Truck Platoons and Highway Bridges

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In my position as director of the Federal Highway Administration's Office of Bridges and Structures, I have repeatedly been asked by both internal and external stakeholders what potential impacts I foresee from truck platoons on highway bridges and tunnels. My immediate response is to ask in return: What is a truck platoon? This may seem to be a flippant and unsatisfying reply, but until a definition exists that describes what constitutes a truck platoon and how platoons will be allowed to operate, we cannot forecast their impact with any certainty.

As you may know, advances in technology have made it possible to electronically connect vehicles so that they can safely operate in unison with very little headway (distance between the front of the trailing vehicle and the back of the leading vehicle). In a manner similar to drafting vehicles on a car racetrack, platooned trucks could collectively achieve significant efficiencies, and those efficiencies could lead to a lower demand for fuel and corresponding drops in operating costs and adverse environmental effects. These are not the only potential benefits of truck platoons, but they are likely the ones most evident to the public.

Highway bridges are currently designed for a notional live-load model that envelops the force effects that current legal truck traffic creates on bridges. Once in operation, highway bridges are evaluated (load rated) for all individual legal and unrestricted truck configurations. Without a clear understanding of the possible loading models that platoons might create, engineers cannot determine whether design loads are adequate, nor can they conduct valid load ratings to determine the impact of truck platoons on the 615,000 existing bridges in the National Bridge Inventory. To meet those obligations, several questions need to be answered.

How Many Trucks Can Be in a Platoon?

In demonstrations in the United States and elsewhere, platoons have included two, three, or four trucks, but present and future technology will certainly accommodate more. The number of trucks in a platoon needs to be determined for two reasons. First, from a load-rating perspective, a truck or a platoon of trucks is modeled as a series of axle loads and spacings. Thus, the platoon will be treated as one long truck with individual and tandem axle weights and spacings.

Second, from a safety perspective, we need to determine how long a platoon can be before it begins to pose unacceptable risks to the traveling public. For example, if a platoon is passing a highway exit, how does that affect other vehicles' access to the exit? Also, what happens when a platoon is exiting? Can the exit ramp accommodate the length of the platoon, or does the platoon back up onto the bridge or cause other traffic to back up onto the bridge?

What Truck Configurations Can Be Platooned?

Although most demonstrations to date have focused on three- to five-axle semi-tractor-trailer combinations, will all legal configurations (including twins and triples in states where those combinations are legal) be permitted to platoon? Will platoons only be composed of similar configurations, or will mixed configurations be permitted? Once platooned, what is the minimum headway between trucks? What is the minimum spacing between platoons? What is the minimum spacing between a platoon and a nonplatooned truck? We need answers to these questions (and likely others) to understand the possibilities of axle spacings in a platoon, and for a platoon operating in traffic.

From a capacity (strength) perspective and considering only gravity loads, the operation of platoons may not significantly affect bridges

A three-truck platoon. All Photos and Figures: U.S. Department of Transportation.

with shorter spans that would not dimensionally accommodate more axles or longer bridges that primarily support their own weight (dead-load dominant). Of much more concern is the inventory of existing bridges with span ranges that will accommodate the additional axles of a platoon, and for which carrying trucks (live load) accounts for a significant percentage of their capacity. For these bridges, the design live-load model (last updated in 1993) may have resulted in a bridge with insufficient capacity to safely carry the load of an unrestricted platoon. Furthermore, their load capacity may have decreased due to structural deterioration over time, leading to the same outcome.

From a service-life and fatigue perspective, the stress range and number of load cycles caused by a platoon may accelerate deterioration of the bridge deck, expansion joints, and other localized details. These issues will potentially add to the backlog of maintenance and rehabilitation needs that bridge owners nationally face every year.

What Weight Limits Apply to Platooned Vehicles?

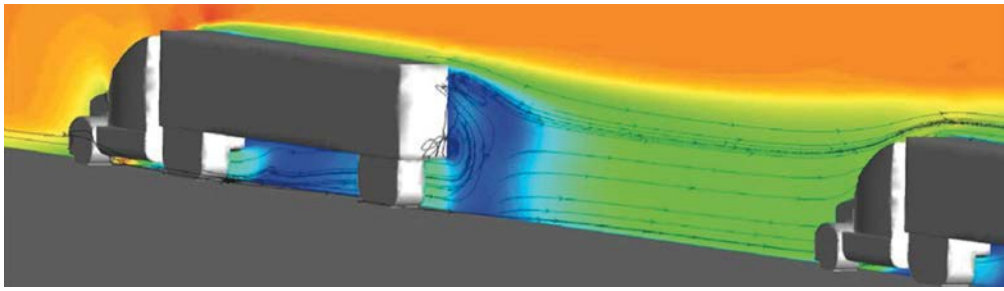
Several issues are involved in the discussion of weight limits. Will platooned trucks be constrained by the same single- and tandem-axle weight limits required by Formula B, or by lower limits? Under the Fixing America's Surface Transportation (FAST) Act, emergency vehicles weighing up to 86,000 lb on three axles are legal. Will they be allowed to platoon or operate with other legal vehicles in a platoon? Will unrestricted permit loads be allowed to platoon?

