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Exploring Future Van Trailers

An Exploration of What's to Come for Trailers

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ABSTRACT

Various combinations of technology developments are possible for future trailers. These possibilities may come about as future market forces evolve and bring about increased productivity at lower cost. Electric power, whether from batteries, and/or solar panels will likely displace gasoline or diesel-fueled refrigeration units. (This also may be true of auxiliary power units (APUs) for tractors). The overall potential is for lighter, quieter, more reliable and productive trailers contributing to reduced fuel burn by tractor-trailer combinations. However, end-user requirements are needed to guide trailer innovators in this quest.

Introduction

This paper presents various innovations and research projects that may one day be incorporated in and/or radically change the "box" as we know it. They are not recommendations, nor prescriptions, but rather possibilities that are appearing on the far horizon, some of which may come about as future market forces evolve. These innovations may bring about increased productivity at lower cost. The possibilities explored herein are taken more or less in isolation, but can be considered "building blocks" and possibly combined in various ways. We don't say future trailers will have all these innovations, but rather that they are possibilities that may be combined in various ways, depending on the varying needs of shippers and motor carriers.

The Possibilities:

1. Lower Height

It appears that the large trailer, extending to 13'6" or more from the roadbed, may in fact be mismatched to some of the loads being carried. A survey of drivers (see **Ref.1**) indicates that trailers are fully loaded, i.e. cube out or gross out only 10 percent of the time. This

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finding is supported by **Reference 2**. This evidence implies that there is a niche for smaller trailers, perhaps beverage- trailer- size that can be incorporated in the mix of trailers used. With ever more sophisticated computer programs it should be possible to match the size of the trailer to the size of the load and reduce the cost of carriage. Trailers not quite so high would have less aerodynamic drag and be lighter thus costing less to purchase and operate (lower drag equals less fuel required to pull it through the air). Lighter also means less rolling resistance, also reducing fuel burn. (Rolling resistance for radial tires is on the order of 5.7 pounds per 1000 pounds of load). There is also the possibility of easier maneuverability in cities and congested areas, also having positive effects on productivity. However, any changes in trailer height would have to be coordinated with the design of future materials handling equipment.

2. Autonomous Trailers

There are at least two versions of this concept. One concept is the robotic truck operating on future highways with guideways dedicated for it (see **Ref. 3**). The concept envisions standard 20 foot containers on bogies drawing electrical power from a contact rail on the highway's median much as does a subway train drawing power from the third rail. When it leaves the highway and its contact rail it switches to its own onboard battery power and drives off the highway to a waiting area. A driver then takes it to its final destination, driving it as a conventional truck.

A second approach is a trailer that does not require modifying highways (contact rails delivering electric power). It contains its own hybrid electric power, thus being able to propel itself. When linked to others like it we have the benefits of the vehicle platoon, pulled by a "tractor" which need be no bigger than a pickup truck since each trailer has its own propulsive power and the tractor need have only enough horsepower to move itself (the HYMO- HYbrid Electric Technology-Based High Mobility Logistics System, **Attachment 1** and **Reference 4**). These trailers could also be equipped with radio control receivers so that once in the terminal area they could be maneuvered by someone with a hand held transmitter, much like a model airplane is flown by radio control. Or the trailer could be maneuvered by "traffic control" operators in a "control tower" in the terminal yard. Or the tongue could be set up to provide control inputs to the trailer so that one person could walk the trailer about maneuvering it using the tongue. Which ever approach is taken yard tractors would be a thing of the past and terminal operations would be speeded up. Another advantage of this concept is that when parked each trailers' battery can feed the tractor cab heating and cooling requirements thus eliminating the need for tractor idling or the need to use truck stop electricity for driver comfort.

The combination electric motor / generator in this hybrid system has the possibility of allowing us to reduce this weight even further while capturing the lost energy that is generated during braking or coasting down hills and / or to stops. These motor / generators could also reduce the efforts of our service brakes while actually reducing the relay time necessary to go into a braking mode or and acceleration mode.

There may be additional benefits to placing these motor / generators on trailers. As trailers begin to use more accessories and need more individual circuits, it would be beneficial to have energy storage and generation on board the trailer, making it electrically autonomous. This would eliminate the need for sending high amperage and voltage between the tractor and trailers. An umbilical cord could be used to send electronic signals in order to activate various functions of the trailer accessories. This could even be done in a wireless environment. The same benefits of using the motor / generators on tractors could be enjoyed by

using them on the trailers for starting and stopping heavy loads.

