Characteristics of Double and Triple Trailer Truck Combinations Operating in the United States

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ABSTRACT

The enactment of the Surface Transportation Assistance Act of 1982 and the various provisions relating to double and triple trailer truck combinations, will have a significant effect on the transportation sector in general and the motor carrier industry in particular. It may be the beginning of a new era of more widespread use of multitrailer truck combinations. One provision outlines a study to be performed of the feasibility of a designated Interstate Truck Route Network that will allow the operation of multiple trailer units up to 110 ft in overall length. This increased emphasis on the longer truck combinations has provided a new incentive to explore various characteristics and important features of these trucks.

The data on doubles and triples from the Truck Inventory and Use Survey (TIUS) and the Truck Weight Study (TWS) conducted by FHWA in cooperation with various state highway departments were used as the basis for the analysis presented in this paper. The analysis is not a comprehensive treatment of the subject; much more work could be done to characterize the double and triple trailer combinations from these two files.

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sus. Its primary purpose is to "collect and publish data on the physical and operational characteristics of the nation's truck resources." Passage of the Surface Transportation Assistance Act of 1982 has made the understanding of the operational characteristics of doubles and triples more urgent because there is a stated requirement for a study to monitor the establishment of a Designated Interstate Truck Route Network. The TIUS is one of the most comprehensive data sources on truck inventory and use. Twenty-nine items of information are required from the truck owner for each truck. Information is required on the engine type, products carried, mileage traveled, range of gross vehicle weight, type of maintenance performed, area of operation, base of operation, and so forth; this information is valuable from the viewpoint of administration, funding, and planning. However, TIUS is only conducted every 5 years, and the information it contains projects an overall picture of inventory and use instead of dealing with a specific topic.

For this reason, out of the 96,494 records in the 1977 TIUS, only 286 records were for doubles or triples of these, 212 records were western doubles with a two-axle tractor (2-S1-2 in AASHTO code) and 70 were triples with a tandem axle tractor (3-S1-2 in AASHTO code). Only four records of turnpike doubles were found in the entire sample. Such a small collection of doubles and triples (0.2 percent of the entire sample) is due to the indiscriminate sample gathering policy of TIUS. Hence, the predominant truck type represented in the file is the small truck. The reliability of the sample would be much enhanced if the sample were larger; nevertheless, because this is the only TIUS sample available, the sample is used in the study of doubles and triples. TIUS does not identify an entire truck combination in one single information item; instead each truck is identified separately by its tractor or trailer. A two-stage process must be used to capture a double or triple from the file. The researcher must check the tractor and then the trailer type of each record and match that against standard configurations to determine if the record is a double or a triple.

In presenting many of the characteristics of doubles and triples in this paper, the expansion factor used by Sydec is also used to extrapolate the characteristics of the samples so that it is representative of the entire population.

**TWS: USE AND LIMITATIONS**

Since 1966 the TWS has been reported annually or biennially by FHWA, which obtains data on truck weights and commodity movements in each state. The data, gathered either manually or through automated weigh-in-motion systems in the field, are coded on cards or stored on magnetic tapes and sent directly to FHWA. The data sampling scheme is determined by each state highway department. FHWA, while encouraging accuracy and reliability in the data obtained, only provides a guideline for each state; therefore, the accuracy and reliability of the data varies widely.

This is one of the drawbacks of TWS. Although a large amount of data is available, the sampling technique in each state as well as the reliability of the sample is not known. A large number of specimens are available, yet it is difficult to calculate the reliability or probability of the sample. The TIUS is almost at the opposite end of the spectrum. TIUS has a structured sampling program, yet it does not have many samples. It is interesting to look at the characteristics of doubles and triples from both ends of the spectrum, judge the results, and determine what should be done in the future to improve the data base, as well as to enhance the sampling technique.

