CONFIDENCE REPORT: PROGRAMMABLE ENGINE PARAMETERS

ABSTRACT

This report documents the confidence that North American Class 8 trucking should have in optimizing programmable engine parameters for improved fuel efficiency. The study team engaged the entire industry in the data that is presented here.

Thanks to all of those who contributed to this important work.

Trucking Efficiency

Trucking Efficiency is a joint effort between NACFE and the Carbon War Room to double the freight efficiency of North American goods movement through the elimination of market barriers to information, demand and supply.

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The tractor-trailer industry's fuel costs have been swiftly and steadily rising over the past decade. In 2013 diesel fuel costs reached $0.65 per mile, costing the industry more annually than the combined costs of drivers' wages and benefits. Despite recent fuel cost decreases, all indications are that fuel price volatility will continue, forcing the industry to find solutions that reduce its fuel dependency to stay profitable.

Fortunately, myriad technologies that show strong potential for achieving cost-effective fuel efficiency gains for Class 8 trucks are readily available on the market today. Unfortunately, multiple barriers have stymied industry adoption of such technologies, including both a lack of data about the true performance gains offered by these technologies and a lack of confidence in the data that does publicly exist today. To overcome those barriers and facilitate the industry's trust in and adoption of the most promising fuel-efficiency technologies, the North American Council for Freight Efficiency (NACFE) partnered with Carbon War Room (CWR) to form Trucking Efficiency.

Engine Parameter Utilization

Electronic engine parameters, often simply called engine parameters or programmable parameters, are software settings available for the diesel engines of trucks; end users can customize parameters to improve efficiency and performance. This Confidence Report focuses on the programmable parameters specifically designed to reduce fuel consumption.

Programmable engine parameters first entered the commercial trucking world with the advent of electronically controlled diesel engines in the mid-1980s. From fewer than two dozen parameters in those early days, the options available to fleets have ballooned into the hundreds. Rather than catalogue all of the parameters available today from all of the different engine manufacturers, this report assesses the way fleets are using parameters today, in order to identify room for improvement and additional fuel savings, highlight and share best practices, and dispel any misconceptions that might be uncovered.

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METHODOLOGY

This report's conclusions were generated through desk research, conversations at a variety of trucking industry events around the country, and a series of structured interviews with engine manufacturers, vehicle OEMs, fleets, and truck dealer sales personnel.

Trucking Efficiency conducted confidential, over-the-phone interviews with nine NACFE-affiliated large fleets, all of whom had significant experience with the optimization of programmable engine parameters.

Insights from medium and smaller fleets were garnered via an online collaboration with the Michelin Fleet Forum—45 fleets participated and 41 had first-hand knowledge of parameter settings and processes.

Trucking Efficiency Confidence Reports to date:

1. Tire Pressure Technologies (August 2013)
2. 6x2 Axle Systems (January 2014)
3. Idle Reduction Technologies (June 2014)
4. Electronically Controlled Transmissions (December 2014)
5. Electronic Engine Parameters (February 2015)

Visit www.truckingefficiency.org to download these and other reports

Benefits of Optimization

This technology can significantly impact fuel economy, among other areas of vehicle performance. A fleet that truly optimizes the parameters of its new trucks by tailoring them to its operations could obtain fuel efficiency improvements of 5–8% compared to leaving those trucks set with the defaults of the engine's original equipment manufacturer (OEM). In some extreme cases, fleets have reported MPG gains for certain individual trucks of as great as 20%.

Meanwhile, improvements of 3–5% above the defaults may be available to fleets that simply set the parameters of their new trucks in a few key areas such as vehicle speed and idle reduction. No testing was done, although fleets and engine OEMs both provided insights into the fuel economy benefits offered by optimizing programmable parameters. ***A 5% improvement would equate to over $4,000 in fuel savings per year per truck at 2013 average fuel costs, and $3,000 at $3.25 fuel price per gallon.***

In theory, programmable engine parameters should be the most attractive pathway for a fleet to improve its fuel economy. As opposed to nearly every other efficiency technology, software-based ***electronic parameters weigh nothing and cost nothing to adopt;*** they are included in every engine made today. Plus, if set thoughtfully and correctly when the truck is purchased, they require zero regular maintenance. No other technology that Trucking Efficiency has studied offers such significant cost savings with no real upfront cost and minimal management cost.

In practice, many people understand the basic concept of using parameters to control certain aspects of vehicle operation, but it is much harder to find people who are comfortable truly optimizing those parameters for fuel economy and who are equipped to do so at the fleet-wide level.

Parameters that Impact Fuel Economy

There are six categories of parameters that impact fuel economy:

1. Vehicle Speeds
2. Vehicle Configuration Information
3. Engine Speed and Torque Limits
4. Idle Reduction
5. Driver Rewards
6. Miscellaneous MPG-Related Features

Each category includes myriad possible parameters, some of which require a specific value to be set (like an MPH or a temperature) and others that just need to be switched on or off. For example, the table below shows some of the common idle reduction parameters, along with the possible settings they could be assigned.

