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The objective of this technical note is to help road owners and managers assess the suitability of heavy vehicle configurations for resource roads. Basic information is presented about the relationship between truck weights and dimensions and elements of road geometry. The information should be useful when evaluating new truck and trailer combinations for a road system, planning the use of specialized equipment transport vehicles, or considering road upgrades. The intent is to encourage managers to ask the right questions and, perhaps in some cases, draw attention to the need for specific analyses to ensure road safety.

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Understanding the relationship between heavy vehicle weights and dimensions, and resource road safety

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Introduction

Canada's resource roads are experiencing a wider variety of heavy vehicle configurations and an increase in the volume and type of road users. These roads also have many different standards and agency jurisdictions within each province. To ensure the safety of all road users, weights and dimensions for heavy vehicles must be appropriate for a road's geometry and structural capacity. At the same time, trucking productivity needs to be maximized to maintain the economic benefits that flow from resource industries.

On public highways, legal limits for heavy vehicle weights and dimensions are governed by provincial highways regulators. However, on resource roads, limits on weights and dimensions for heavy vehicles are not well understood. Typically, resource roads are unpaved. Their design, construction standards, and state of maintenance will vary depending on the needs of industrial users. Furthermore, other demands on resource roads include steadily increasing volumes of public (non-industrial) traffic. Due to the variability in road geometry and heavy vehicles, it is not practical to provide provincial limits for vehicle weights and dimensions that would apply to all resource roads. Rather resource road managers and users must understand the considerations in assessing road networks to determine if a proposed heavy vehicle configuration can be implemented safely.

When assessing the suitability of heavy vehicles for resource roads, managers, users, and regulators must judge how the vehicle will interact with the road's structures and geometry. They must also consider vehicle performance under changing road conditions. In this decision-making process, the proposed weight and dimensions of a vehicle need to be evaluated relative to different elements of road structures and geometry. Road structures include bridges and culverts. Examples of road geometry elements include horizontal and vertical alignment, horizontal and vertical sight distances, running surface width, cut slope and fill slope arrangement, road crown and super-elevation, clearing widths, and pullout dimensions and spacing.

To meet its objective, this technical note is structured around some basic attributes of heavy vehicles, that is, their weight, dimensions, gradeability, and braking capacity. For each basic attribute, some factors are listed that need to be considered. For example, selected factors might include particular elements of road geometry, the bearing capacity of road infrastructure, or mechanical aspects of a vehicle. Each factor is accompanied by a brief explanation or suggestion for achieving safe vehicle operation. The topics covered in this technical note are broad suggestions. There may be other site-specific factors that resource road managers must consider to ensure road safety on their operations.

The amount of payload influences the stability of truck & trailer combinations. A dynamic stability analysis may be necessary to determine if a truck is safe to drive under the intended road and loading conditions.

Vehicle weight

Manufacturer's specifications

The load on vehicle components should not exceed the manufacturer's gross axle weight ratings. In the event that a vehicle's rating plates are unreadable or missing, the minimum rating of the tires, wheels, or axle assemblies should be used.

Road infrastructure capacity

Culverts and bridges have specific design loads that should not be exceeded in everyday use. For example, Forest Service Roads in B.C. have a specified design vehicle load (e.g., BCL 625, BCFS L100). Vehicle axle and gross vehicle weights should not exceed the design loading or any local load limits (e.g., for down-rated structures). For further information, see the B.C. Ministry of Forests, Mines and Lands *Engineering Bulletin #1 – Clarification of GVW as Applicable to Bridge Load Rating* **(http://www.for.gov.bc.ca/hth/engineering/documents/Bulletins/Eng-Bulletin-No1-Clarification-of-GVW-Load-Rating-for-Bridge-Structures-Sept29-09.pdf).**

Roadbed structural capacity

Vehicle axle weights should be matched to the roadbed's structural capacity to prevent undue rutting of the surface course, base course, and subgrade layers, or the collapse of road shoulders and pullouts. The structural capacity of a resource road will be higher when well frozen but lower when thawing or when saturated by heavy rains and poor drainage conditions. On provincial highways, there are legislated limits for axle weights. Some provincial resource roads, such as Forest Service Roads, and public highways may have weight restrictions imposed during wet periods when the road bed may be saturated and during the spring thaw period.

Are your road's pullout dimensions adequate to meet the needs of longer truck configurations? An evaluation of pullout dimensions, location, and spacing can help improve safety for all road users.

Pay special attention around bridges to ensure that horizontal and vertical approach curves can accommodate long loads. An off-tracking analysis will determine if the road's horizontal alignment is suitable for the proposed vehicle configuration.

Some roads may need a traffic management plan prior to transporting large equipment. Pilot cars are usually required, and, in some cases, sections of road may need to be closed temporarily to accommodate long and/or wide loads. Communication with road users is a key part of any plan.

Vehicle length

Road geometry influences the load length that can be safely accommodated.

Road horizontal alignment

Long loads must clear roadside structures, for example, signs, bridge guard rails, and any other objects within the road's right-of-way. The minimum turning radius for a truck and trailer combination should allow the truck to negotiate the road's tightest horizontal curves and turn-around areas. For example, switchbacks are often bottlenecks that need to be evaluated to ensure that heavy vehicles can navigate the road system.

Road vertical alignment

To prevent damage to the road surface and the load, overhanging loads should not come into contact with the road surface or drag within sag vertical curves.

Oncoming traffic

Consideration must be made for safe passage of other traffic. Clear signage should be provided advising other users of long loads and to watch for sweepers. In some cases, pilot vehicles may be warranted to warn oncoming traffic of long loads.

Pay special attention to bridge widths when considering a new vehicle configuration. Vehicles must not touch delineator signs, guard rails, or any above-deck trussing. Evaluate off-tracking at curved bridge approaches to ensure that vehicles do not make contact at the ends of the structure.

