THE IMPORTANCE OF COMMERCIAL VEHICLE WEIGHT ENFORCEMENT IN SAFETY AND ROAD ASSET MANAGEMENT

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Published in:

Traffic Technology International 2000,
Annual Review pp. 234-237
January, 2000
Introduction

Commercial vehicle weights and dimension laws are enforced by highway agencies to ensure that excessive damage (and hence reduced life) is not imposed on the highway infrastructure. Illegally overweight trucks rob the [highway] system of its life without reimbursing the public and compete unfairly with other trucking firms (1). These same overweight trucks pose a safety hazard to the travelling public who share the road and create a substantial economic burden to taxpayers.

The purpose of this paper is to demonstrate the need for, and cost effectiveness of, enforcement of commercial vehicle weights and dimensions laws. Additionally, this paper will show that effective weight enforcement, in conjunction with a comprehensive data collection program form the foundation for a scientific based road asset management framework, which is vital to make effective road asset management decisions.

Background

Traditionally, traffic data collection and weight information has been used for planning and weight enforcement purposes. For planning purposes, comprehensive highway traffic and weigh data is essential to develop reliable forecasts of road user demands and provide an optimal level of service across the road infrastructure. For enforcement purposes, weigh-in-motion has been used to monitor the commercial traffic stream and violators of weights and dimensions laws. With recent advancements in applied mechanistic-empirical road design and preservation methods, highway agencies are now using weigh-in-motion information to reliably predict the load related life cycle damage of roads. These mechanistic based performance predictions combined with effective planning and weight enforcement strategies greatly enhance the ability for public road authorities to implement effective road asset management strategies.

Another important benefit to effective traffic data collection and weight enforcement is truck safety. Recent studies have shown a correlation between overloading and safety non-compliance. Justifiably, there currently is a high level of focus on truck safety. While commercial trucks are involved in a relatively small number of accidents (based on total miles traveled), accidents involving commercial trucks are often more serious in terms of fatalities, injuries and property damage.

Unfortunately, in the past, reliable traffic data and weight information has not been performed to the level of reliability and completeness to support a mechanistic-empirical road asset management framework. In addition, traffic data collection and weight enforcement has traditionally been performed by separate highway or law enforcement agencies with little regard for partnering and cooperation across agencies.

As budgets for manpower and equipment within public road management agencies are being reduced, there is a clear need for combined traffic data collection and enforcement
efforts in an overall road asset management framework as shown in Figure 1. By partnering efforts of traffic data collection and weight enforcement, significant reductions in weight enforcement and traffic data collection activities may not be reduced, in fact, the overall exposure and effectiveness may significantly increase.

![Figure 1 Road Asset Management Framework](image URL)

**Enforcement Effectiveness**

There are those that would argue, based on violation rates observed at isolated weigh stations on primary highway systems, that we do not need to enforce weights of heavy commercial trucks. However, evidence suggests that the low rates of overweight violations currently being observed on many primary highway systems are indicative of the impact of an effective weigh enforcement program. In addition, recent observations of accelerated damage on many secondary and country road systems may be indicative of the impact of low or non-existent weight enforcement has on the performance of the road network.

As a result, it is generally agreed that the overloading violation rate is a function of enforcement visibility. We know that where enforcement is visible, and continuous, overweight violation rates are quite low (typically around 1% for continuously operated weigh stations on the U.S. Interstate System). Table 1 summarizes and Figure 2
illustrates the general functional form between enforcement visibility and overweight based on several studies performed by seven state enforcement agencies \((2,3,4,5,6)\).

