Synergistic Integration of Rail and Highway Transportation

Long-haul freight truck traffic on the National Highway System, 311 million miles per day in 2015, has been projected to increase over 55% to 488 million miles per day by 2045.[1] Meanwhile, current infrastructure proposals provide little hope for expansion of US road network mileage. This suggests that US highways, with little mileage growth projected, will be expected, within 20-25 years, to carry as much as 50% more truck traffic and, most likely, similarly increased auto traffic.

Railroad shipping, while more efficient and less damaging environmentally than trucks, cannot overcome the inherent convenience of point-to-point truck shipping.[2] For years, competition between the railroad and trucking industries was a zero sum game. That game has changed somewhat with the growth of intermodal shipping. Moving more short haul truck shipments to rail-truck intermodal (and possibly increasing long range intermodal shipping as well) has the potential to relieve what might otherwise be a catastrophic increase of US highway congestion, and result in greater use of rail lines which lay dormant much of the time. For these reasons, growing truck-rail intermodal's share of shipping volume would seem to be a logical objective of both railroads and the trucking industry. Consistent with that objective, truck-rail intermodal shipping has grown tremendously over the past 20 years, at least for shipment distances over 500 miles. This has reduced some truck road mileage. But changes in railroading, particularly computerized scheduling and the competing time and cost involved in road-to-rail and rail-to-road transition of freight load, limit much more growth of the intermodal model.[3] [4]

Meanwhile driver limitations, both those based on regulations and on declining driver availability, plague the trucking industry and the future of electrically driven trucks is further clouded by the expected downtime required for recharging.[5] Railroads face problems as well. More efficient computerized train scheduling can do little to overcome the time limitations imposed by train assembly, disassembly and reassembly, particularly evident in the massive marshalling yards of major rail lines, not to mention the time constraints associated with conventional intermodal shipping.[6]

That trucks can transport freight directly from points of origin to points of destination, while most such points are not located along railroad lines, largely explains the success of truck shipping, particularly in the short-range haul market. This disproportionate dependence on trucks, that may increase with the advent of at least partially autonomously drivable trucks, comes with significant environmental and economic consequences. As compared to trains, trucks currently require far more fuel and emit far more pollutants per mile per ton of freight.[7] While these consequences may be somewhat ameliorated as electrically driven trucks become common, it is doubtful that trucks, traveling on traffic-congested roads with grades, curves, and roadway impediments, will ever match the efficiency of trains of multiple units propelled by a single locomotive, traveling with steel wheels on relatively level, relatively straight, relatively smooth steel rails. As rail usage becomes more and more highly digitally controlled, this efficiency will only increase.

Collectively these factors suggest that significantly increased truck-rail intermodal would be a win-win for both railroads and the trucking industry. Trains of autonomously drivable, easily transitionable, rail travel-capable and road travel-capable trucks could well facilitate achievement of that objective, while also increasing the use of existing railroad networks. Not only could these trucks combine the efficiency of rail travel with the convenience of point-to-point transport, such trucks could also facilitate more efficient train assembly, disassembly and reassembly, greatly simplifying rail yard management. Still another possibility is *en route* charging of electrically powered trucks. A combination of existing technologies could make such dual mode vehicles a reality.

The existing technologies?

First, autonomous trucks (ATs). Market forecasts for ATs typically focus on expanding regulatory permissions to include truly driverless trucks and marrying ATs to specifically adapted routes. Only the most optimistic forecasts include fully autonomous on-road trucking in the near or intermediate future. But fully autonomous trucks are already operational in the limited confines of specific tasks and routes. Rio Tinto Mining and Fortescue Metals in Australia, for example, have had just that at their mining operations for some time.[8] Digitized rail networks, complemented with digitized roadway transition locations, may well accommodate fully autonomous trucks on rails and in rail-road transitions as ATs make those transitions.

Wheels and the marriage of wheels with ATs to travel on both rails and roads and easily transitionable between the two modes of travel is a second, and likely more challenging, adaptation necessary for ATs to travel on both rails and roads. The literature includes a wide variety of wheels and wheel implementations which permit both rail and road travel. The most promising of these may be a combination of coaxially mounted roadway and railway wheels, with the roadway wheels of slightly larger diameter than the railway wheels, as disclosed, for example, in a US patent issued to Christopher Nugent in 1932.[9] Various later patents, such as US Patents 7,077,065[10] incorporated the same basic concept, as illustrated by drawings from those patents. (Figures 1 and 2)