**SOME CHARACTERISTICS OF DOUBLES AND Triples AS OBSERVED FROM TIUS**

The previous section stated that there were 286 records of doubles and triples captured from the 1977 TIUS. The TIUS provides a large amount of data for each truck, and in this analysis these data were arranged in a variety of ways to provide insight to the characteristics of the larger truck units. The following are examples of analyses performed on the TIUS data:

1. Gross vehicle weight distribution,
2. Annual mileage distribution,
3. Weight-to-horsepower ratio,
4. Primary products carried, and
5. Operator class.

**Gross Vehicle Weight Distribution**

Gross vehicle weight (GVW) distribution is an important operating characteristic of the vehicle. Figure 1 illustrates that the majority of the GVWs for the western doubles fall within this range.

**FIGURE 1** Gross vehicle weight distribution for western doubles with two-axle tractor (1).
This suggests a higher performing capability for the doubles and triples or, to state it differently, these truck units should be able to travel most grades without difficulty. This assumes that the highway segment was designed to AASHTO standards.

**Primary Products Carried**

Table 2 (1) gives the primary products carried for doubles and triples as recorded in the TIUS files. It can be seen that 2-S1-2s were used mainly for carrying farm products, processed foods, building materials, and mixed cargoes; 3-S1-2s were used for products similar to those carried by 2-S1-2s, although less for farm products than for petroleum or petroleum products.

**TABLE 2 Primary Products Carried by Doubles and Triples (1)**

<table>
<thead>
<tr>
<th>Primary Products Carried</th>
<th>2-S1-2a (%)</th>
<th>3-S1-2b (%)</th>
<th>3-S1-2-2c (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm products (crops, fruit)</td>
<td>30.5</td>
<td>8.6</td>
<td>87.5</td>
</tr>
<tr>
<td>Live animals</td>
<td>1.7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mining products</td>
<td>0.7</td>
<td>2.0</td>
<td>6.3</td>
</tr>
<tr>
<td>Food and other forest products</td>
<td>0.7</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td>Processed foods</td>
<td>8.0</td>
<td>6.8</td>
<td>-</td>
</tr>
<tr>
<td>Textile mill products</td>
<td>0.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Building materials</td>
<td>20.6</td>
<td>19.6</td>
<td>6.3</td>
</tr>
<tr>
<td>Household goods (moving)</td>
<td>-</td>
<td>3.1</td>
<td>-</td>
</tr>
<tr>
<td>Furniture or hardware</td>
<td>0.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Paper products</td>
<td>1.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chemicals or related products</td>
<td>2.7</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td>Petroleum or petroleum products</td>
<td>1.0</td>
<td>14.6</td>
<td>-</td>
</tr>
<tr>
<td>Primary metal products</td>
<td>-</td>
<td>1.3</td>
<td>-</td>
</tr>
<tr>
<td>Fabricated metal products</td>
<td>1.4</td>
<td>3.1</td>
<td>-</td>
</tr>
<tr>
<td>Machinery (except electrical)</td>
<td>0.3</td>
<td>1.9</td>
<td>-</td>
</tr>
<tr>
<td>Transportation equipment</td>
<td>0.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Scrap, refuse, garbage</td>
<td>0.7</td>
<td>5.8</td>
<td>-</td>
</tr>
<tr>
<td>Mixed cargoes</td>
<td>28.4</td>
<td>31.0</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>0.9</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Western double with two-axle tractor.

**Operator Class**

Table 3 (1) shows the operator class distribution for each of the three vehicle types; 2-S1-2 and 3-S1-2 were mostly operated by private operators, Interstate Commerce Commission (ICC) common carriers, and intrastate carriers. The sample for triples is too small for statistical analysis.

**CHARACTERISTICS OF DOUBLES AND TRIPLES FROM TWS**

**Types of Doubles and Triples Represented**

Altogether 58,279 records of trucks were classified.
as doubles and triples in FHWA TWS files from 1966 through 1980. Of these records, 99.3 percent were doubles, and the remainder were triples. There were 67 types of doubles in the file and 12 types of triples. Figures 3 and 4 show the major types of doubles and triples found in the TWS from 1966 to 1980. The average GVW, average wheelbase, and the sample size for each major type are also given.