A sample of programmable parameters related to idle reduction

Feature/Parameter	Range	Default
Idle Engine Speed — Parameter	500 – 800 RPM	600 RPM
Idle Shutdown — Feature Option	Enable/Disable	Disable
Idle Shutdown Timer — Parameter	2 – 1,440 minutes	60 minutes
Idle Shutdown Manual Override — Feature Option	Enable/Disable	Disable
Idle Shutdown in PTO — Feature Option	Enable/Disable	Disable
Idle Shutdown PTO Load Override — Parameter	0 – 100%	10%
Idle Shutdown Ambient Air Temperature Override — Feature Option	Enable/Disable	Disable
Idle Shutdown Intermediate Ambient Air Temperature — Parameter	0 – 120° F	60° F
Idle Shutdown Hot Ambient Air Temperature — Parameter	0 – 120° F	85° F
Idle Shutdown Cold Ambient Air Temperature — Parameter	0 – 120° F	30° F
Idle Shutdown Hot Ambient Automatic Override — Feature Option	Enable/Disable	Disable
Idle Shutdown Manual Override Inhibit Zone — Feature Option	Enable/Disable	Disable

Barriers to Optimization

While the fuel-economy benefits are great, optimizing parameters is unnecessarily complex. In particular, eight discrete issues arise at three specific points during the optimization process.

Understanding Parameters:

1. The large number of parameters: The sheer plethora of parameters available today requires extra effort to fully understand (and new ones are still being regularly created to take advantage of emerging technologies such as global positioning systems).

2. Interrelations between multiple parameters and/or between parameters and other systems on the truck: In order to optimize their parameters, fleets must understand how changing one parameter may necessitate a change in others, and will moreover need to tailor all of those parameters to the overall specifications of an individual truck, including its duty cycles, drivetrains, rear axle ratios, and additional installed technologies.

Selecting and Ordering Parameters:

3. Variation in OEM terminology and precise functionality: Each engine OEM has its own terminology and brand names for its parameters, and even some slight differences in how they function. Even within a single OEM there will be differences from one engine model to the next. Furthermore, the majority of fleets have multiple years and models of engines in active operation, sometimes from multiple OEMs.

4. Variation in ordering tools required to set parameters on new trucks: The tools and methods that dealers must use to communicate a fleet's desired parameter settings to the OEM vary greatly between one OEM and the next.

5. Incorrect initial parameters settings: Even once a fleet has chosen its parameters and a dealer salesperson has placed the order, there are often persistent issues with the parameters for a new truck being set incorrectly or incompletely by any one of a few different actors.

Maintaining Parameters:

6. Variation in service tools and lack of telematics: Changes in duty cycles or even insights from new truck performance data may indicate that a certain parameter should be altered on a group of trucks. But right now changing parameters requires someone physically connecting with the truck. This can be a time-consuming task for a large fleet. Telematics technology would allow for parameters to be updated remotely.

7. Negative reactions from drivers: Fleets must communicate the benefits of parameters to their drivers, as often a driver's initial reaction to anything that places restrictions on vehicle operation is quite negative. Drivers or maintenance technicians have sometimes subverted or tampered with parameters, although this has diminished through advances in things like password protection for engine parameters.

8. Parameter records maintenance: Technology for keeping records of parameter settings is likewise scattershot at present. If programmable parameters are to truly be optimized for fuel efficiency, it is critically important that fleets keep records of how parameters were initially set on a given truck model and any changes that were later made to them, so that parameters' effects on fuel consumption can be understood. Record keeping is equally critical in the unlikely, but not impossible, case that maintenance or systems failure cause the settings to be erased.

Recommendations

We recommend a suite of six best practices for fleets to successfully optimize parameters:

- Record keeping of parameter settings
- "Parameter templates" that cover a group of similarly specified trucks
- Pilot or spec review time with OEMs to discuss parameter settings
- Parameter verification checks to ensure vehicles are set as desired
- Read or write tools to use with parameters
- Protect passwords

Fleets can also use this Confidence Report to obtain:

