which can quickly evaluate alternate routes which also allows real time changes.

5. Planning/Geometric Design Software

A variety of methods are being used to evaluate the movement of oversize/overweight vehicles depending. These include a variety of solutions;

a. Route planning software (sample)

i. In-house solutions
ii. Route Builder - Bentley System Inc.
iii. WVPASS/Superload - Bentley Systems Inc.
iv. MiPARS - Bentley Systems Inc.
v. TxPROS (Texas Permitting and Routing Optimization System) - ProMiles Software Development Corporation.
vi. AMPL and XPRESS-MP
vii. ARS Routing Software

b. CAD based software to evaluate routes.

The process of evaluating oversize/overweight vehicle routes in CAD is now a common occurrence and can be performed in a few steps outlined below.

i. capture the relevant portion of road or highway in Google Earth
ii. zoom to the intersection, roundabout or interchange of interest
iii. overlay the image in CAD software and scale image as necessary
iv. choose, configure, customize the appropriate specialized vehicle in swept path software
v. create specialized vehicle swept paths and observe conflicts with road infrastructure and make adjustments to the path if required
vi. take note of the vehicle operating limits and if these are exceeded

Figures 11, 12 and 13 capture a portion of the Alberta High Load Corridor along Highways 2, 35 and Pats Creek Road.

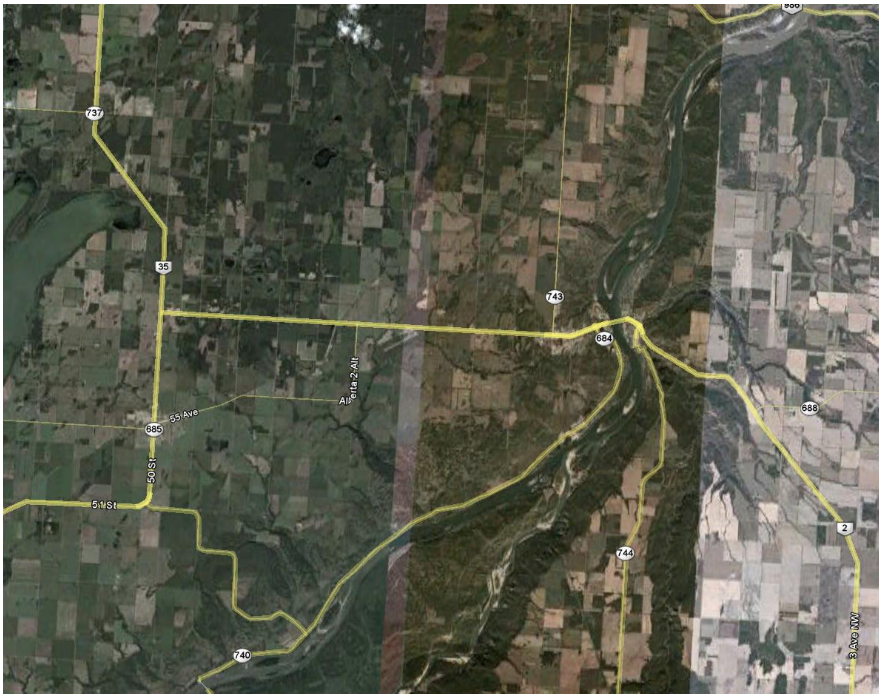

Figure 11: Google Earth Image highlighting Highways 2 and 35.

Figure 12: Google Earth Image highlighting Highway 2.

Figure 13: Google Earth Image highlighting Highway 2 and Pats Creek Road.

