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WHAT IS THE EFFECT OF DRIVER BEHAVIOR ON FUEL EFFICIENCY?

EXAMINING THE ROLE OF THE DRIVER IN REDUCING CARBON DIOXIDE EMISSIONS AND SAVING FUEL

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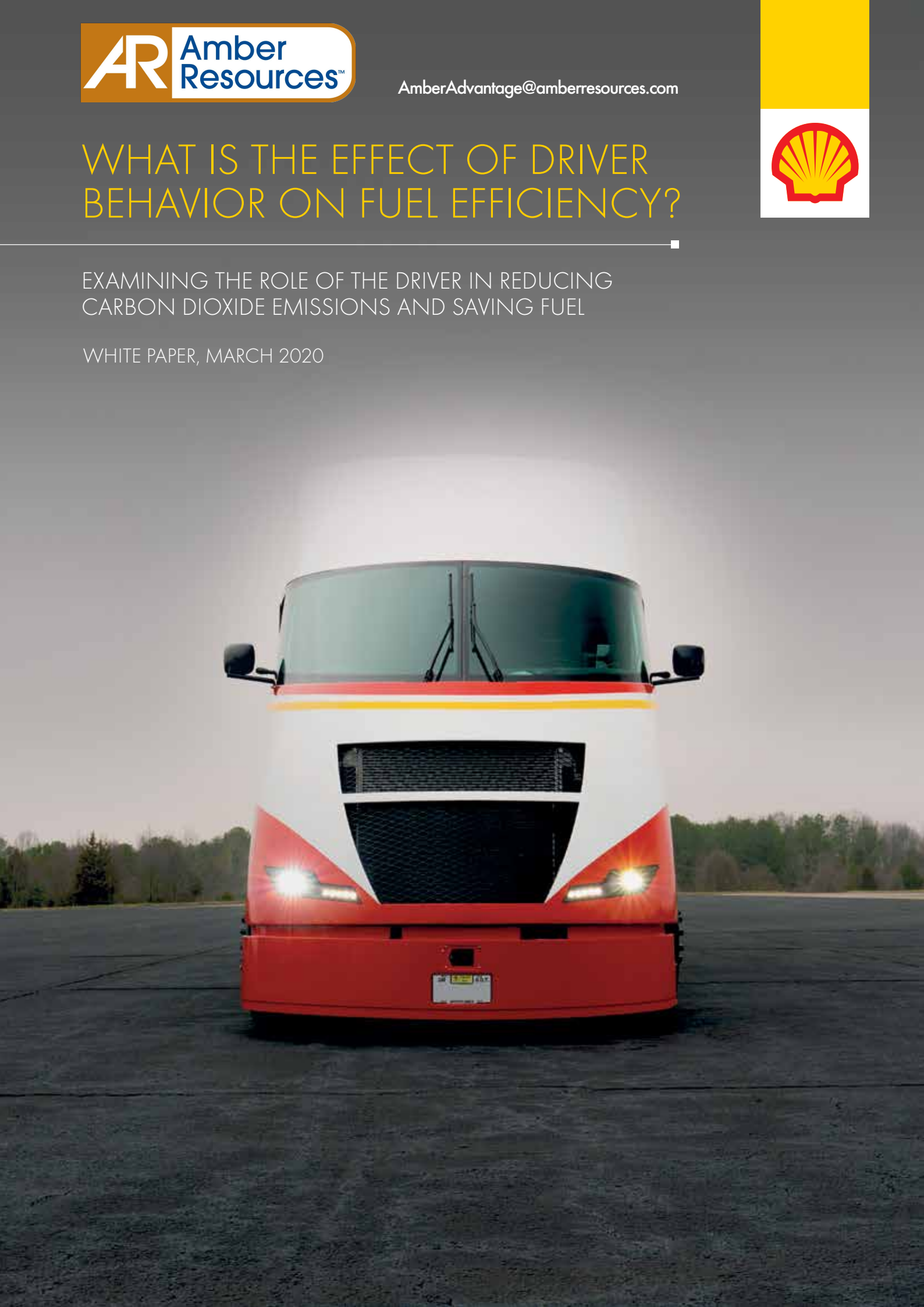

“**THERE ARE MANY WAYS** IN WHICH A DRIVER’S ACTIONS AND HABITS CAN AFFECT REAL-WORLD FUEL EFFICIENCY, NOT ALL OF WHICH ARE IMMEDIATELY OBVIOUS.”

WHAT IS THE EFFECT OF DRIVER BEHAVIOR ON FUEL EFFICIENCY?