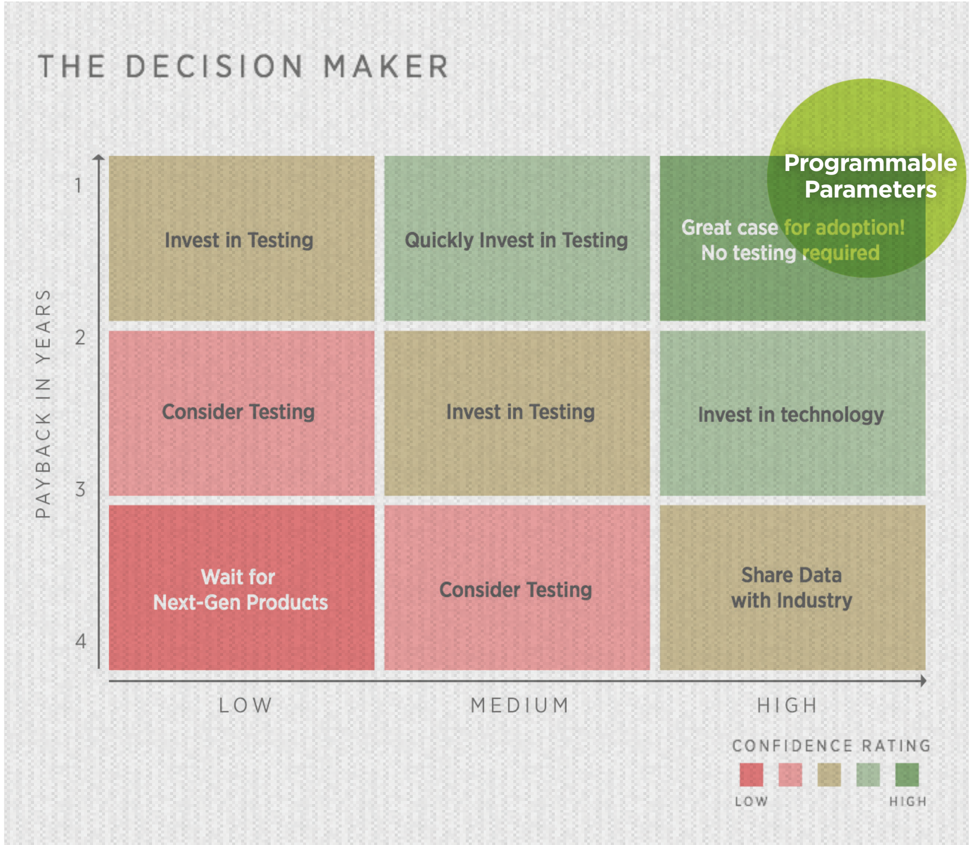
- A clearer picture of what they stand to gain from prioritizing parameters;
- A full understanding of the pitfalls surrounding the implementation of this technology; and
- IInsights into the actions and motivations of their peers, OEMs, and dealers.

Dealers, vehicle and engine OEMs, and other stakeholders from legislators to engineers and technology developers will also find recommendations relevant to their particular role in an industry-wide effort to ensure that programmable parameters are being optimally utilized by the trucking industry today.

Note that Trucking Efficiency is a vendor-agnostic organization, and therefore the report does not compare the features or tools of individual engine OEMs. Given the complexity of this topic and the degree to which the suite of fuel economy parameters will need to be tailored to each fleet and even each truck, this report also does not make specific recommendations about which parameters should be set and with what values in order to maximize fuel economy.

Confidence Rating

The confidence matrix above indicates the Trucking Efficiency study team's confidence in the investment case for optimizing fuel-economy-related electronic engine parameters. This Confidence Rating indicates a high confidence that programmable parameters, if optimized, greatly enhance fuel economy with a short payback period.



Confidence Matrix for Electonic Engine Parameters

Two additional tools are presented along with this Confidence Rating:

- The Manufacturer Parameter Name Comparison Tool compares the specific brand names of the various fuel-economy parameters available from engine manufacturers, and was created from the publicly-available documentation from OEMs, dealerships, and fleets.

- The Engine Manufacturer Information Tool lists contact points at each OEM for any fleet that needs assistance in getting its parameters optimized.

Both tools are available as appendices to the report itself and as separate downloads from www.truckingefficiency.org.

Trucking Efficiency hopes this report will catalyze significant new interest in the optimization of electronic engine parameters as a method for the industry to profitably increase its fuel efficiency and obtain other benefits for fleets, drivers, and the environment. Trucking Efficiency is always seeking to expand the data or case studies that we can provide to the industry. We invite you to share with us your own experiences with programmable parameters.

"The overarching message for fleets is, if you are not currently optimizing parameters for fuel economy, do so. It's worth the effort."

MIKE ROETH, NACFE AND CARBON WAR ROOM.

TRUCKING EFFICIENCY

Trucking Efficiency is a joint effort between NACFE and Carbon War Room to double the freight efficiency of North American goods movement. The operation eliminates market barriers associated with information, demand, and supply.

Worldwide, heavy-duty freight trucks emit 1.6 gigatons of CO_2 emissions annually—5.5% of society's total greenhouse gas emissions—due to the trucking sector's dependence on petroleum-based fuels. Truck manufacturing is also a growth market that, though profitable, could result in massive increases in trucking's emissions—unless the trucking sector improves its fuel efficiency as fast as it expands.

With fuel prices still commanding nearly 40% of the cost of trucking, the adoption of efficiency technologies by all classes of trucks and fleets offers significant cost savings to the sector while reducing emissions. These technologies are relatively cheap to implement, widely available on the market, and many have the potential to be retrofit onto existing trucks. But in spite of the potential cost savings, even the most promising of these technologies are not yet being widely adopted by the North American trucking industry due to a lack of confidence in the data on efficiency technologies, and a lack of shared information among fleets.

Trucking Efficiency addresses those barriers by providing detailed information on efficiency technologies, including data from across a variety of fleets and best practices for adoption.

www.truckingefficiency.org

Trucking Efficiency welcomes outside views and new partners in our efforts to help accelerate the uptake of profitable, emissions-reducing trucking technologies.

ABOUT CONFIDENCE REPORTS

Our Confidence Reports assess current technologies, discuss challenges and best practices for their adoption, and provide figures on performance gains and payback periods, along with a multitude of datasets from industry testing. They are intended to help end users and manufacturers determine whether to adopt a specific technology or set of solutions. The reports are born out of conversations with the industry, which made clear the need for a credible and independent source of information on fuel efficiency technologies and their applications.