<table>
<thead>
<tr>
<th>State</th>
<th>High Enforcement Level Violation Rate</th>
<th>Low Enforcement Level Violation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virginia (2*)</td>
<td>0.5 to 2.0 %</td>
<td>12 to 27 %</td>
</tr>
<tr>
<td>Maryland (2)</td>
<td>1.0 %</td>
<td>34 %</td>
</tr>
<tr>
<td>Arizona (2)</td>
<td>1.5 %</td>
<td>30 %</td>
</tr>
<tr>
<td>Wisconsin (3)</td>
<td>1.0 %</td>
<td>20 %</td>
</tr>
<tr>
<td>Idaho (4)</td>
<td>11.9 %</td>
<td>32 %</td>
</tr>
<tr>
<td>Florida (5)</td>
<td>1.4 %</td>
<td>13 %</td>
</tr>
<tr>
<td>Montana (6)</td>
<td>1.0 %</td>
<td>29 %</td>
</tr>
</tbody>
</table>

*Number represents number of weigh stations included in study.

**Table 1 Overweight Violation Rate across State Agency**

**Figure 1 Overweight Violation Rate versus Enforcement Level**

**Effect of Magnitude of Overloading**

When overloading is occurring, the number of trucks and the magnitude of the overloading is the key issue. As documented in the past, the relationship between vehicle weight and pavement damage follows an exponential geometric relationship closely resembling a fourth power. Recent research in the area of mechanistic-empirical pavement performance predictions indicates that the exponential factor used to predict damage may be considerably higher than a fourth power relationship, especially on
thinner pavement structures in adverse climatic conditions such as freeze thaw. As a result, a slight increase in truck loading may result in orders of magnitude more damage to the road structure.

To illustrate, work performed in Idaho (4) indicates that the magnitude of the overloading on evasion rates around weigh stations averaged 12% (i.e.: the average overload on a truck was 12% in excess of the legal allowable). According to the traditional fourth power rule, the increased pavement damage incurred is in the order of 57% than originally accounted for in the design projections. For the observed violation rate of 32% (i.e: 32% of the trucks being overloaded), the road damage on this route was approximately 20% higher than originally projected. This means that the road will reach the design limit in 80% of the originally estimated time.

**Weigh Station Avoidance**

It is accepted that a certain number of commercial vehicles will avoid weigh stations when they know they are overloaded, or are in fear of safety inspections. Generally, drivers respond to the probability of being inspected when making a decision to avoid a weigh station.

A study in Virginia (2) and another in Idaho (4) found that truck operators avoid weigh stations by using an alternative route around the weigh station. Up to 14% of the regular traffic was discovered to avoiding the weigh station when it was open. Also in these studies, it was found that operators would travel up to 160 miles to avoid a weigh station.

The Virginia study also documented the practice of weigh station running or plugging, where drivers purposely convoy large numbers of trucks in order to exceed the ramp capacity of the station. Overloaded and heavier vehicles travel at the rear of the convoys, with the intent of bypassing the facility when the ramps are filled, and the station is temporarily closed. Over 38% of the vehicles that were running by the station as a result of these convoys were shown to be overloaded.

**Safety Violations and Overloading**

The issue of commercial truck safety is the number one focus of virtually every commercial vehicle enforcement agency in North America. This is not without merit. In 1993, over 30% of all the trucks on the road had safety deficiencies such that the truck or driver could be placed out of service. In 1994 during Roadcheck '94, this level was at 25% (7). Since these studies, much additional effort has been placed on improving these rates of safety violations. The results have not been as effective as originally planned. This does not mean that the enforcement efforts are not effective. The volume of truck traffic is increasing at high rates. The trucking industry is suffering through times of low
gross profit margins. In a highly competitive market, smaller operators have trouble competing and cut back on important service in order to reduce costs. These same operators are the ones that may feel they have to overload in order to make payments.

With limited human resources, highway agencies have a difficult task of identifying vehicles with the most serious safety problems. Is there a relationship between overloading and operating a commercial vehicle with safety deficiencies? A Wisconsin (3) study found that as many as 70% of overloaded trucks also were in violation of motor carrier safety and driver regulations. This indicates that overloaded trucks are three times as likely to be in violation of safety regulations when compared with the estimated safety violation rate for general truck traffic.

