Motor Vehicle Sizes and Weights

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It is sometimes remarked that there would be no problem in the size and weight of motor vehicles if in highway transportation, as in railway transportation, the roadways were built and the rolling stock operated under the same management. As it is broadly understood this remark affirms one truth, while in its literal sense it denies another. The problem of the size and weight of vehicles does occur in practically identical form in both rail and highway transportation. The difference is that in railway transportation the single management responsible for both roadway and rolling stock has found a workable solution; in highway transportation a hydra-headed division of responsibility has thus far debarred reasonable solution.

I have deliberately used a term that suggests a multifarious complicity in the muddle that surrounds our subject, because it more correctly describes the cause of the difficulty involved than does the usual ascription to control divided two ways between road builders and vehicle operators. For, while it is true that, to this as to most other questions, there are two principal sides--the sides of the public provider and the private user of the highways--there are differences almost as wide on each side as the differences between the two sides.

Forty-eight States and a Federal District contain the highways, but in each there is a legislature, a highway department, a motor vehicle administration, a police department, and numerous counties and municipalities--all with a hand and a voice determining in some degree how the highways are built and what rules are prescribed or applied for their use.

Among the users there are truckers, themselves a class divided, there are bus operators, farmers, industrialists, business men, and a large group of passenger automobile owners, each with a particular and variant view of the kind of roads that should be provided and how they should be used.

Out of the promiscuous intercourse of these varied agencies and groups, their purposes and desires changing both with time and place, we have a highway system that answers to no clear rule of intended usage. This highway system is used by a traffic that should, but does not, conform to a variety of unenforced controls, many of which have been devised with no sufficient regard for the character and condition, the capacities and weaknesses of the highway system.

In the widespread maladjustment of the highways and their traffic there are few conditions of faulty relationship in which the size and weight of vehicles are not in some degree involved. All traffic is composed of vehicles of various sizes and weights. The propriety of the road-traffic relationship is determined generally by the relation existing in respect to the largest and heaviest vehicles. A road that is wide enough for the widest vehicles is amply wide for

narrower vehicles. A bridge that will clear the highest vehicle will obstruct no vehicle of lesser height. A curve that can be rounded with convenience by the longest vehicle will present no difficulty to the operation of shorter vehicles. A pavement that will support the heaviest wheel or axle load will more certainly support lighter wheel and axle loads; and the bridge that will support the most demanding of vehicle loads will not fail under vehicles less demanding.

So far as the road relationship is concerned, therefore, the problem of motor vehicle size and weight is one of determining the appropriate dimensions and weights of the largest and heaviest vehicles to be operated. The problem has two aspects: One as it is viewed from the standpoint of the capacities and strengths of the existing highway plant; and another as it is viewed from the standpoint of the capacities and strengths that should be provided in highways newly constructed. Much of the discord that enters into consideration of the problem emanates from failure to recognize that it has these dual aspects.

Any discussion of the problem of motor vehicle size and weight should recognize this duality of the problem at the outset. In one of its aspects the problem is one of determining what largest and heaviest vehicles can reasonably be accommodated with efficiency and safety on the highway system as it is. In its other aspect it is a problem of determining what, perhaps, larger and heavier vehicles should be contemplated in the design of new highways and bridges in order that, eventually, as the new construction replaces the old in

sufficient extent, it may become possible with safety and efficiency to accommodate general operation of the larger and heavier vehicles.

From one viewpoint, the conditions controlling a reasonable solution of the problem are the strength and capacity of existing roads and bridges. From the other viewpoint the controlling condition should be the maximum limits of size and weight of vehicles within which highway transportation may be expected to achieve an optimum economy, costs of the road and vehicle both included. A solution reached from the latter viewpoint, envisaging the economy of highway transportation alone might require some revision if highway transportation is viewed as a part of the entire transportation system, embracing rail, water and air as well as highway facilities.