In order to generate confidence on the performance claims of efficiency technologies, Trucking Efficiency gathers and centralizes the multitude of existing data sources about the performance results of different technology options when employed in a variety of vehicle models and duty cycles, and makes all of that data openly accessible and more easily comparable through Confidence Reports. Furthermore, we assess the credibility of the available data, and provide an industry-standardized ranking of confidence in performance results, including ROI and efficiency gains.

The full list of Confidence Reports can be found at www.truckingefficiency.org

CARBON WAR ROOM

Carbon War Room is a global nonprofit, founded by Sir Richard Branson and a team of like-minded entrepreneurs, that accelerates the adoption of business solutions that reduce carbon emissions at gigaton-scale and advance the low-carbon economy. The organization focuses on solutions that can be realized using proven technologies under current policy landscapes.

Carbon War Room aims to create well-functioning, high-growth, and low-carbon marketplaces by launching operations collaboratively in sectors where we have proven that profitable emissions-reduction opportunities exist. The War Room's current operations include Maritime Shipping Efficiency, Energy Efficiency in the Built Environment, Renewable Jet Fuels, Smart Island Economies, and Trucking Efficiency.

www.carbonwarroom.com

NACFE

The North American Council for Freight Efficiency works to drive the development and adoption of efficiency-enhancing, environmentally-beneficial, and cost-effective technologies, services, and methodologies in the North American freight industry by establishing and communicating credible and performance-based benefits. The Council is an effort of fleets, manufacturers, vehicle builders, and other government and non-governmental organizations coming together to improve North American goods movement.

www.nacfe.org

CONTACT US

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1 Introduction

This Confidence Report forms part of the continued work of Trucking Efficiency, a joint initiative from the North American Council for Freight Efficiency (NACFE) and the Carbon War Room (CWR), highlighting the potential of fuel-efficiency technologies and practices in over-the-road goods movement. Prior Confidence Reports and initial findings on nearly 70 technologies available today can be found at www.truckingefficiency.org.

The fuel costs faced by the tractor-trailer industry have been swiftly and steadily rising over the past decade (Figure 1). By 2013, as Figure 2 shows, fuel costs had reached $0.65 per mile, surpassing even the costs for the driver (wages plus benefits). And although very recently a reduction in fuel costs has occurred, all indications are that fuel prices will continue to be volatile, thus the industry is in need of solutions which reduce its fuel dependency if it is to stay profitable.