In 2018, the Starship truck made a 2,315-mile journey across the USA and achieved nearly two and a half times greater freight ton efficiency (FTE) than the North American average.[1] The accompanying impressive reductions in carbon dioxide (CO_2) emission and fuel savings were achieved by combining many currently available technologies. It also looked at driver behavior, which plays a surprisingly large role in fuel efficiency.

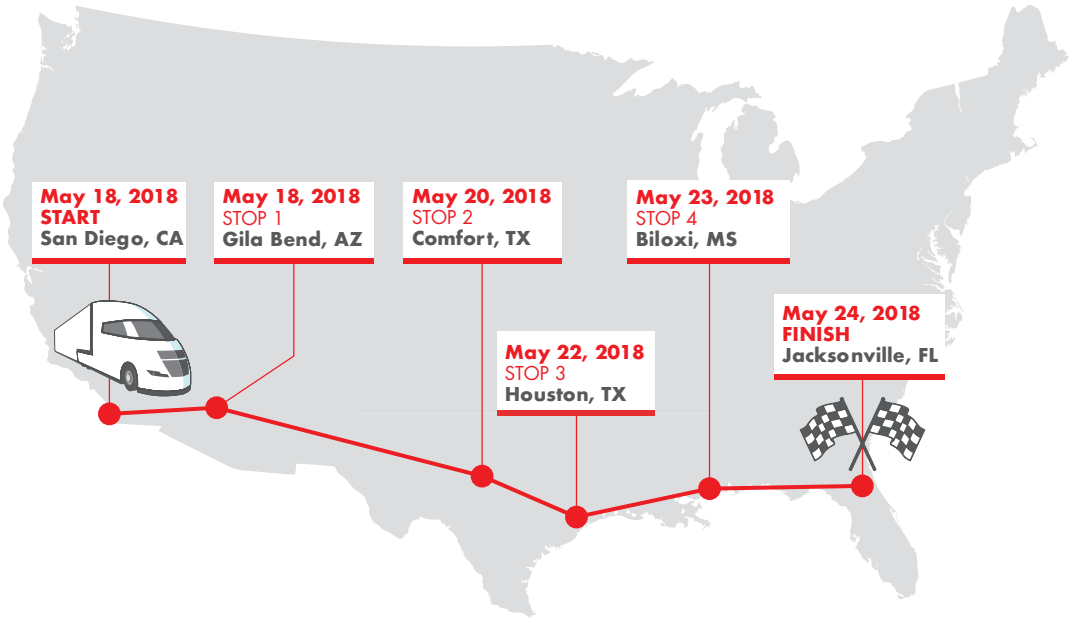

FIGURE 1. The Starship truck's six-day transcontinental route.

During its coast-to-coast crossing (Figure 1), the Starship truck carried 19.95 tons of freight, yet still managed a fuel economy of 8.94 mpg for an FTE of 178.4 ton-miles/US gal.[2] In comparison, the average North American truck has a fuel economy of 6.4 mpg[1] and carries 11.25 tons for an FTE of 72 ton-mile/US gal.

Carrying a full load contributed significantly to the impressive results. If every truck in the USA were to carry its maximum load, 871,000 fewer trucks would be necessary. If the remaining trucks achieved the Starship truck's 8.94-mpg fuel efficiency, then the fleet's CO_2 emissions would be cut by 60%.[3]

The Starship Initiative set out to design an exceptionally energy efficient Class 8 truck by combining current technologies to reduce the energy used to transport goods in an affordable and accessible way – so no new concepts or wildly expensive solutions. The truck was co-engineered by AirFlow Truck Company and Shell Lubricants.

The idea was to demonstrate how good today's trucks could be if promising energy efficiency concepts, including aerodynamic features such as truck and trailer side skirts and boat tails, and low viscosity fuel economy lubricants, were to be drawn together in one place. Each of the major truck, driveline and operating features that contribute to energy use were considered, including driver behavior.

There are many ways in which a driver's actions and habits can affect real-world fuel efficiency, not all of which are immediately obvious. The North American Council for Freight Efficiency's (NACFE) recent "Run on Less" initiative, supported by Shell, demonstrated that driver behaviors make a significant difference, even in advanced trucks with the latest automated transmissions that ensure optimal gear selection. Indeed, it is easy to underestimate the efficiency benefits that can be gained through modifying driver behavior.

The driver employed to drive the Starship truck across the American continent used a wide range of techniques to minimize fuel consumption. This article explores the impact of driver behavior to highlight some of the ways in which drivers can maximize truck fuel efficiency in a real-world setting. In addition to helping to reduce fuel usage and costs, better driving behavior also reduces carbon dioxide emissions.