Amid a confusion of claims and counter-claims which ignore the differences between these two aspects of the problem, two efforts have been, and are being made to reach acceptable conclusions from the two points of view clearly distinguished.

One of these was the effort of the Highway Transport Committee of the American Association of State Highway Officials which resulted in 1946 in adoption by the Association of a Policy Concerning Maximum Dimensions, Weights and Speeds of Motor Vehicles to be Operated over the Highways of the United States. This effort approached the problem from the viewpoint of the strength and capacity of existing roads and bridges.

The other is the investigation now being pursued by the Committee on the Economics of Motor Vehicle Size and Weight of the Highway Research Board. This effort is attacking the problem from the viewpoint of possible eventual achievement of a highway transportation system of optimum economy.

The objective of both efforts has been, and is to define the maximum sizes and weights of vehicles that are consistent with the two controlling conditions. In respect to one--the effort of the American Association of State Highway Officials--it is possible to discuss conclusions reached, as enunciated in the published Policy. In respect to the other--the effort of the Highway Research Board--discussion must be limited to a consideration of purposes; conclusions must await the completion of an extended investigation, still in its earlier phases.

The Policy of the Association definitely recommends for uniform adoption in the laws of all States the following limits of motor vehicle size and weight:

Maximum width of vehicle	96 inches
Maximum height of vehicle	12 feet, 6 inches
Maximum length of vehicle -	
Single trucks	35 feet
Single busses (with 2 axles)	35 feet
Single busses (with not less than 3 axles)	40 feet
Truck-tractor and semitrailer combinations	50 feet
Other combinations (not more than 2 units)	60 feet
Maximum loads on vehicles	
Single axles	18,000 pounds
Groups of axles - - - tabulated loads varying with the distance between extreme axles of any group, measured to the nearest foot, ranging from 32,000 pounds for axles spaced 7 feet or less apart to 73,280 pounds for all axles within a distance of 57 feet.	

These limits were not decided without due consideration. There is a good reason for every one of them separately, and together they form a system of limits of calculated and appropriate relationship. Change of certain of the limits without corresponding change in others will adversely affect this relationship.

Three considerations, in the order named, were paramount in the determination of these limits:

1st. The prevailing strength and capacity of existing roads and bridges to support and accommodate traffic including vehicles of the indicated maximum sizes and weights in substantial frequency;

2nd. The provision of a scope within which vehicle design and operating practice may be adjusted to the necessities of efficient haulage; and,

3rd. The provision of a system of limits having a reasonable prospect of uniform adoption in the laws of all or a majority of the States.

Anticipating the possibility that future transport necessity and proved economy may justify the employment of vehicles larger and heavier than those provided for within the present limits, certain of these limits may in time be appropriately revised upward while others remain permanently fixed. The alteration would be accomplished in such manner as to permit the most practicable adjustment of the road system to the needs of the enlarged vehicles.

The limits that are intended to remain permanently fixed are the height limit of 12 feet, 6 inches, and the axle load limit of 18,000 pounds. From the viewpoint of the capacity of the existent

road system any upward change of these limits would have vastly disturbing effects. Large mileages of road surfaces and foundations would require stregthening if the axle-load limit were raised; many existing vertical clearances would require alteration, and the difficulty of providing clearance at many intersection grade separating structures yet to be built, particularly in cities, would be greatly increased if the height limit were raised. From the viewpoint of transportation need, these two limits can remain fixed with least restriction upon a rational enlargement of highway vehicles. Greater load may be carried in the presence of the fixed axle-load limit by multiplying axles. Payloads requiring vehicle height in excess of 12½ feet are, and will probably remain of such rarity as to be more appropriately accommodated as exceptional movements, routed in avoidance of limiting bridge clearances.

In contrast with these limits, which should be regarded as permanently fixed, the limits of width, length and group-axle loading should be viewed as subject to possible increase in response to demonstrated need.