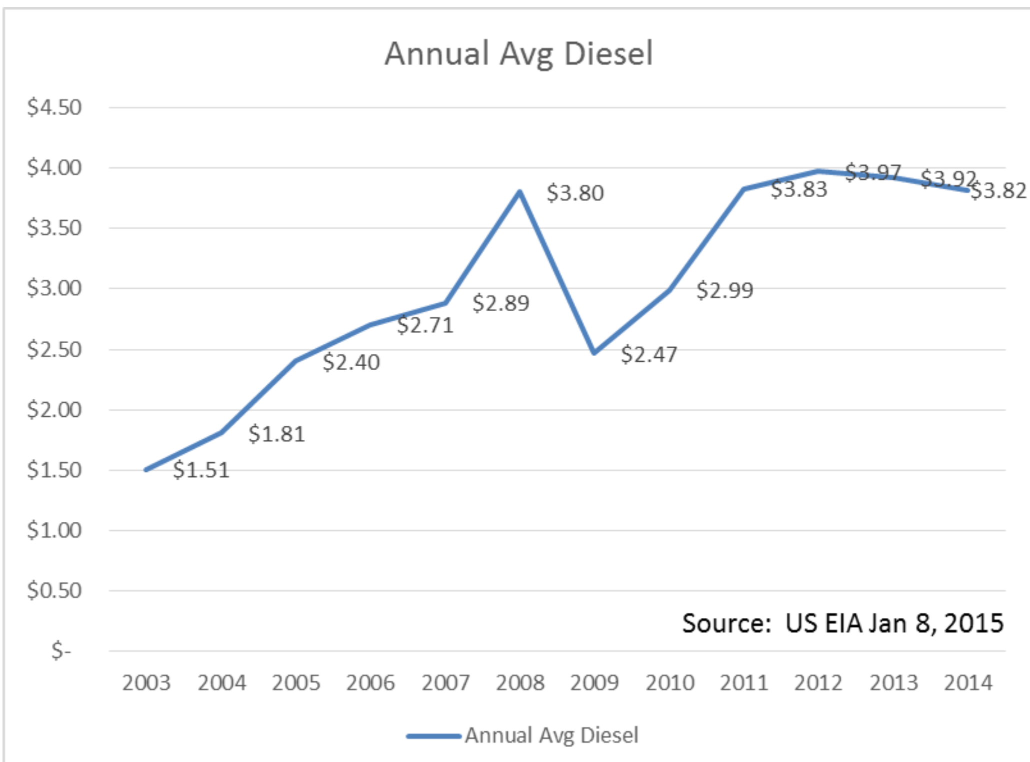


Figure 1: US Annual Diesel Fuel Prices

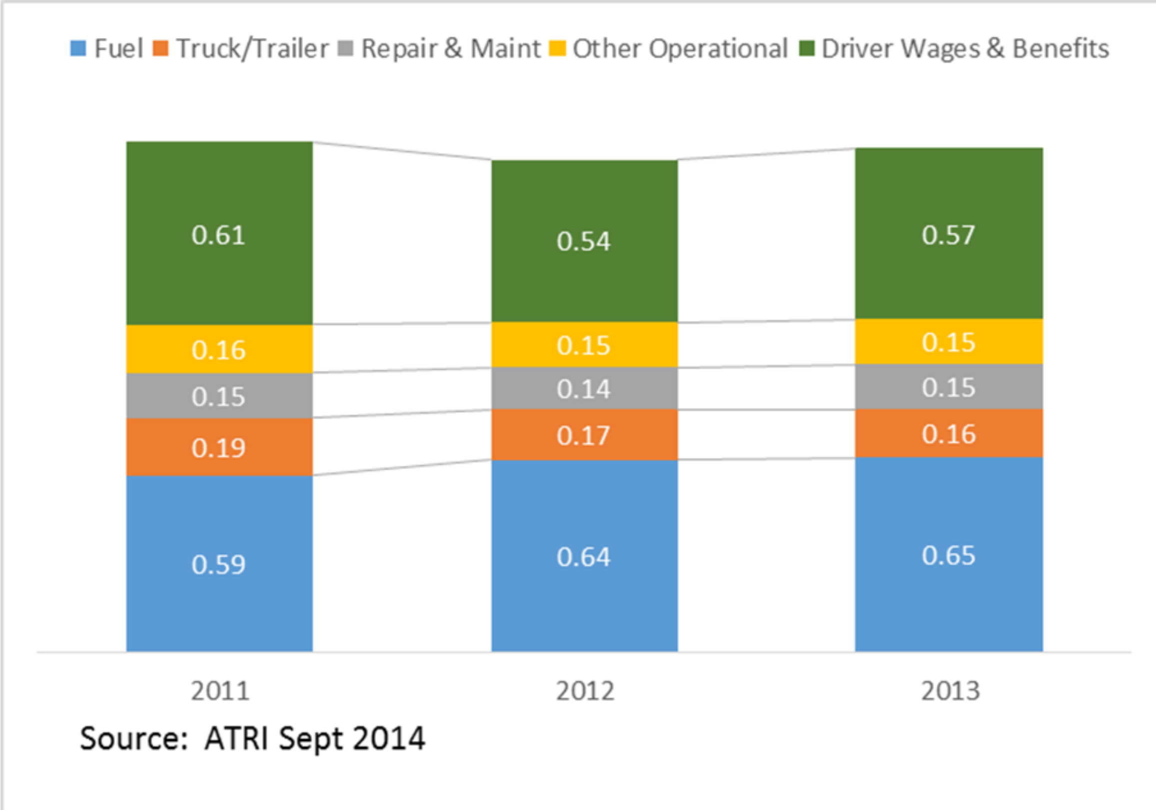


Figure 2: Trucking Operational Cost

Source: American Transportation Research Institute 2014.

Investment into proven technologies and practices that allow a truck or fleet to increase their fuel efficiency – meaning that they can do the same amount of business while spending less on fuel – is a hugely promising option for the industry in light of this trend.

To understand, and thereby better facilitate, the uptake of such technologies, NACFE conducts an annual review, "the Fleet Fuel Study," of the industry-wide adoption rates of nearly 70 fuel-efficiency technologies currently available for Class 8 tractors and trailers. This work, available on the www.nacfe.org website, has been called "the most comprehensive study of Class 8 fuel efficiency adoption ever conducted." (Truck News, 2012)

Figure 3: Fleet Fuel Study Participants

The overriding take-away from the most recent Fleet Fuel Study, completed in 2014, is that fleets are enjoying dramatic improvements in their fuel efficiency by adopting combinations of the various technologies surveyed — savings of about $7,200 per tractor per year compared to a fleet that has not invested in any efficiency technologies. This finding was drawn from research into the use of fuel-efficiency products and practices by ten of the largest, most data-driven fleets (Figure 3). Those fleets represent both regional and long-haul tractors and trailers, in both dry goods and refrigerated cargo movement, and boast a combined inventory of 41,000 tractors and 130,000 trailers. The 2013 and 2014 studies each reviewed a decade of those ten fleets' specific experience with the sixty-plus technologies. Each fleet shared the percentage of their new purchases of tractors and trailers that included any of the technologies. They also shared ten-years-worth of annual fuel economy data for the trucks in their fleet. With these two pieces of information, which will be updated every year, NACFE is able to generate insights into the following aspects of the industry:

- Adoption curves for each of the technologies, indicating which technologies have the steepest adoption rates, which are being adopted steadily but slowly, and which are not being purchased at all. These curves also show how uniformly (or not) fleets are acting in their adoption patterns.
- Identification among the various fleets of the innovators, early-majority, late-majority, and even laggards, in new technology adoption.
- Comparison of technology adoption rates to overall fuel efficiency.