> **FUEL-EFFICIENCY CONSCIOUS DRIVERS** OPERATE THEIR VEHICLES WITH A SENSITIVE APPROACH TO THE ACCELERATOR AND BRAKE... ANTICIPATING ROAD CONDITIONS TO ENABLE THEM TO CHANGE SPEED MORE SMOOTHLY AND THUS REDUCE FUEL CONSUMPTION.

HOW DOES DRIVER BEHAVIOR AFFECT FUEL ECONOMY?

There are many factors influencing the fuel efficiency of a tractor–trailer truck setup (Figure 2). Many of these opportunities are linked to optimizing engine and vehicle design, but a surprising number can also be influenced by driver behavior.

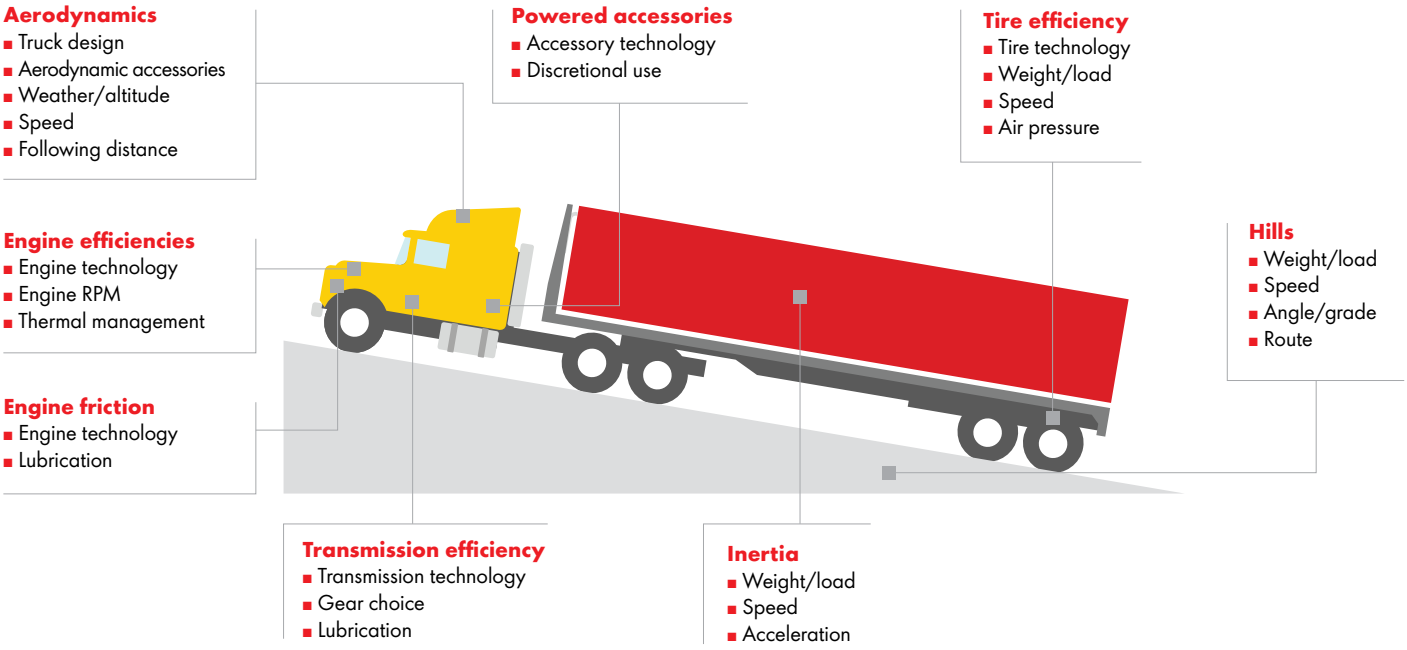

FIGURE 2. Factors influencing the fuel economy of a tractor–trailer truck setup.

There is also parameter setting, which sits between vehicle design and driver behavior. For example, good driver behavior such as driving at the optimum speed (see below) can be customized into the truck's settings, in this case, by limiting the maximum speed.

Here are four tips for cutting fuel consumption by modifying driver behavior.

1. Limit your top speed

Air resistance or drag increases with a vehicle's speed. The rate of increased resistance can be significant. Doubling the speed increases the air resistance by a factor of four. Indeed, every 1 mph over 55 mph costs 0.1–0.2 mpg in fuel economy. That may sound insignificant but consider a driver cruising at 60 mph and thus incurring a fuel economy penalty of 0.5–1.0 mpg. For 10 trucks, each traveling 100,000 miles annually, the additional fuel cost could be over $127,000 (see below) and have an associated environmental cost for CO_2 emissions.