The 96-inch limit of width is generally essential now in view of the large mileage of the highway system still surfaced with pavements less than 20 feet wide. As rapidly as possible the lane width of road surfaces should be increased; and, when this improvement has sufficiently advanced, the width limit should be increased to 102 inches. An advisory note attached to the Association's recommendation suggests this future change. And well substantiated needs of vehicle

design, particularly relating to the brake efficiency of trucks and the body convenience of busses, already point to the eventual necessity.

In the length and group-axle limits, and the essential relation existing between them and jointly with the fixed axle-load limit, there is the greatest potential of change consistent with future transport necessities.

The length limits, as recommended for the several classes of vehicles, have in one respect a reasonable consistency. Accepting, as a base, the 35-foot length of single trucks, this length determines certain measures of off-tracking of the rear from the front wheels on curves. These measures are approximated by the similar off-tracking of tractor-semitrailer combinations and full trailer combinations at the recommended lengths of 50 and 60 feet, respectively. This rule of consistency, influencing the decision in respect to the combination lengths in such way as to make equal demand with single trucks for pavement width on curves, will have less weight in the presence of the certainly wider pavements of the future. The road-width restriction removed, the greater off-tracking of longer trailer combinations will lose much of its force as a determinant of reasonable vehicle length. The limitations imposed by turning space available at city street intersections will be the last to yield to any demonstrated need of greater length.

Extension of the length limit must also take account of any greater difficulty that may be entailed thereby in the accomplishment of the passing maneuver. Increasing the length of vehicles tends to

increase the time required for other vehicles to pass them, and correspondingly to increase the length of the opposing traffic lane, on two-lane roads, occupied by the passing vehicle. It does not appear, however, that these consequences will be of much moment within the range of any probable extension of combination-vehicle length.

Under conditions where variation of length alone might be expected to affect the difficulty of passing subject vehicles, observations by the Public Roads Administration show, on the average, almost the same numbers of vehicles trailing, in the same time intervals, behind short as long vehicles, within the range of vehicle length available for observation. Results of observations of this sort on a section of level, 20-foot pavement of unrestricted sight distance, near Bakersfield, California are given in table 1. These observations indicate that within the range covered by the most liberal of present laws, vehicle length, per se, may have practically no effect upon the difficulty of passing.

Table 1.- Vehicle queues formed behind vehicles of various wheel-base length on a level section of 20-foot pavement of unrestricted sight distance, near Bakersfield, California

Subject vehicle wheel-base group	No. of subject vehicles	Average wheel base subject vehicle	Speed subject vehicle	Average number of vehicles trailing within				Average traffic volume
				5 seconds	10 seconds	15 seconds	20 seconds	
feet		feet	mi.p.h.					veh.p.h.
Over 50.0	22	53.1	37.8	1.0	1.4	1.9	2.3	478
40.0 - 49.9	57	45.9	37.5	.9	1.5	2.0	2.4	474
30.0 - 39.9	51	34.4	39.0	1.0	1.5	2.1	2.5	499
20.0 - 29.9	50	27.5	37.8	.8	1.2	1.7	2.1	485

Longer queues that presumably may be formed behind the longer vehicles on grades in the presence of short sight distance are probably attributable to the weight rather than the length of the vehicles, and with more reason to the associated inadequacies of vehicle power and road sight distance rather than to vehicle weight. Appropriate vehicle power as a concomitant of vehicle size and weight is a condition that perfected law and practice of the future must assure; and short sight distance is a serious fault of existing highways that must, and will be remedied whether vehicles be long or short, heavy or light.

The possible objections to moderate increase of length being of little force and doubtful validity, against them there are strong reasons arguing the necessity of increase of length as a condition precedent to substantial increase of gross vehicle weight. Here, it seems to me, the interests of road and bridge protection on the one hand and efficient vehicular operation on the other run in common, though there are probably both highway officials and vehicle operators who do not agree that this is true.