1.1 Trucking Efficiency's Confidence Reports

NACFE's Fleet Fuel Studies provide useful insights into adoption trends in the industry, as well as into the specific practices of different major fleets. NACFE hopes that this information could alone spur additional investment, particularly by fleets that may be lagging behind the overall industry when it comes to certain widely-adopted technologies. However, in the course of conducting the studies, it became clear that some technologies are still only being adopted by the most progressive or innovative of fleets in spite of their showing strong potential for achieving cost-effective gains in fuel efficiency. In order to facilitate the wider industry's trust in and adoption of such technologies, NACFE and CWR formed Trucking Efficiency and began this series of reports, called "Confidence Reports," which will take an in-depth look at those most-promising but least-adopted technologies one-by-one.

Confidence Reports provide a concise introduction to a promising category of fuel efficiency technologies, covering key details of their applications, benefits, and variables. The reports are produced via a data mining process that both combs public information and collects otherwise-private information (which is shared with Trucking Efficiency for the purpose of the reports), in order to centralize an unparalleled range of testing data and case studies on a given technology set.

The *optimization* of electronic engine parameters for fuel economy is one such technology set. Compared to other technologies covered in the Confidence Report series, this report does not simply look at adoption, as all trucks come with engine parameters installed. However, not all fleets are choosing to truly optimize that software for fuel efficiency, and therefore the goal of this Confidence Report differs slightly from the rest in the series, as it was recognized from the study's inception that it would not be feasible to catalogue all of the parameters available today from all of the different engine manufacturers, nor to assign reliable estimates of potential performance gains to each of them. Rather, this report seeks to assess the way fleets are *using* parameters today, in order to identify room for improvement and additional fuel savings, highlight and share best practices, and dispel any misconceptions which might be uncovered.

The core objective of this Confidence Report is to provide the leadership of fleets with a comprehensive overview of selecting, setting, and ensuring the optimization of electronic engine parameters for improved fuel efficiency. Visit www.truckingefficiency.org to view this and other completed reports on tire pressure systems, 6x2 axles, idle reduction and electronically controlled transmissions.

1.2 Methodology

Trucking Efficiency's Confidence Reports are researched by an unbiased team of trucking industry experts. For this electronic engine parameters report the core study team included: Dave Schaller, Consultant, Schaller LLC; Robert Weimer, Consultant; and Mike Roeth, NACFE Executive Director and CWR Trucking Efficiency Lead.

In September 2014, this study team began assessing the current state of the optimization of electronic engine parameters for improving the fuel efficiency of Class 8 tractor trailers. The team used a "360^{o}" technique to gather existing data on the programing of parameters, in order to uncover any points of industry-wide agreement or areas of confusion. The study team started this research by meeting with heavy duty engine suppliers, dealer sales personnel, and fleets over the course of the autumn months.

Following these general discussions the study team conducted targeted deep-dive interviews with four of the industry's engine manufacturers, and for the first time ever, four truck and engine dealerships, relating to test data, feature nomenclature and availability, compatibility issues, and the process by which engines are programmed, whether for new trucks or in the field on existing trucks.

Nine large fleets were also confidentially interviewed by the study team. All nine had significant processes in place to optimize their engine parameters, usually for dozens of specific duty cycles (via templates), as well as relatively robust processes to ensure their new trucks are programmed correctly and that the parameters remain as desired over time. Finally, the study team collaborated with the Michelin Fleet Forum to survey medium and smaller fleets about their perceptions of and experiences with programming engines specifically for reducing fuel consumption; 45 fleets participated in that survey, of which 41 had first-hand knowledge of parameter settings and processes.

The study team presented its initial findings, drawn from these interviews and surveys, to a group of fleets, manufacturers and others – participants in a Trucking Efficiency Workshop held in mid-November, 2014, in Allentown, PA. These workshops are quarterly, regional meetings where small groups discuss and even debate the findings of Trucking Efficiency's reports. A schedule of upcoming workshops can be found at www.truckingefficiency.org.

1.2.1 Preliminary study questions used in study team interviews

Sample Questions for Fleets:

- Which of the fuel economy related programmable parameter groups do you use on your vehicles?
- Are the programmable parameters in your fleet's trucks all set identically?
- How difficult is it to change parameter settings across your fleet when you decide to change some of the settings (such as maximum vehicle speed or idle temperature settings)?
- Do you monitor trucks to insure the parameters are set the way you intend them to be set?
- What is your fleet's biggest challenge with programmable parameters?
- Has your fleet had the engine manufacturer visit to help optimize the values of your programmable engine parameters?
- Does your fleet have procedures to ensure you have a "master file" of engine settings that is the latest version, and that this master file set is on all new truck orders?

Sample Questions for OEMs and Suppliers:

- Is any standardization sought with other OEMs in the names and terms for parameters?
- What is the most effective way to train fleet personnel on programmable parameters?
- Which parameters provided the greatest improvements in fuel economy? Where could fleets do a better job of obtaining fuel savings with parameters?
- When working with fleets on improving their parameters, what types of improvements in fuel economy are typical, and what is the most extreme improvement available?
- How many generations of engine controllers & parameters do you currently have in the field? In the next 5 years, what percentage increase in the number of programmable parameters is foreseen? (Perhaps due to other technologies such as automated transmissions, GPS smart terrain, safety systems, CSA, etc.)