Example calculation

Let us say an average fuel economy of 6 mpg improves to 7 mpg using a combination of the suggestions made here.

6 mpg = 0.1667 US gallons per mile (gpm)

7 mpg = 0.1426 gpm

This is a reduction of 0.02381 gpm, or 2,381 US gallons per 100,000 miles (the assumed annual mileage).

A fleet of 10 trucks, each traveling 100,000 miles a year, would reduce its annual fuel consumption by 23,810 US gallons.

At $3/US gallon, that is a savings of $71,429/year!

2. Limit your RPM

For a given vehicle speed, lower engine revolutions per minute (RPM) use less fuel.

Even with the highest quality, lowest viscosity lubricants, there is always internal engine friction, which contributes to fuel consumption. In general, engines operate more efficiently at high torques and low engine speeds (RPM). This means that the fuel efficiency penalty of internal engine friction is lowest when the vehicle is operating in a high gear.

A fuel-efficient driver tries to avoid high engine speeds and moves smoothly up through the gears as the vehicle speed is increased ensuring that the truck is operating in the highest reasonable gear at all times.

Braking converts the kinetic energy associated with the truck's motion into heat which is lost to the atmosphere. Fuel-efficiency conscious drivers operate their vehicles with a sensitive approach to the accelerator and brake. Instead of speeding up rapidly and braking sharply, they anticipate the road conditions to enable them to change speed more smoothly and thus reduce fuel consumption. For example, rather than racing to a red light or queue of traffic, stopping sharply and then accelerating quickly away, they will see the red light or slowing traffic and reduce speed gradually. They may not have to stop if the lights change or the traffic starts to move before they get there.

Over time, smooth braking and acceleration help to reduce wear on the tires and transmission, which also contribute to improved fuel efficiency and lower maintenance costs.

3. Plan an economic route

Route planning to help reduce fuel consumption is already familiar to most commercial drivers. Route planning tools can help them to identify the fastest route, avoid traffic congestion and optimize fuel stops along their route.

Often, the fastest journey is the most fuel efficient but there are further potential gains from avoiding hills and making the most of long, straight stretches of road. As explained above, the engine is under the most strain when accelerating and up-hill driving is particularly fuel-thirsty work. Avoiding hills, minimizing the amount of time spent bringing the truck up to speed and maximizing cruising time is, therefore, a sensible way to save fuel over a long journey.

4. Minimize idling

Truck driving is a hard job and drivers expect some comforts during their breaks, so modern vehicles have a variety of powered in-cab accessories, including radios, lights, air conditioning and mobile phone chargers. These functions are vital for long journeys, especially those with overnight stops or in remote locations.

Power for these is typically taken from the vehicle's engine, which leads to higher fuel consumption. It is common for engines to idle overnight, when it is legal to do so, to keep the in-cab accessories running to, for example, heat the cab while the driver sleeps. During this time, the engine is not contributing to the journey and its operation is a drain on the fuel consumption.

Some trucks have the option to use a small diesel engine or battery pack for auxiliary power to eliminate main-engine idling. The Starship truck goes one step further and has a 5,000-watt solar array on the trailer roof that charges the tractor's 48-volt battery by day. This battery powers the cab air conditioning and, when down-converted to 12 volts, powers the lights, wipers, blower motors, gauges and other electrical components.

Driver behavior can help too. For example, cooling the cabin before stopping or parking with the windshield facing away from the sun can help to lower the energy costs during breaks.

> **FROM A DRIVER PERSPECTIVE,** LOWERING ENGINE REVS IS AN IMPORTANT FACTOR FOR IMPROVING HEAVY-DUTY TRUCK FUEL ECONOMY.
>
> Bob Sliwa, AirFlow Truck Company founder, fleet operator and truck driver

What about "platooning"?

Drivers should maintain safe stopping distances between their vehicles. However, there are fuel efficiency benefits from automated platooning or "road trains" in which trucks with wireless vehicle-to-vehicle communications travel in a tight convoy. Automated platooning is authorized in some jurisdictions and not in others.[5]

When the leading driver makes speed, braking and steering decisions, the following vehicles automatically make the same maneuvers. The fuel savings come from improved aerodynamics (in the same way cyclists 'draft' each other or racing cars get a 'tow' from the car they are closely following) and from reducing the proportion of time each individual truck spends braking and accelerating as they catch up to the vehicle ahead.