Look carefully at road sections with long fill-slopes when planning to transport heavy equipment on lowbed trailers. Off-tracking onto a soft shoulder will have serious consequences if fill strength at the road edge is inadequate.

Vehicle width

Vehicle stability

From a vehicle stability perspective, it is more desirable to have a wider load than a higher one.

Running surface width

Narrow, single-lane roads must be able to accommodate the vehicle itself, and have sufficient widening on curves to enable trailer off-tracking.

Road pullouts

Oncoming traffic must be able to pass a wide vehicle either through sufficient lane width or at pullouts with suitable dimensions and spacing.

Fill strength at the road shoulder

Ensure that road shoulders and pullouts are strong enough to support wide vehicles. Road shoulders must be firm especially where running surface widths are narrow, in pullouts, and where the trucks will off-track onto the shoulder above a fill-slope. Long fill slopes in steep terrain may have a high global instability hazard and the consequences of failure can be severe.

Occasional movement of heavy equipment requires special consideration. For example, ensure that the height of a crane's gantry when positioned on a lowbed will not surpass the specified minimum clearance for a power line as stipulated by the power utility.

Vehicle height

Vehicle stability

As the load height on payload-carrying trucks increases, the vehicle's center-of-gravity shifts upward, decreasing vehicle stability and increasing the likelihood of rollovers. The density of goods hauled also influences the center of gravity, for example, dry beetle-killed timber compared to wet timber, and large rock compared to crushed aggregate. Proposed load heights should be analyzed to ensure vehicle stability. Resource roads have variable super-elevation and crowning characteristics that need to be considered in an analysis.

Utility lines and other overhead hazards

There must be sufficient clearance between the load and overhead obstructions, such as trees, utility lines, and overpasses, to avoid contact or encroachment on a specified minimum safe zone. Utility lines, such as power lines, require additional specified clearances depending on line function.

Vehicle ground clearance

Road vertical alignment

Some vehicles typically used to transport products on public highways have low ground clearance but occasionally make their way onto unpaved resource roads. For example, chip vans, belly dump trucks, and trucks with double drop-deck trailers may have difficulty with tight vertical curves when travelling on resource roads. If the vehicles also have long trailer axle spacing, tight horizontal curves combined with tight vertical curves will be difficult to traverse. Vehicles require sufficient vehicle ground clearance so that the chassis does not come into contact with the road surface when traversing crest and sag vertical curves. Also, there should be adequate clearance between the boxes on multiple trailer configurations so that the boxes do not come into contact when the vehicle negotiates a tight sag vertical curve.

When determining hauling limits for steep grades, you must estimate the traction level at the road-truck interface. FPInnovations' steep-grade risk-assessment calculator for highway legal configurations provides two methods of estimating traction coefficients.

Some operations have road conditions that warrant an assessment of a heavy vehicle's capacity to descend steep grades safely. FPInnovations developed two tools to help carry out risk assessments for log trucks descending steep grades. The tools, for off-highway and highway legal log trucks, can be accessed at: [Steep Grade Descent Guidelines for Log Trucks]

Vehicle gradeability and braking capacity

Road grade

Grade designs are generally based on vehicle ascent capabilities, but consideration should also be given to descents (i.e., braking capability). Grades are defined as either favourable or adverse. Generally, favourable grades are ascended by empty vehicles, while adverse grades are ascended by loaded vehicles. A vehicle's ascent capability (or gradeability) is primarily determined by the proportion of load carried by the drive axles relative to the overall mass of the vehicle. Gradeability is reduced on switchbacks due to the increased turning resistance, so care must be taken to minimize switchback grade, particularly on adverse grades.

Road surface condition

The construction material, level of compaction, temperature, moisture content, tire properties, and the presence of ice or snow all influence a vehicle's gradeability and braking capacity. These parameters determine the traction coefficient (or friction level) between the tires and road surface. Under low traction conditions (such as ice or wet clay conditions), the tractive forces on the drive tires may be insufficient to propel the vehicle up the grade. Similarly when a vehicle is descending a grade under low traction conditions, the braking forces at the tire-road interface may be insufficient to control a vehicle thereby resulting in an unsafe situation (i.e., runaway).

Vehicle brakes

In addition to traction, safe descent of grades depends on payload, vehicle load distribution, number of drive axles, proper use of engine retarder, brake capacity, brake adjustment and the type of brakes. Most heavy vehicle configurations are equipped with drum brakes which are susceptible to fade at elevated brake temperatures. Maximum brake capacity is achieved when brakes are adjusted according to manufacturer's specifications. Braking capacity diminishes when brakes are out of adjustment.

Notes on application to British Columbia

Workplaces under the inspection jurisdiction of WorkSafeBC must conform to the Occupational Health and Safety (OHS) Regulation. Operators in the resource sectors should review Part 26, titled *Forestry Operations and Similar Activities* and, in particular, the sections pertaining to *Hauling* and *Roads and Road Maintenance*, located at: http://www2.worksafebc.com/publications/OHSRegulation/Part26.asp#SectionNumber:26.65

For vehicles operating on B.C. provincial highways, weights and dimensions are governed by the Commercial Transport Regulations. These regulations can be accessed through the B.C. Ministry of Transportation and Infrastructure website located at: http://www.th.gov.bc.ca/cvse/acts-regulations.htm.

The exceptions for highway-configured vehicle compliance with CVSE regulations will be where vehicles do not travel onto public highways or where there is reloading and/or reconfiguring of loads prior to travel onto public highways.

Disclaimer: The material contained in this technical note is for information purposes only and does not supersede Provincial and Federal Acts and Regulations related to roads, vehicle specifications, vehicle operation, and worker safety.

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