The HYMO is a hybrid electric system and requires the use of batteries. A version of it would use of hydraulic motors and hydraulic pressure accumulators (mechanical hybrid). While the ability to charge an electrical storage battery would be lost, the hydraulic motors would have more torque and less weight than the electric motor/generators. They would also have the capability of producing greater stopping efforts than the motor/generator. Their energy could be used for moving the vehicle in either a forward or reverse direction with equal power. Just as with the electric motor/generator the energy gained during stopping or coasting could be reapplied during the starting process. The efficiency of the accumulator would be greater than that of storage batteries since the accumulator would not lose energy with non-use, and also going in this direction would eliminate the problem of used battery disposal. Space and the additional weight of the accumulator could present a problem for some vehicles and carriers, although it is hard to imagine this weight being greater than that of batteries.

3. Aerodynamic Trailers

This discussion is apt following on the description of the HYMO. If it is assumed that a series of trailers is used in the HYMO we have what is referred to as a platoon. Current examples of platooning are the Daimler Promote-Chauffer system—an unmanned tractor-trailer following a driven one and receiving radio commands by which it mimics the maneuvers of the lead vehicle, and your everyday convoy, a string of combination vehicles following each other on the highway, and doubles and triples. The crucial point about platoons is that the total aerodynamic drag of the platoon is less than the cumulative drag of the individual vehicles. So, if I drive in a platoon I burn less fuel than I do traveling alone.

For individual trailers there are active and passive aerodynamic drag reduction techniques under investigation. An active approach, originated by the Georgia Tech Research Institute (GTRI), utilizes air blown out of slots around the perimeter of the trailer rear face, to not only drastically reduce drag, but enhance braking and eliminate trailer sway. A passive approach, originated by engineers at NASA Langley makes use of perforated panels on the sides and top of the rear of the trailer. Wind tunnel tests indicate a drag reduction approximately equal to the GTRI approach, but without the additional braking and stability enhancements.

If either of these approaches were combined with smaller trailers, as per Item 1 mentioned previously, very significant reductions in vehicle aerodynamic drag would be obtained.

4. Refrigeration Innovations

There are several research projects in ways to cool applicable to future trailers. One is **absorption refrigeration** (also used for cooling and this aspect would apply to tractor cab cooling as well). An absorption cooler does not use an electrically driven compressor to mechanically pressurize a refrigerant. Instead it uses a heat source such as natural gas or a large solar collector to evaporate the already pressurized refrigerant from an absorbent/refrigerant mixture. Absorption coolers need a small amount of electricity for pumping the refrigerant, but this is small compared to that required by a compressor in a conventional electric refrigerator.

Another is the **magnetic refrigerator**. NASA and a private company have been/are researching a concept using a metal which heats up when magnetized and cools down when demagnetized (called the magnetocaloric effect). This is more efficient than compressing a gas and eliminates the need for a refrigerant. Currently Iowa State University has become involved (see **Refs. 4 & 5**).

Resonant macrosonic synthesis uses acoustics to compress gases in a refrigerator. Sound waves are generated in a specially shaped cavity. Gas pressure can reach hundreds of psi. An acoustic compressor would eliminate the need for moving parts and could use any refrigerant (see **Ref 6**).

Thermolectric refrigeration is an approach that utilizes materials that change temperature when an electric current passes through them (see **Ref. 7**). These materials could replace today's compressors with systems having no moving parts and use no gases that deplete the ozone layer. Instead of using a gas 9refrigerant) to absorb and release heat a thermoelectric device expands and compresses electrons. One thousand two hundred thermoelectric devices heated by radioactive sources were used on the Voyager spacecraft and there were no failures in a quarter billion device-hours. These same thermoelectric materials can also convert waste heat from vehicle engines into electricity.

Solar cooling and refrigeration can be accomplished with **Stirling Cycle** coolers using Helium or Nitrogen as the working fluid. The Stirling Cycle engine is an external combustion engine. The heat fueling the engine comes from outside the engine. This enables the Stirling engine to operate on any of a variety of fuels- natural gas, propane, gasoline, diesel, and heat from the sun. Plus the engine is extremely quiet. There are at least four companies marketing Stirling coolers, but none dedicated to reefer trailers. **Reference 8** is a source of information on Stirling engines.

Solar powered cooling was recently demonstrated by Sainsbury plc, a leading British food retailer. Solar panels on the roof charge a battery bank. Power is supplied via an inverter to an AC motor-powered refrigeration unit. (see **Attachment 2**). This is a roundabout way of using solar energy, with penalties on the payload of the trailers whereas the Stirling engine discussed above is a direct use and would not entail such a penalty.

Putting it All Together

As suggested in the introduction, various future combinations of these developments are possible. Moreover, it appears that electric power, whether from batteries, and/or solar panels will displace gasoline or diesel-fueled refrigeration units. (This also may be true of auxiliary power units (APUs) for tractors). The overall potential is for lighter, quieter, more reliable and productive trailers contributing to reduced fuel burn by tractor-trailer combinations. What is needed is a set of requirements from trailer users to indicate effective and productive directions for innovators to take.

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