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Technical Memorandum

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PROJECT TITLE:	Study Concerning Permit for Intermodal Shipping Container in Texas-Arkansas Border
SUBJECT:	Study in Response to House Bill 2319
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This Technical Memorandum was prepared in collaboration between the Texas Department of Transportation (TxDOT), the Texas Department of Motor Vehicles (TxDMV), the University of Texas at Austin (UT Austin) and the University of Texas at San Antonio (UTSA) in response to House Bill 2319 of the 85th Texas Legislative Session

House Bill 2319 (HB2319)

This study was conducted to evaluate the impact of permits issued under the provisions of House Bill 2319 of the 85th Texas Legislative Session and implemented under Texas Transportation Code, Chapter 623: Permits for Oversize or Overweight Vehicles. HB2319 relates to the movement of vehicles transporting an intermodal shipping container. In this bill, intermodal shipping container means an enclosed, standardized, reusable container that: (i) is used to pack, ship, move, or transport cargo; (ii) is designed to be carried on a semitrailer and loaded onto or unloaded from: a ship or vessel for international transportation or a rail system for international transportation; and (iii) when combined with vehicles transporting the container, has a gross weight or axle weight that exceeds the limits allowed by law to be transported over a state highway or county or municipal road.

This bill authorized the Texas Department of Motor Vehicles (TxDMV) to issue an annual permit for the international transportation of an intermodal shipping container moving by a truck-tractor and semitrailer combination that has six total axles and is equipped with a roll stability support safety system and truck blind spot systems only if:

- The gross weight of the combination does not exceed 93,000 pounds,
- The distance between the front axle of the truck-tractor and the last axle of the semitrailer, measured longitudinally, is approximately 647 inches,
- The truck-tractor is configured as follows:
    - One single axle that does not exceed 13,000 pounds,
    - One two-axle group that does not exceed 37,000 pounds, in which no axle in the group exceeds 18,500 pounds, and
    - The distance between the individual axles on the two-axle group of the truck-tractor, measured longitudinally, is not less than 51 inches and not more than 52 inches, and
- The semitrailer is configured as follows:
    - One three-axle group that does not exceed 49,195 pounds, in which no axle in the group exceeds 16,400 pounds, and
    - The distance between the individual axles in the three-axle group of the semitrailer, measured longitudinally, is 60 inches.

Vehicles operating under a permit issued under the provisions of this bill are restricted to routes that are: (i) located in a county with a population of more than 90,000, (ii) on highways in the state highway system, and (iii) not more than five miles from the border between the states of Texas and Arkansas (the border between Texas and Arkansas is depicted by the dotted gray line). Effectively, the permits issued under the provision of this bill have all been routed over a 2.5-mile section of US Highway 71/59 in Bowie County, from the Arkansas state border in the north to the eastbound entrance ramp for Interstate Highway 49 in the south (Figure 1). As can be observed in Figure 1, this route only includes one state-managed segment of highway. It should be noted that only seven of these permits have been issued to date since its inception: one in 2018 and six in 2022.

A permit issued under this bill does not authorize the operation of a vehicle on: (i) load-restricted roads or bridges, including a road or bridge for which a maximum weight and load limit has been established and posted by the Texas Department of Transportation (TxDOT) or (ii) routes for which the TxDOT has not authorized the operation of a vehicle combination as described above.