The Cost of Overloading

A study undertaken in Texas showed that a typical truck on a Texas highway could travel approximately 12,500 miles before encountering a weigh station. This same study showed that a 20,000-pound overload over this distance would generate $3700 more profit for the truck operator as compared to operating legally (8). With the slim operating margin currently being seen by truck operators, it makes it in the truck operator’s best interest to overload. However, this gives unlawful operators an unfair advantage over operators that adhere to weights and dimensions regulations. Taxpayers and legally operating trucking companies pay for the additional damage to the road infrastructure.

How much does overloading cost in additional road damage? During the 1977-1978 congressional hearings on the impact of overloads on the Highway Trust Fund, it was reported that the Interstate system was deteriorating fifty percent faster than it could be replaced due to a number of factors, one of which were overloaded trucks. Strict weight enforcement was deemed essential to preserve the road infrastructure, and the Surface Transportation Assistance Act of 1978 allowed penalties to be imposed on states, which did not comply with weight enforcement programs (8). A federally funded study undertaken in the United States in 1990 indicated that overloaded truck axles costs between $160,000,000 and $670,000,000 per year in pavement damage (8).

Table 2 presents the results of an economic analysis performed in Washington State in 1992 (9). The table shows the economic benefit to the truck operator, compared to the additional pavement damage caused for various levels of overloading and distances hauled. It is important to note that in all cases, the damage to the pavement is far in excess of the economic benefit enjoyed by the operator. In fact, at higher load levels, and longer haul distances, there is a nearly a 350% difference.

In a model developed by researchers in Idaho, the benefit in prevented pavement damage can be estimated for a Port of Entry weigh station in a typical interstate application. This study indicated that a single weigh station, with an area of coverage of 160 miles would prevent approximately $46,000,000 in pavement damage over the life of the pavement.
Unfortunately, some of this damage is transferred to secondary roads surrounding the weigh station by evading trucks.

<table>
<thead>
<tr>
<th>Miles Traveled</th>
<th>Overload (1000's of pounds, and %age of 80,000 pounds)</th>
<th>3</th>
<th>5</th>
<th>10</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4%</td>
<td>6%</td>
<td>13%</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Operator Savings</td>
<td>$2.20</td>
<td>$3.60</td>
<td>$7.30</td>
<td>$21.80</td>
</tr>
<tr>
<td></td>
<td>Pavement Damage</td>
<td>$2.50</td>
<td>$4.40</td>
<td>$11.20</td>
<td>$74.40</td>
</tr>
<tr>
<td>100</td>
<td>Operator Savings</td>
<td>$7.30</td>
<td>$12.10</td>
<td>$24.20</td>
<td>$72.60</td>
</tr>
<tr>
<td></td>
<td>Pavement Damage</td>
<td>$8.30</td>
<td>$14.60</td>
<td>$37.20</td>
<td>$248.00</td>
</tr>
<tr>
<td>300</td>
<td>Operator Savings</td>
<td>$21.80</td>
<td>$36.30</td>
<td>$72.60</td>
<td>$217.80</td>
</tr>
<tr>
<td></td>
<td>Pavement Damage</td>
<td>$24.80</td>
<td>$43.90</td>
<td>$111.60</td>
<td>$744.10</td>
</tr>
</tbody>
</table>

| Ratio of Pavement Damage to Operator Savings | 1.14 | 1.21 | 1.54 | 3.42 |

Shifting the Problem

Public road assets may fall under the jurisdictions of federal, state-provincial, or local municipal-county levels of government. While federal and state weight enforcement programs on primary highways may be effective in preventing overloading on the primary road system, evidence suggests that some percentage of the overloading may shift from primary roads to secondary roads with less visible enforcement. This is a potential significant problem in that many secondary roads may not have been designed for large amounts of commercial vehicles, especially those that are overweight.