Sample Questions for Dealer Sales Personnel:

- How well-understood are each of the fuel economy related programmable parameter groups for your customers?
- What significant issues have your customers encountered with programmable parameters?
- Do most fleets appear to have tight controls on the master list of programmable parameters?
- How often do your customers change some aspect of how the programmable parameter settings?
- Have you and/or your factory representative worked with any of your fleets to help optimize the values of your programmable engine parameters? (What was the fuel economy improvement that resulted?)
- Can you or any of your sales teammates change a vehicle's parameters with your laptop?
- How often does your OEM train you on parameters, and how do they provide that training?

2 Overview of Electronic Engine Parameters

Electronic engine parameters, often simply called engine parameters or programmable parameters, are customizable software settings available for the diesel engines of trucks, with which end users can tailor the operation of those engines for improved efficiency and performance. Some engine parameters are specifically designed to lower fuel consumption, and this subset of parameters are the focus of this Confidence Report.

Programmable engine parameters first entered the commercial trucking world with the advent of electronically controlled diesel engines in the mid-1980s. Programmable parameters provide yet one more way for the trucking industry to highly customize an already complex product – the engine.

Although they were first introduced with only two dozen or so specific features, there are now over 100 different parameters on any engine being operated in the North American Class 8 truck market. All of these settings are invisible to users, as they exist simply as software housed inside the engine's ECM (Electronic Control Module). In many cases even the ECM is hidden behind the frame rail and under the hood of a truck. ECMs are highlighted on the cutaway display engines in the photos below.

Figure 4: Location of Engine Control Modules

Engine parameters are analogous to the features on many of the personal electronics now common in our daily lives. For instance, televisions now have numerous user-selected parameters that can be programmed by the owner to fit their individual tastes and needs. It is likely that your television now has software-based settings for things such as colors, brightness, and other basic elements that were originally actual physical knobs on the television. It is also likely that you current television has gone far beyond that to include features such as channel lock-outs that prevent children from seeing certain channels, or the ability to automatically enable close captioning whenever the set is muted.

Such software features are not only found on televisions. Other common devices with programmable parameters include:

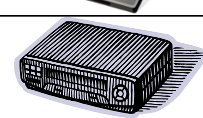
Smart Phones	Ring Tones, Screen locks, Wallpaper, Language, Screen Brightness, Camera flash on/off/auto, Block call times…	
Laptops	Mouse Button (Right handed/left handed), Wallpaper, Screen Savers…	
Car audio	Loudness on/off, Speed sensitive volume, Radio presets, Equalizer selection…	

Figure 5: Programmable Features on Personal Electronics

All such software is developed by engineers working to satisfy customer requirements, which are many and diverse. Different companies also seek to differentiate their products from competitive offerings in the marketplace, with brand-names, patents, trademarks, and copyrights.

In another similarity to personal electronic devices, each Original Equipment Manufacturer (OEM) of trucks and engines today has different descriptions or terminologies for their specific products and features, just as Windows-based PCs vary in terminology and function from Mac computers, and Apple cell phones vary from Androids. It is highly unlikely that many people have explored all of the possible software programmable features on their televisions or cell phones. We are likely to seek out a particular setting only when we find a need for it, and otherwise to leave all of the other features in whatever default mode the manufacturer selected. In this, as the Confidence Report research confirmed, the trucking industry is analogous to the individual consumer – setting a few parameters and leaving the rest with the defaults. In other ways, the situation of a trucking fleet is much more complicated. Most of us only carry one personal cell phone, and we often stick with the same brand when we upgrade specifically because we are familiar with its functions. Fleets, on the other hand, purchase trucks and engines in a variety of makes and models from a variety of OEMs over time.

2.1 Categories of Fuel Economy Parameters

Out of the hundreds of programmable parameters available today this Confidence Report focuses only on those most directly capable of enhancing fuel economy for highway tractors which are advertised and orderable in most Class 8 engines.

Given the large quantity of parameters, and the diversity of features and terms used to describe them, this report is not structured to replace the OEM-generated materials a fleet will have to consult to understand how to optimize each OEM's particular set of parameters when placing a new truck order. Rather, this report discusses the broad pathways by which engine parameters can be used to improve fuel economy. Readers should note that additional parameters for some of the engines are only alterable at a dealership level, and that there may even be parameters which are entirely proprietary and confidential, and can only be altered by highly trained OEM personnel.

The Confidence Report breaks down the parameters which can impact fuel economy into six categories, according to the aspect of fuel use that the parameters address or the mechanism by which they address it, though there is some overlap between them. Those categories of parameters are:

1. Vehicle Speeds
2. Vehicle Configuration Information
3. Engine Speed and Torque Limits
4. Idle Reduction
5. Driver Rewards
6. Miscellaneous MPG-Related Features

See Figure 6 for more general details on these. For an expanded listing of the engine parameters available from engine manufacturers for each of these categories, see the Appendix and Tools portion of this report package.