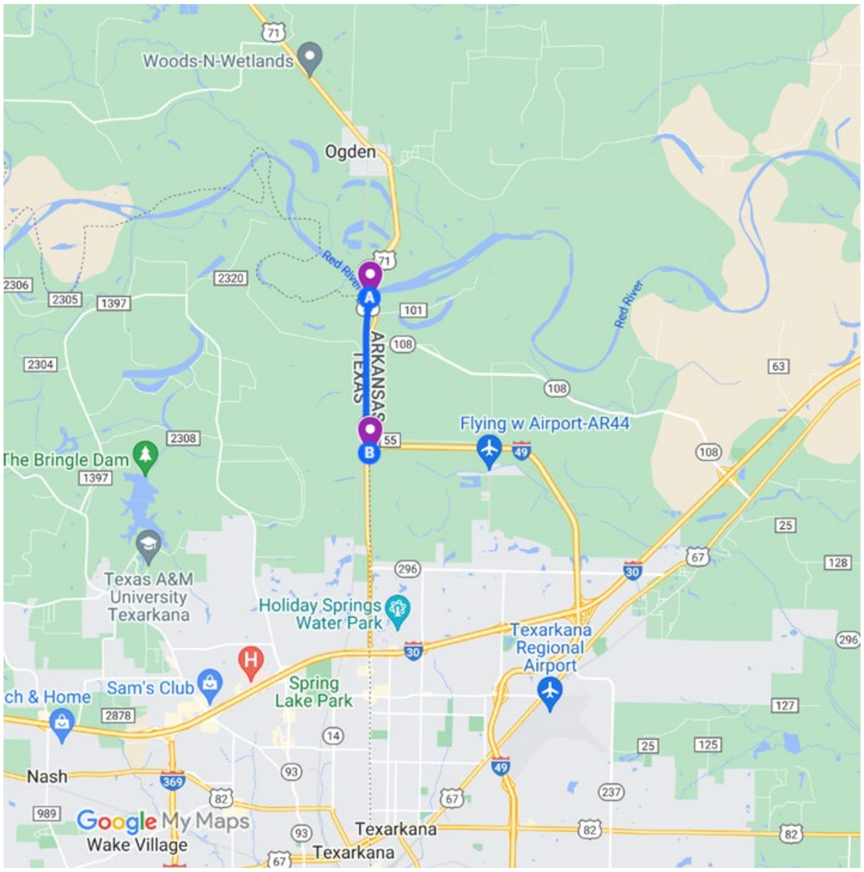

Figure 1: Route Allowed for Permits issued under the Provisions of HB2319

The TxDMV initially set the fee for a permit issued under this bill to $1,000. However, starting September 1, 2022 and every two years, TxDMV should reassess this fee and adjust it accordingly in an amount based on a reasonable estimate of the costs associated with the operation of vehicles issued a permit with these conditions over the designated routes, including any increase in the costs necessary to maintain or repair those highways. This estimate will be based on the results of the consumption study conducted by the Texas Department of Transportation (TxDOT).

Analysis Procedure for State Roads

The pavement consumption analysis was based on the methodology developed under the 2012 Rider 36 Study (Prozzi et al, 2012) and updated during the 2022 House Bill 2223 (HB2223) Study. Pavement consumption is expressed in relative terms to the consumption of the pavement by a standard axle, using the term Equivalent Consumption Factor (ECF). Traditionally, the standard axle is an 18,000-lbs single axle. A given pavement structure that reaches a pre-defined failure criterion under a given axle load and configuration is defined as having equivalent consumption (or equivalent performance) to a different loading condition when it results in the same level of distress in the same time period.

Three distress criteria, such as pavement surface rutting, fatigue cracking and ride quality (or roughness), were applied in calculating the ECFs. The ECFs were calculated as follows:

ECF = GEF x ALF

Where GEF is the "Group Equivalency Factor" for a given axle group, and ALF is the "Axle Load Factor" for a given axle load. The GEF is defined as the ratio between the life of a pavement under a single axle to the life of pavement under a group of axles (i.e., tandem or tridem). This factor considers only the number of axles and inter-axle spacing and expresses the number of single axles that would cause the same damage to the pavement as the axle group. By this definition, the GEF of a single axle is one. The ALF is defined as the ratio between the life of pavement under a single axle of 18,000 lbs. and the life of pavement under a single axle of a different load. By this definition, the ALF of a single axle of 18,000 lbs. is one.

The concept of ECF was first introduced during the Rider 36 Study in 2012 as an enhancement and update on the "Load Equivalency Factor" (LEF) developed in the early 1960s as a result of the American Association of State Highway Official (AASHO) Road Test. The fundamental principle behind equivalent consumption involves the assumption of equivalencies between different axle loads and configurations that result in the same level of pavement distress, pavement performance, or pavement consumption. In establishing such equivalencies, the standard 18,000 lbs. single axle was used as a frame of reference. This is referred to as an Equivalent Single Axle Load (ESAL). For this study, ECFs were determined for different axle configurations and loads over asphalt concrete pavements (ACP) such as those structures encountered on the route allowed for these permits (Figure 1), which corresponds to a segment of a state-managed highway.