Because of this dynamic shift of heavily loaded trucks from the primary to the secondary road system, there may be a clear need to augment primary highway weight enforcement with increased levels of enforcement on the secondary road system at the local-municipal level. This again illustrates the benefits to be gained from cooperation not only across traffic monitoring functions such as weight enforcement and data collection, but also across multi-jurisdictional public road agencies.
A Tactical Network Approach
Successful Approaches

What type of weigh enforcement strategy is best to prevent overloading? It is generally agreed that a combination of fixed and mobile facilities provides the best overall weight enforcement program (10). As noted earlier, visible weight enforcement presence is a key factor to a successful weight enforcement program. Past observations show that a relatively low probability of being caught for overweight infractions significantly discourages overloading. The equipment that is required to accommodate these facilities is available, and has been proven in operation.

Fully automated weigh station facilities are common on high volume, high cost facilities such as Interstate segments. These facilities utilize Weigh In Motion (WIM) for prescreening, and static scales for enforcement and citations. The WIM for these systems can operate on the mainline, or within the area of the weigh station. The systems can incorporate electronic identification of the vehicles, for the automated verification of operating credentials. Along with this credential verification is the ability to evaluate safety history and risk by utilizing technology being designed for the Commercial Vehicle Information Systems and Network (CVISN) project.

Fully mobile crews can utilize portable wheel load weighing equipment and mobile communications systems to provide enforcement in remote areas and on secondary roads. These crews offer the ability to impose a certain amount of doubt in the truck operators mind as to the risk of being caught overloaded. Technology exists to streamline the task of weighing trucks on secondary roads. Portable WIM technology can offer quick roadside screening capabilities to quickly focus on the out of compliance drivers.

Semi-portable systems include the construction of lay-by sites, or roadside pullouts and the installation of some fixed equipment at a site to allow mobile teams the ability to effectively check credentials on a higher volume of vehicles. WIM systems can be used in a double duty role, collecting data on truck movements on these routes the majority of the time, while offering the ability to act as a screening tool for mobile crews.

The concept of a virtual weigh station is being explored by many States. Efforts in Indiana have shown the effectiveness of WIM technology in a dual role as data collection system and enforcement tool. Technologies available offer the ability to operate a weighing and credential verification facility remotely.

The above approaches should not be considered as alternatives for an effective enforcement program. The above approaches are complimentary, and a mixture and planned approach will offer a cost effective program. It is critical to study the unique
aspects of the region, and to design a system and method to best suit the circumstances. Issues that must be considered in this design include:

- Specific State statutes on commercial vehicle enforcement. This may include changes to statutes and could involve a review of fine structures and an education of judicial officials on the importance of the issues.

- Specific State operating requirements and taxation issues. In many States, there are several agencies involved in the enforcement of commercial vehicle law. In many cases, these agencies do not have consistent goals.

- Geographic concerns and the relationship existing between primary and secondary highways.

- Shipping patterns, and goods movement patterns that exist in the State. This may include issues concerning seasonal goods movements common in construction and agricultural based economies.

- Interagency cooperation within a highway agency to ensure that all approaches and equipment fulfills a greater plan. For instance, Police Agencies enforcing weights and dimensions laws should cooperate with the agency involved in collecting traffic data. The police agencies can utilize permanently installed equipment to enhance the enforcement process, and can use collected data to plan enforcement strategies. Highway design and planning groups should stay in constant touch with the data collection group in order to ensure that data collection meets planned rehabilitation.

**Conclusions**

The impact that commercial vehicle overloading has on pavement damage and safety are real and of a considerable magnitude. Taxpayers and conscientious truck operators pay directly for overweight violations of the law. Truck operators that operate overweight are also as likely to be safety deficient as well. As a result, an added benefit to screening commercial traffic with respect to overloading also provides the ability for agencies to screen for trucks with the highest probability of having safety concerns for both driver and truck.

Technology exists to better plan and execute a successful enforcement program. The technology is proven and is very cost effective.
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