The figures illustrate that the doubles with the more widespread use are the 2-61-2 (83.2 percent) and 3-61-2 (8.6 percent), which corresponds with the observation from the TDU6. The turnpike double (3-52-4), which has received much attention, was represented by only 164 records, or 0.3 percent of the total records of doubles and triples. This suggests that although this vehicle type has strong economic potential, it is not widely used. Among the various triple trailer combinations, the most widely reported was the 2-51-2-2, which had 260 records out of the total 391 records of triples (66.5 percent); the three-axle tractor triple (3-61-2-2) ranks second with 83 records or 21.2 percent of all triples records. No records of the two-axle tractor triple were found in TWS. Perhaps this is due to the small sample size of triples provided by the TWS.

Weight of Doubles and Triples

Figure 5 shows the number of doubles weighed in each of the 48 contiguous states that conducted surveys in 1980 and their mean, minimum, and maximum weight.

FIGURE 3 Major types of doubles in the TWS file: 1966 to 1980.

FIGURE 4 Major types of triples in the TWS file: 1966 to 1980.
Also the 1980 national summary is provided, including the 85th percentile of the weight of doubles. Figures 6 and 7 show the sample size and the weight ranges of turnpike doubles and triples weighed in 1980, respectively. A similar set of figures was prepared for doubles and triples for each year from 1966 to 1980. A review of the data suggests that the western doubles show more widespread use where they are permitted by law. The use of turnpike doubles is restricted to the western states, the state of Michigan, and designated turnpikes in the eastern states. The use of triples was almost entirely restricted to a few western states, except in 1974, where two triple combinations were also weighed in Michigan.

Share of Doubles and Triples in Traffic

Figure 8 shows the mean percentages of truck combinations in the United States, 1966 to 1980.
nations in the truck traffic from 1966 to 1980. The illustration is based on the classification survey data reported by the states to FHWA. States that are blank are those that do not allow doubles or triples, that did not report any observations, or have insignificant data. It is interesting to note that combinations make up a large percentage of the truck traffic in many states around or close to the Great Lakes, such as Ohio, Wisconsin, Kentucky, Michigan, Indiana, Illinois, Iowa, and Minnesota. Figure 9 shows from a slightly different perspective the average percentage of trucks in total traffic from 1966 to 1980. Results show that 13 states (i.e., Kentucky, Indiana, Wisconsin, North Dakota, Montana, Wyoming, Colorado, Texas, Oklahoma, Arkansas, Arizona, Oregon, and Alaska) have, on the average from 1966 to 1980, between 30 and 36 percent of trucks in total traffic. Figure 10 summarizes the data in Figures 8 and 9, showing the spread of combinations in relation to traffic in the United States from 1966 to 1980.

Steering Axle Weight

In size and weight studies, the interesting point is the steering axle weight of the truck. This parameter is significant from a number of perspectives. One, it is useful in establishing the practical maximum gross vehicle weight (PMGVW) a vehicle can carry, which is an important parameter in shifting procedure. Steering axle weight is also important from a safety and highway loading viewpoint. For convenience, the 67 types of doubles in the truck weight survey from 1966 through 1980 were grouped into three categories according to the lengths of their wheelbases. Those with a wheelbase of 65 ft or less are referred to as small doubles, those with a wheelbase between 65 and 85 ft as medium doubles, and those with a wheelbase greater than 85 ft as large doubles. The data show that the average steering axle weight for small and medium doubles from 1970 through 1980 is about 9,000 lb and that large doubles fall somewhere between 9,000 and 10,000 lb. The average steering axle weight for triples has been about 9,500 lb. The distribution of average steering axle weight for small doubles is shown in Figure 11.

Gross Vehicle Weight

GVW distribution is important mainly from the points of view of highway loading, vehicle payload, and vehicle weight violation. Figures 12 and 13 show the GVW data for two-axle tractor, western doubles for the years 1967 and 1980, respectively. In Figure 12, the two peaks indicate that the empty weight is close to 30,000 lb, and the loaded weight is approximately 75,000 lb. Comparing Figure 12 with Figure 13, a rightward shift is noted in the national weight distribution; the left peak shifted to 35,000 lb while the right peak remains at 75,000 lb. A slightly greater percentage of overweight vehicles is also observed.