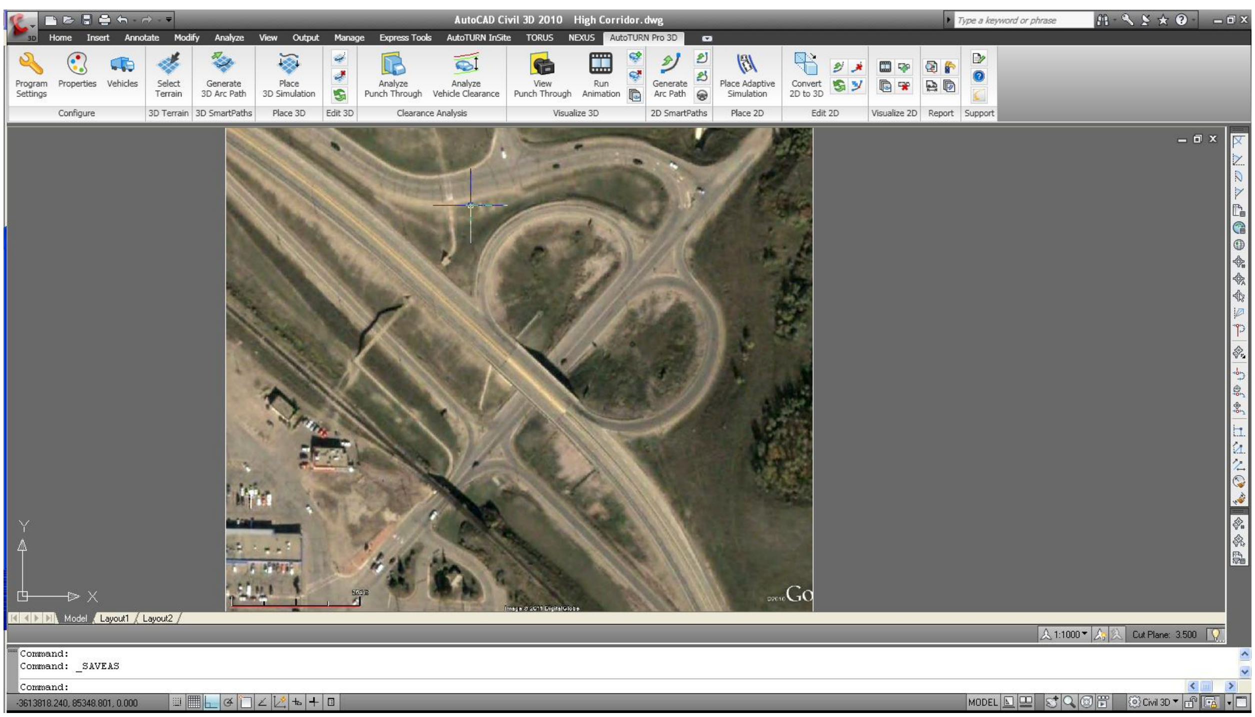

Figure 14: Image of Highways 2 and Pats Creek Road from Google Earth imported into AutoCAD Civil 3D 2010 and scaled.

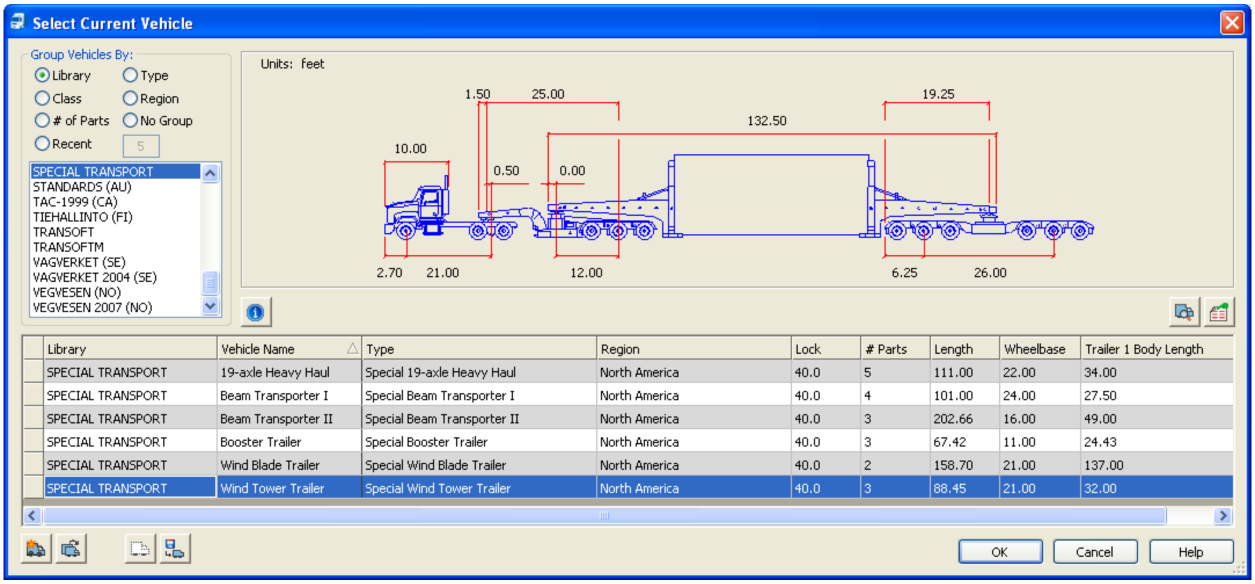

Figure 15: Sample of Wind Tower Trailer in AutoTURN 8.0 software by Transoft Solutions Inc.