Clearly, we must determine the weight limits allowed for single axles and tandem axles on platooned trucks before we can fully define the load models to evaluate bridges and establish their safe live-load carrying capacities (load ratings). Without defined load models, bridge owners will not be able to fulfill their regulatory obligations under 23 U.S. Code Sec. 144 (implemented through 23 CFR 650), which requires calculation or reevaluation of bridge load ratings to ensure safety.

How To Restrict or Post a Bridge for a Platoon?

We will need to adjust our bridge posting practices to accommodate platoons. Typically, when bridges have less capacity than is needed to safely carry legal and unrestricted loads, posting signs indicate a gross vehicle weight (GVW) limit or GVW limit associated with a certain number of axles. In the future, some bridges may require an additional posting sign pertaining only to platoons to indicate a minimum headway between trucks.

Formula B, also known as the Bridge Formula, limits the weight-to-length ratio of a vehicle crossing a bridge. This is accomplished by spreading the weight over additional axles or by increasing the distance between axles. From https://ops.fhwa.dot.gov/Freight/resources/bookshelf/index.cfm.



Aerodynamic drag is reduced by platooning.

We also need to understand how nonlead trucks or trucks passing a platoon will interact with restrictions or load postings. Currently, truck weight and height restrictions are self-enforced. Because truck headway in a platoon will be small, it is likely that only the lead truck will have the advance notice needed to detour around a posted weight- or height-restricted bridge. Will the lead truck be responsible for communicating those restrictions to the other platooned vehicles, or will the lead truck simply take on the responsibility to enforce on the entire platoon the restrictions as they apply to the heaviest and tallest truck?

How Fast Will Platoons Travel?

A truck's speed is a primary contributing factor to the impact (dynamic load) it creates on a bridge, adding to the apparent vertical loads. If a structure is horizontally curved, centrifugal forces may be generated at higher than expected levels for a platoon. Therefore, it is important to consider whether platoons will operate at posted speeds or at something less than posted speeds.

How Will Platoon Braking and Collisions Affect Bridges?

Brakes alone do not slow or stop a truck. The bridge or pavement is in the load path. If braking in a platoon is coordinated, will the larger horizontal loads imparted cause an increased rate of failure of bridge bearings and expansion joints?

If the lead truck drives into a parapet or rail, will it lead the other trucks into the same rail? If so, rail design loads will need to change. Will that have a corresponding effect on the strength of the connection to the deck, or on the design of the deck itself?

How Else Will Platoons Affect Traffic?

One important issue related to traffic flow involves passing. Will a platoon be permitted to pass a nonplatooned truck? Will a platoon be able to pass another platoon?

Another issue is traffic density. The factors that are currently used to capture the load effects of the presence of multiple (side-by-side) trucks are based on truck-density data within existing traffic. Will platoon operations alter those statistics significantly? Also, will the operation of platoons in urban areas be restricted to select windows of time (such as 10 p.m. until 6 a.m.) to minimize their impact on rush hour traffic?

Finding Answers

As a community, we need to identify and capitalize on lessons learned from past practices and research. The American Association of State Highway Officials Road Test conducted in the 1950s and 1960s documented the accelerated deterioration in bridge decks and pavements that can occur with channelized traffic. Placing a wander requirement on platooned trucks so that wheels are not always in line along the length of the platoon will probably decrease the efficiency of platoon operations, but it will increase the service life of the transportation infrastructure. A balance between these two will need to be identified or negotiated.

This article has not offered an all-inclusive list of the issues and questions that need study before the effects of truck platooning on infrastructure can be projected. For example, another question is: How does the model for wind effects on live load change if the live load is now a wall of trucks with minimal headway to allow wind to pass through? I am sure there are others. The point I hope I have made is that platoons, like other advances, will be technologies that have the potential to change how freight is moved and how the infrastructure that supports that movement is affected. To accommodate this new technology, we need to research and consider the potential effects so as to best preserve the existing infrastructure and appropriately design and construct future structures.