By every test of highway administrative experience, axle loading above 18,000 pounds is suspect as a cause of observed damage of the highway system as it now exists. To strengthen the entire highway system is a task requiring decades. Vehicle gross weight and pay load can be safely increased, however, without waiting for, or requiring highways to be made stronger, by adding axles loaded within the 18,000-pound limit. Adding axles requires space--vehicle length--

in which to add them. The same addition of length that conservatively distributes vehicle load to wheels in contact with the highway also distributes the load in reasonable relation to desirable conditions of vehicle design. And, finally, the same addition of length and axles that is necessary to distribute loads borne by the highway and the vehicle, is imperative in a definite measure for the protection of existing bridges; and in some measure is involved as an essential condition for the design of new bridges of any strength.

The group axle loads and corresponding axle spacings recommended by the American Association of State Highway Officials are predicated upon the safe working capacity of H-15 bridges. Bridges of this, the predominant existing design standard, will support with equal safety, heavier vehicles of appropriately increased length and axle spacing. They will support without failure, but with reduced margin of safety, heavier vehicles of the same lengths and axle spacings. But only by the adoption of a stronger standard of bridge design can the factor of bridge safety contemplated in the Association's recommendations be preserved in the presence of heavier group axle loads within the same axle spacings and limits of length. Bridge design practice is now trending in this direction, as indicated by the increasing adoption of H-20 and H-20 S-16 design loading for bridges on the Federal-aid and State highway systems.

Vehicle weighings, the country over, show from year to year a persistent, indeed an increasing tendency toward heavier gross vehicle weight in the vehicles weighed. Whether this tendency accords with a sound overall economy of highway transportation remains to be determined, and is the objective of the economic studies in progress. However the answer to this question may turn, it might be possible, without further investigation, to conclude that the least expansive of three possible solutions of the problem presented by the tendency toward heavier gross vehicle weight, all costs considered, would be to distribute these heavier total weights in accordance with the axle load and spacing limits recommended by the Association of Highway Officials but within greater limits of length. Next, in point of expense would be to follow the length as well as the axle load and spacing recommendations of the Association and provide for a general strengthening of bridges. The most expensive course would be to encourage or permit the heavier gross weights to be reflected in heavier axle loads, damaging to nearly all existing road surfaces and requiring greater strength in all surfaces of future construction.

Unfortunately, it is precisely this most expansive evolution that is permitted--no, not permitted only, rather encouraged--by many of the features of existing State regulatory laws and many of the changes inadvisedly made in these laws from time to time.

Any law that provides either no limit or a high limit of axle load in the presence of gross weight limits unrelated to vehicle length and axle loading and spacing, has this effect. A law limiting gross vehicle weight in magnitudes defined only by classes of vehicles, may have the same effect, even if it moderately limits axle loads.

Much of the tinkering that is done by legislatures from time to time, resulting in changes of one or more limits of the regulatory law without corresponding appropriate change of other limits may have a like effect.

To illustrate how the character of regulatory law may encourage a development of practice in vehicle loading that may be easily accommodated in highway provision in one instance and very burdensome in another, table 2 presents a comparison of the kind of operation that has developed in New Jersey and California, two States with quite different regulatory laws, as shown by the weighing of vehicles regularly conducted in each State.

Table 2.- Averages of axle loads and gross vehicle weights of loaded heavy vehicles weighed in New Jersey and California during 1947

	New Jersey	California
Average gross weight of all loaded vehicles, lbs.	45,513	54,075
Average number of axles per loaded vehicle	2.94	4.77
Average axle load of all loaded vehicles, lbs.	15,482	11,347

It is apparent that in California, where the law prescribes an axle load limit of 18,000 pounds, a maximum gross vehicle weight of 76,800 pounds and a maximum length of 60 feet, the average gross weight of vehicles in use is greater, as desired by vehicle operators, while the average number of axles is greater and average axle load less, as desired by road and bridge designers, than in New Jersey where the

law prescribes no limit of axle load, a maximum gross vehicle weight of 60,000 pounds, and a maximum length of 50 feet. The heaviest vehicles weighed in the two States were of almost equal gross weight, above 90,000 pounds. But, included among the axle loads in New Jersey were many above 30,000 and one above 40,000 pounds, whereas in California, law violating axle loads were mostly under 20 thousand and none over 30 thousand pounds. In New Jersey, axle loads over 20 thousand pounds were 8.6 percent of those weighed; in California the corresponding percentage was 0.3.