Automated platooning should only be attempted with the correct technology and when it is legal.

What is the effect of improving driving habits?

Unlike for changes made to the vehicle such as switching to a low-viscosity lubricant or improving the aerodynamics, the impact of driver behavior is more difficult to visualize and quantify. However, the impact of behavioral changes is significant: fuel efficiency improvements of up to 30% are possible through adopting the techniques described above.

To understand the potential benefits of efficient driving techniques, it is first worth looking at a fleet's variability in fuel consumption over time for trucks with base-level features and typical drivers (Figure 3).

The variability in fuel efficiency can be attributed to factors such road conditions, weather, engine and vehicle condition, and driving style. Changing just one physical factor to a more fuel-efficient option, for example, using a low-viscosity lubricant, improves the average fuel efficiency, but the variability remains (Figure 4).

However, improving driving habits can reduce variability and lower the average fuel consumption. If driver behavior across a fleet becomes more standardized by adopting the techniques outlined above, then fluctuations in fuel consumption from differences in driving style are reduced, which results in an overall improvement to the fuel efficiency and less variation (Figure 4).

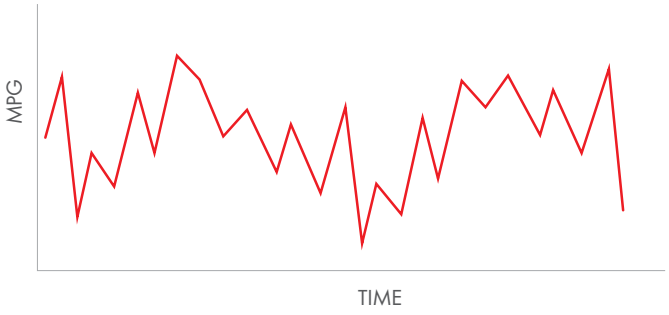

FIGURE 3. Variability in fuel consumption over time (illustrative).

FIGURE 4. Fuel consumption: the effect of changing a physical component.

FIGURE 4. Fuel consumption: the effect of fuel-efficient driving techniques.

> **IN-CAB DISPLAYS** AND FINANCIAL INCENTIVES FOR SAVING FUEL ARE HELPING TO IMPROVE DRIVER BEHAVIOR ACROSS THE FLEET.
>
> Mike Roeth, Shell consultant and member of the North American Council for Freight Efficiency

Conclusion

The Starship truck successfully demonstrates the efficiency possible through bringing together today's technologies such as low-rolling-resistance tires and low-viscosity fluids, and adopting a fuel-efficient driving style.

About 7% of the world's truck fleet is scrapped each year. Consequently, hardware improvements such as an improved engine design would take 14 years to penetrate the market, assuming it instantly appeared in every new truck. It is infeasible for fleet companies focused on making money from day-to-day operations to make instant, radical changes to their hardware.

However, there are two changes that can be made quickly: low-cost changes that can significantly improve fuel economy. First, low-viscosity engine oils and transmission fluids can be used. For example, low-viscosity (5W-30) Shell Rotella heavy-duty engine oil helps to reduce fuel consumption by reducing internal engine friction while providing the protection required to meet the American Petroleum Institute FA-4 performance standards. In 24-day field trials using six different trucks, Shell Rotella® T5 Ultra synthetic blend 10W-30 demonstrated a 2.6% fuel economy benefit compared with a standard 15W-40 oil.[5]

Second, fuel-saving driver behaviors can easily be applied to maximize the benefits of lubricant choice.

FOR MORE INFORMATION, CONTACT US

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Learn how we are Southern California's
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[1] North American Council for Freight Efficiency: "Run on less report," (2018): nacfe.org/run-on-less-report

[2]North America Council for Freight Efficiency data verification report for Starship truck coast-to-coast test drive

[3]Reductions in annual CO_2 emissions calculated as if all trucks in the USA operated at the same FTE (ton-miles/US gal) as the Starship and the scale of the fleet was reduced to balance the increased loading. CO_2 emissions refer to those from the combustion of diesel fuel alone with a standard emission rate of 22.4 lb of CO_2 per US gallon of diesel fuel.

[4]https://www.mhlnews.com/transportation-distribution/guide-states-rules-automated-vehicle-platooning

[5]Clevenger, S.: "Low-viscosity engine oils will support push for improved fuel economy, Shell says," TTNews (2018): www.ttnews.com/articles/low-viscosity-engine-oils-will-support-push-improved-fuel-economy-shell-says.com