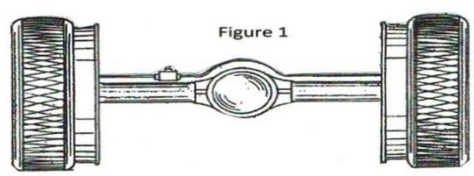


Figure 1

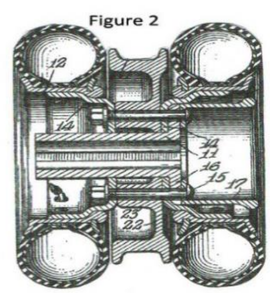


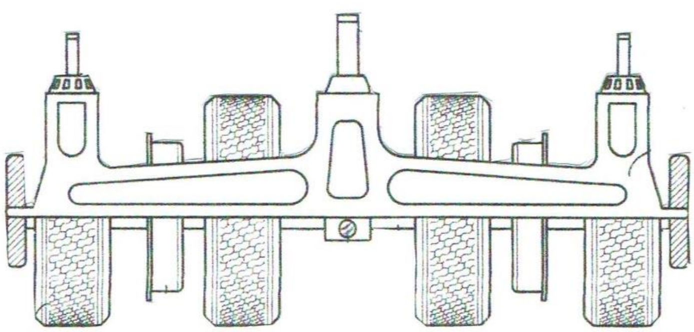
Figure 2

To account for the differential peripheral velocity of wheels of different diameters, adaptation of such wheel sets to long distance travel might also include instantaneous electronic adjustment of drive speed to any driven axle as the wheel set on that axle transitions from rail to road travel or vice versa.

Transitioning of a truck supported by such wheels from roadway travel to railway travel, or vice versa, would occur at railway-roadway intersections where inclined road grades or ramps along the railway on either side of the intersecting roadway engage the truck's roadway wheels as the truck approaches or leaves the intersection traveling in the railway direction. The path of a truck in the intersection, having approached the intersection from either the railway direction or the roadway direction, could be diverted to the alternative direction if the truck is to be transitioned at that intersection. Regulatory requirements for an in-person driver in an AT making a transition could be avoided if the roadway is not a public roadway but rather a limited access road to a holding or parking area, from which the truck could be driven onto public highways in a conventional manner.

Trucks of any significant length would likely require at least one set of supporting wheels mounted on bogies, like that of conventional railroad cars, to facilitate tracking on rail curves. As adapted for a tractor trailer AT, one might envision two bogies similar to, but somewhat lighter than, conventional rail car bogies, one at the rear end of the trailer and the other at the rear end of the tractor on which the forward end of the tractor sits. As seen in Figure 3, each of the bogies would likely include two wheel-sets, each of the wheel-sets including, coaxially mounted, a pair of railway wheels laterally spaced for rail travel, and two pairs of roadway wheels, one pair outboard of the railway wheels and one pair inboard of those wheels, thus to provide both sufficient heavy load support and lateral stability in road travel.

Figure 3



While the practicality of autonomously drivable trucks capable of highway and railway travel, as described conceptually here or as developed based on other concepts (see for example vehicles under development by Intramotev, Inc of St. Louis [11]) remains to be proven, such developments would provide other benefits ancillary to the diversion of trucks from highways to railways. For example, trucks of this type could be operated individually on rail lines and in rail yards but more likely would be entrained for long range travel using remotely controlled couplers at the forward and rear truck ends. Such trains may or may not include a locomotive to provide some or all of the driving force for the trucks, thus allowing for overall minimization of energy usage in particular circumstances.

As another possible ancillary benefit, such trucks would likely include automotive-type brakes in truck roadway wheels, thus rendering unnecessary the compressed air transmission lines commonly associated with conventional railroad couplers.

Electrically powered trucks would also complement the conversion to electrically powered, non-fossil-fueled trains, as such trains become more common. Such trains may necessarily include battery-laden rail cars transporting massive amounts of energy to power the trains. In that eventuality, truck couplers might also include power transmission connections for recharging the trucks *en route,* reducing truck recharging down time in truck destination areas. Charging such battery cars in geographic areas of the country where the potential for sun and wind powered electrical generation exceeds total current power generation by orders of magnitude[12], might also alleviate, at least to some extent, a projected need to greatly expand electrical transmission infrastructure accompanying the projected expansion, possibly doubling, of existing power generation capacity.[13]

A dream? Maybe not. But the alternative is 50% more long range trucks and traffic on existing roads and little or no more growth of truck-rail intermodal shipping. That might be the mother of all nightmares.

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[1] Freight Facts and Figures (US Dept of Transportation, Bureau of Transportation Statistics, Washington, DC 2020, page 17)

[2] Freightera.com/blog/train versus truck efficiency, February 2019, page 2

[3] Outlook for intermodal largely uninspiring after poor 2019, Ashe, JOC.com; US Railroads: Intermodal Outlook for 2020 mediocre, January 10, 2020

[4] Will Sort-Haul Rail Intermodal Ever Work? (Blaze, Railway age, December 3, 2020.

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[6] Chicago intermodal rail delays 'unprecedented' since January (Ashe, JOC.com, February 22, 2018)

[7].The Environmental Benefits of Moving Freight by Rail (Association of American Railroads, July 2019)

[8] Autonomous Trucks, Sooner than you think,(Vantuono, Railway Age, February 24, 2017)

[9] US Patent 1,853,572

[10] US Patents 7,077,065 and 2,135,307

[11] Intramotev – Autonomous Rail; https://intramotev.com

[12] Electricity Explained, Electricity Generation Capacity, and Sales in the United States, (U.S. Energy Information Administration, https://www.eia.gov , March 28, 2021); Wind generation potential in the United States (Wikipedia [with cited reference sources], last updated, May 29, 2018

[13] Electricity Grid Not Ready For EV Revolution, Energy Central News, June 11,2021; Equity, Security, and Load, FERC Conference Considers the Challenges and Potential of Electrification, Utility Dive, May 3, 2021