The California law closely approximates the recommendations of the American Association of State Highway Officials. The New Jersey law, undoubtedly the country's worst, is farthest in principle and in its specific provisions from the Association's proposals. A highly satisfactory vehicle operating practice is in actual effect in California. In New Jersey, vehicle operators insist that their business would be jeopardized by a change in the law that would require them to conform with what is the established California practice.

Pending the more exact evaluation of the fundamental economics of motor vehicle size and weight now in progress, the recommendations of the American Association of State Highway Officials constitute the best guide to an improved adjustment of State regulatory laws to the present requirements of vehicle operation and the necessities of a conservative highway policy. Laws made to conform to these recommendations

have a basic design consistent with principles inherent in the economy of highway transportation. As more precise economic study points the way, they may be altered, probably liberalized, in some of their specific provisions.

In this sense the Association's recommendations have been said to establish a floor level of vehicle regulation. Vehicle operators, as represented through their industry organizations, proclaim their acquiescence in the floor level, and immediately reach for a ceiling of unpredictable height.

The public response to operators' demands will be, I hope, that it is better first to establish a reasonably stable base at the floor and to erect a more towering structure of vehicle size and weight limitation only as sound plans are developed as a result of further study.

The further study in progress under the auspices of the Highway Research board fortunately enjoys the blessing of highway and automotive engineers, public highway authorities, vehicle manufacturers and both truck and bus operators.

In a first phase, completed last autumn, the direct operating costs of fuel and time were determined for vehicles of a range of gross weight from 20 to 140 thousand pounds. For seven vehicles of representative weights between these limits the direct costs of operation over the Pennsylvania Turnpike and an equal length of U.S. Routes 11 and 30 were measured. The test sections of the two roads comprise a wide range of road condition; the vehicles in the various runs were operated with axle loads of 14,000, 18,000 and 22,000 pounds. The seven sizes of vehicles were powered to produce as nearly as practicable the same gross weight-horsepower ratio for each.

The observations made have furnished important basic operating cost data for later combination with other data to be obtained in subsequent phases of the research aimed at:

1. The determination of other elements of operating cost related to gross weight.
2. The transportational necessities of industry and business for shipment of goods in payloads of various magnitudes.
3. The probable order of frequency of need for vehicles of different size classes and the order of mileage of road affected by the operation of each class.
4. An experimental and statistical determination of the character and cost of road provision for traffic involving representative frequencies of the various weight classes up to each class as a maximum.
5. And, finally, the combination of vehicle operating and road costs, determined in relation to each size of vehicle, in such manner as to determine the vehicle weight or size class corresponding to the lowest combined costs of vehicle and road per unit of gross weight and payload moved.

The highway experiments, constituting one of the phases, are likely to attract widespread attention as one of the most elaborate, largely conceived, and searchingly detailed of highway researches. They will

have to be all of this to develop the many facts of road-vehicle relationship that are needed for the desired answer. Some of these facts are as yet not even approximately determined, which accounts for the uncertainty and doubt of practical decisions affecting the size and weight of motor vehicles.

When these uncertainties and doubts have been removed by the projected research, and not before, there will be a guide to sound regulation of vehicle size and weight better than that which is now available in the recommendations of the American Association of State Highway Officials, and providing better than the Association's recommendations a guide to the determination of future road and bridge design standards.