Figure 14 shows the GVW distribution of triples in 1980. A total number of 129 samples were collected in that year, indicating a significant increase in the reported use (or observations) of triples since 1970. The figure shows that many of
the triple combinations are operating at weights greater than 80,000 lb; the largest group observed weighed more than 100,000 lb.

**Weight Violations**

Examples of violations by doubles and triples in Texas are used in this discussion. Figure 15 shows violations of single-axle weight limits from 1970 through 1980 for the two-axle western double. The figure provides a comparison of the number of western doubles weighed in Texas that were not in violation of the single-axle weight with those over the legal limit. The results suggest an increase in recorded small doubles operating in excess of the legal limit.

**Empty Vehicle Trips**

Another important fact obtainable from the files of doubles is how often a particular vehicle type runs empty on the highway. Figure 16 shows that the aver-

The TWS represents the other end of the spectrum. It has a very large sample, is conducted either annually or biennially, is conducted by each state highway department with FHWA in cooperation with the state highway department and lacks a cohesive, well-planned sampling strategy. The sampling plans are often varied according to the budget of the state highway department.

The TIUS is answered by truck owners on their company premises, whereas TWS is conducted on the road. Although TWS is also aimed at obtaining knowledge of the nation's trucks, data is obtained from a different perspective and places more emphasis on the dimension and loading aspects of the vehicle. For data on vehicle loading and axle spacing, TWS is definitely a much better resource than TIUS. However, for other aspects of the truck resources, such as the commodity carried, operator classification, engine makeup of the vehicle, TIUS is the preferred source.

At present, researchers or students of the field can only take these facts into consideration and make the best use of these two data sources when studying doubles or triples. Although the statutory environment for doubles and triples may be quite different after the passage of the Surface Transportation Assistance Act of 1982, the data collected in the past can still be useful both in ascertaining the trend of development of doubles and triples in the past and in serving as a guide to the future. The shortcomings of the past data sets, discovered in the course of this study, will surely help to determine future data requirements.

Although the TWS and TIUS data may have met current needs, both data sets are inadequate in some aspects to understand the operations and performance of doubles and triples in the future. As noted previously, TIUS has been structured to examine the truck resources in the United States across the whole spectrum. It does not target any specific needs of doubles and triples, or other vehicle types. In the future it may be necessary to include a special section of the survey to deal with specific questions. If doubles and triples have sufficient economic potential to have widespread use in the future, and if the need to understand such vehicle types also increases, a special section in the survey to deal with specific issues is warranted.

As for TWS, if a better sampling structure can be incorporated into the program, the reliability and usefulness of the data will definitely be much enhanced. At present the nonuniform techniques used from state to state make it difficult to characterize trucks on a nationwide basis. However, if the sampling plan is better defined and implemented on a national basis, statistical techniques could be used to process data and to assist federal, state, and local governments in their policy decisions.

SUMMARY AND CONCLUSIONS

Figures 1-16 have shown some of the important or interesting aspects of the operation of doubles and triples in the United States from 1966 to 1980 based on the two most available data sources on trucks: TWS and TIUS represent two ends of a sampling spectrum. The TIUS is conducted by the Bureau of the Census, has a well-planned sample design, and is aimed at getting a broad picture of the entire range of the nation's truck resources.

The question of what types of commodities are carried by these trucks is also an important one. It must be noted, however, that because dynamic weighing methods are used, much commodity-related information is no longer available from TWS and commodity information from TWS must be used judiciously. Therefore, only data from states where manual weighing and driver interviews are still conducted may be relied on. For the sample as a whole, the TIUS commodity information is more accurate than TWS, because TIUS has a more uniform sampling procedure. This does not nullify the usefulness of TWS in providing commodity-related information; however, the data must be qualified, and the validity of the data should be accepted only from states where driver interviews are still included in the study.

REFERENCES


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