As mentioned earlier, three failure criteria were evaluated: fatigue cracking, surface rutting and roughness or ride quality. Each pavement is designed to reach terminal distress values under given traffic and environmental conditions only by the end of its design period, which is typically 20 years. However, due to inherent differences in the failure mechanisms, it is impossible to reach all terminal distress levels simultaneously at the end of the design period. Thus, it is necessary to determine the traffic volume that would result in a terminal distress value for each of the failure criteria separately and then obtain a weighted average.

Once the traffic volumes are determined, the next step involves analyzing the representative pavement structure for a range of different axle loads and configurations and determining the traffic required to reach each failure criterion. Note that axles with an ECF of less than one will take longer than 20 years to reach the failure criteria; while axles associated with an ECF of more than one will take less than 20 years to reach the same failure condition.

It is also important to note that in this process, one would develop separate ECFs based on each distress criteria mentioned above. However, from a practical point of view, a given axle configuration and load should have a single ECF. Thus, it is important to establish both a weighing mechanism to be applied to the individual ECFs of each distress and a combined and unique ECF for the axle load and configuration.

The inherent variability of each ECF is another key concern. For example, an ECF calculated using the surface rutting criterion could result in a lower standard error (that is, lower uncertainty) as compared to an ECF obtained using the fatigue cracking or roughness criteria, which are predicted with the highest uncertainty. Thus, the authors of this study recommend that ECFs with lower variability receive a relatively higher weight in these instances. In analyzing the allowed route under this permit, the ECF was obtained as the average plus one standard deviation.

Impact on State Roads

Given the gross vehicle weight (GVW) limits and the axle configuration and loads, as described in HB2319, several load distributions are possible. From the point of view of pavement consumption, a sensitivity analysis was conducted and four different possible load distributions capture the extreme cases. These load distributions are presented in Table 1 with the respective associated Equivalent Consumption Factors (ECFs). A review of weigh-in-motion (WIM) data for highways and roads located in the study area identified a single WIM station nearby. The WIM station was located 20 miles from the specific study area on a different type of facility so the WIM data was considered not representative for this study.

Table 1: Equivalent Consumption Factors for the Six-Axle Vehicle

Axle loads in pounds			ECF
Single	Tandem	Tridem	
13,000	37,000	43,000	3.94
13,000	30,805	49,195	3.51
11,000	37,000	45,000	4.06
11,000	32,805	49,195	3.73

Table 1 indicates there is some variability in ECFs depending on how the total gross vehicle weight is distributed amongst the three axle groups of the vehicle. Each vehicle under this permit will have its own weight distribution associated with a particular EFC, which could range from 3.51 to 4.06. For this reason, and in order to obtain a representative value, the ECF corresponding to the 84th percentile (average plus one standard deviation) was used to assess the pavement-associated consumption cost. The resulting ECF was 4.05.

During the HB2223 Study, it was determined that, expressed in August 2022 dollars, a state-average unit consumption cost for flexible pavements was 4.6 cents per ESAL per mile. Thus, the average consumption cost for 93,000 lbs. six-axle vehicle as described in the bill is $0.19.

Analysis Procedure for On-System Bridge

As documented in detail in the HB2319 discussion paragraphs in the beginning of this document, the bridge analysis objective is to estimate the bridge consumption costs of the container chassis configurations specified by HB2319. The vehicle configuration used for the bridge analysis is summarized in Figure 2. This configuration is capped at 93,000 pounds of Gross Vehicle Weight

(GVW) and has further axle load limits and spacing specified in the Bill as described in the introduction of this document.

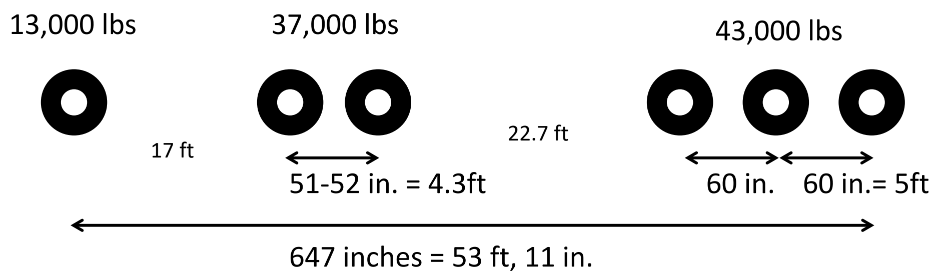

Figure 2: HB2319 Vehicle Configurations for the Bridge Consumption Analysis

The analysis approach calculates bridge consumption costs per mile, to support the requirements stated in the HB2319. The methodology treats each passage of the representative vehicle configuration (axle loads and spacings) as a fractional consumption of the bridge's design life. In its methodology, the University of Texas at San Antonio (UTSA) team consider costs due to consumption of the bridge life. The methodology is documented in several reports for similar bridge consumption cost determination projects (Prozzi et al, 2012).