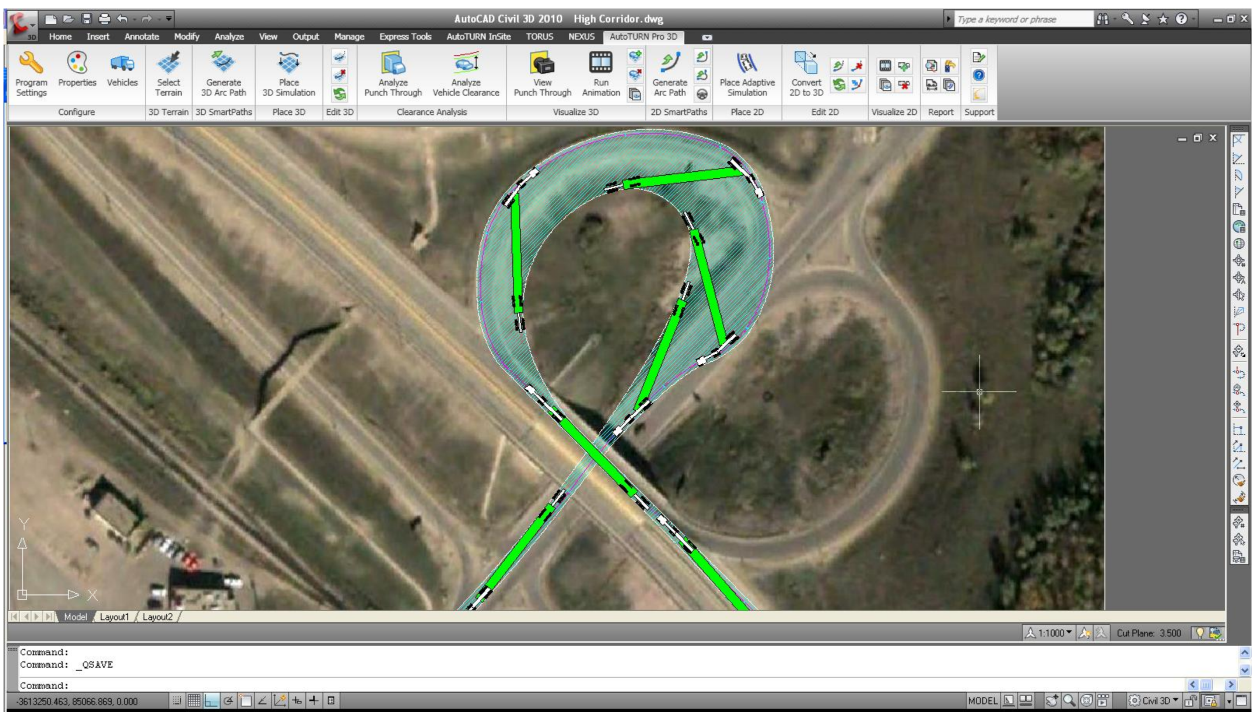

Figure 15: Image of Wind Tower Trailer swept path along Highway 2 and Pats Creek Road generated by AutoTURN 8.0 software.

6. Framework for Future Research

The following is a suggested framework for future research initiatives on oversize vehicles e.g. the gathering information on the typical oversize vehicle for wind turbine component transportation and studies on the vehicle's turning capability.

i. Collection of historical data on how certain types of vehicles negotiated a particular route.
ii. Gather information on relocated road furniture in historical routing exercises
iii. Identify the most commonly used vehicle configuration per province
iv. Determine the effect of these vehicles on current roadways; how well do current roadways accommodate these vehicles?
v. Compare historical vehicle paths with those modelled using software. Note where the major differences are and recalibrate the software if necessary.
vi. Determine the turning radius and swept path of specialized vehicles to be used to move overdimensional loads.
vii. Compare the controlling radius and swept paths with the road geometry for the routes to be evaluated.

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