In addition, HB2319 restricts this configuration to a 5-mile radius from the Texas/Arkansas state border. The Bill also states that TxDOT may restrict the permit to a specific route. TxDOT elected to restrict the route for the HB2319 permits to a short segment that only includes the southbound lanes of US59 from the Arkansas state border to the intersection with IH49 (Figure 1). This short segment of Texas road is approximately 2.5 miles long and involves only one bridge that constitutes the bridge approach spans to the bridge over the Red River – the state border. This bridge is an On-System bridge identified by its unique ID 190190021701007.

Impacts on On-System Bridge

As discussed in the previous paragraphs, the road and bridge infrastructure encompassed by this analysis is very reduced with the bridge consumption analysis limited to only one bridge. By applying the methodology developed as part of the Rider 36 Study (Prozzi et al, 2012), one passage of the vehicle configuration depicted in Figure 2 will amount to a bridge consumption of $3.78. Dividing this bridge consumption by the mileage of the segment, in this case 2.5 miles, one may calculate the bridge consumption cost per mile for this segment to be $1.51/mile driven. This value will be combined with the pavement consumption calculated in previous sections to arrive to a total road consumption per mile for this permit.

Crash Analysis

For the analysis period of this study (2018 to 2022 year-to-date), none of the vehicles operating under the permits subject of this bill were involved in crashes within the study area.

Infrastructure Consumption Analysis

From January 26, 2018 to the time of preparation of this report, only seven permits have been issued under the provisions of HB2319. However, no information was available at this time regarding the number of trips each of these permitted vehicles traveled on the designated route in one year. Personnel from the Texas Department of Transportation conducted a phone survey and obtained only one estimate of annual vehicle-miles-traveled (VMT), which was 500 miles.

Because of the limited response obtained, it was decided to conduct a sensitivity analysis to determine whether the permit fee is commensurable with the pavement and bridge consumption cost. The results of the sensitivity analysis are presented in Table 3 as a function of the number of trips. Table 3 shows that a $1,000 fee is sufficient to cover approximately 235 annual trips.

Table 3: Infrastructure Consumption Cost as a function of the Number of Trips

Number of Trips	Pavement Consumption	Bridge consumption	Total Consumption
10	$ 5	$ 38	$ 43
50	$ 24	$ 189	$ 214
100	$ 48	$ 378	$ 428
235	$ 117	$ 881	$ 1,000
365	$ 173	$ 1,380	$ 1,562
700	$ 333	$ 2,646	$ 2,996

Conclusions

In preparation of this report, a team of researchers from the University of Texas at Austin and the University of Texas at San Antonio gathered and evaluated relevant data provided by the Texas Department of Transportation and the Texas Department of Motor Vehicles as well as data contained in the Crash Records Information System (CRIS). To reach the conclusions of this study, the following data were analyzed:

- Gross vehicle weights, axle configurations and weights of vehicles operating under this permit that were involved in a motor vehicle crash,
- Types of vehicles operating under this permit,
- Annual traffic volumes and variations, and
- Weigh-in-motion data for highways and roads located in the study area

Using this information and a methodology developed under Rider 36 Study and recently updated during the HB2223 Study, the team of researchers, in collaboration with personnel from TxDOT and TxDMV, performed a series of analyses to determine and quantify the impacts to and consumption of the on-system bridge, and the impacts to and consumption of state roads. Although the study for HB 2223 included both on- and off-system bridges, only one of the on-system bridges was used in the analysis for this bill (HB2319).

Infrastructure consumption is linearly related to the number of trips on the designated route, which can vary from as little as one annual trip to as many as several trips per day depending on the origin and destination pair. The sensitivity analyses conducted in this study indicated that the current fee structure is adequate if the 93,000-lbs. six-axle vehicle performs up to 235 trips per year over the designated route. If the annual number of trips that these vehicles traveled fully loaded is in excess of 235, the current annual fee does not recover the roads and bridges consumption cost.

References

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