PARAMETER GROUP	SAMPLE PARAMETERS IN THIS GROUP
Vehicle Speed Limits	• Accelerator Maximum Vehicle Speed • Maximum Cruise Control Speed • Road speed governor droop • Gear down protection
Vehicle Configuration Information	• Tire Revolutions Per Mile • Rear Axle Ratio • Transmission Top Gear Ratio(s) • Vehicle Speed Sensor Pulses Per Revolution
Engine Speed (& Torque) Limits	• Progressive Shifting (RPM allowed by vehicle MPH ranges) • Load Based Speed Control • Vehicle Acceleration Control
Idle Reduction	• Number of minutes before Idle Shutdown Timer turns off the engine • Hot Ambient Air Temperature • Cold Ambient Air Temperature • PTO override
Driver Rewards	• MPG Thresholds For Rewards • Idle Time Thresholds For Rewards • Additional MPH Allotted For Attaining Thresholds
Miscellaneous MPG Related Features	• Engine Brake Service Brake Activation • Engine Brake Cruise Control Activation • Upshift Recommended Gauge Cluster Light Enable (Manual Transmissions)

Figure 6: Sample Parameters from each Category

For the sake of this Confidence Report, "generic," easy-to-understand parameter names will be used. Given that all truck OEMs offer some portion of their models with Cummins engines, the Cummins parameter names should be the most familiar to the widest audience, and therefore in many cases the Cummins name for a parameter has been used here. Some OEMs already organize their parameters into groups or buckets of features, but this is not common, so the categories used in this report are not universal across the industry.

NOTE FOR THE READER:

As the "rabbit hole" of each of these six categories runs too deep for this report to fully explore the different combinations of parameters within each category, as offered by each OEM, much less how these parameters should be set for a given fleet's operations, the study team chose to look closely at only the first category, that of vehicle speeds, and to look particularly closely at the different OEM features available for one parameter within that category – maximum vehicle speed. General overviews are then given for the remaining five categories. Moreover, note that not even the information on vehicle speed limits given here is exhaustive, and that a similar plethora of information exists for each of the other five categories.

2.1.1 Vehicle Speed

Using programmable parameters to optimize vehicle speeds for maximum fuel efficiency is much more complicated than simply saying “the truck will not be allowed to go faster than XX mph.” As such, there are a variety of parameters which fall into the category of controlling vehicle speeds in different ways under different circumstances. Not every manufacture’s engine will have all of these, but all engines will have more than one.

The most generic and widely available parameters that fall within the category of controlling vehicle speed in various situations or under certain conditions are:

- Accelerator Maximum Vehicle Speed
- Accelerator Lower Droop
- Maximum Cruise Control
- Gear Down Protection
- Global Maximum Vehicle Speed
- Driver Reward Best Speed
- Road Speed Governor Drop
- Reserve Speed Increase Delta

The most commonly used out of the programmable parameters is one that sets a limit on what speed can be obtained by fully depressing the accelerator pedal on level ground. . While this feature may seem like it should be straightforward in function (limiting road speed) and value (decreasing overall drag of the vehicle and forcing operation in the engine’s sweet spot for fuel economy), fleets specifying engines today encounter a range of names and even slight variations in functionality from OEMs for this parameter, including:

- Accelerator Maximum Vehicle Speed (Cummins)
- Max Road Speed (Detroit)
- Customer Vehicle Limiting Speed (Mack)
- Max Accelerator Vehicle Speed (Navistar)
- Maximum Accelerator Pedal Vehicle Speed (PACCAR)

The key words for understanding this parameter are “accelerator” and “level,” because a vehicle could go faster in certain situations depending on how other related parameters have been set. Establishing this is absolutely critical to fuel efficiency, so that the powertrain can then be set up to operate in the sweet spot of the engine’s fuel map (the amount of fuel required under different speed, torque and other inputs). Thus the rest of the parameters in this category will need be set based on whatever decision is made by the fleet regarding its maximum vehicle speed parameter. Mainly, every fleet must establish whether any of the parameters will allow operation <u>above</u> the flat ground accelerator maximum, as all of the other parameters in the above list can be set to allow operation above the Accelerator Maximum Vehicle Speed under one or another condition.

For example, if the Accelerator Maximum Speed were set to 62 MPH, but the Accelerator Lower Droop parameter were set to 3 MPH, then the vehicle could actually reach 65 MPH on a downhill run, in order to build momentum for the next hill. A fleet who decided to set these two parameters set thusly would *then* need to ensure that the drivetrain gearing of their trucks was specified to be able operate efficiently not at the theoretical “max speed” of 62 MPH, but at the higher speed of 65 MPH.

All decisions about engine parameters will have a close interrelationship with decisions about other physical specifications of the vehicle. For example, if a fleet aims to encourage drivers to use cruise control to improve fuel efficiency, they could set the Maximum Cruise Control parameter to operate at a higher speed than the maximum accelerator pedal parameter would allow on flat ground (such as a cruise speed maximum of 63 MPH versus an accelerator pedal maximum of 62 MPH). But other fleets may choose to handle this parameter differently, setting their maximum cruise control speed slightly lower than their maximum vehicle speed, to allow the driver to depress the pedal and accelerate for passing.

Some engines also have a “Pass Smart” feature that allows the driver to pump the accelerator pedal twice to attain an additional programmed amount of vehicle speed for passing situations. This opens up another group of parameters not only on the amount of speed, but also possibly the time duration and frequency with which a driver can utilize this benefit.

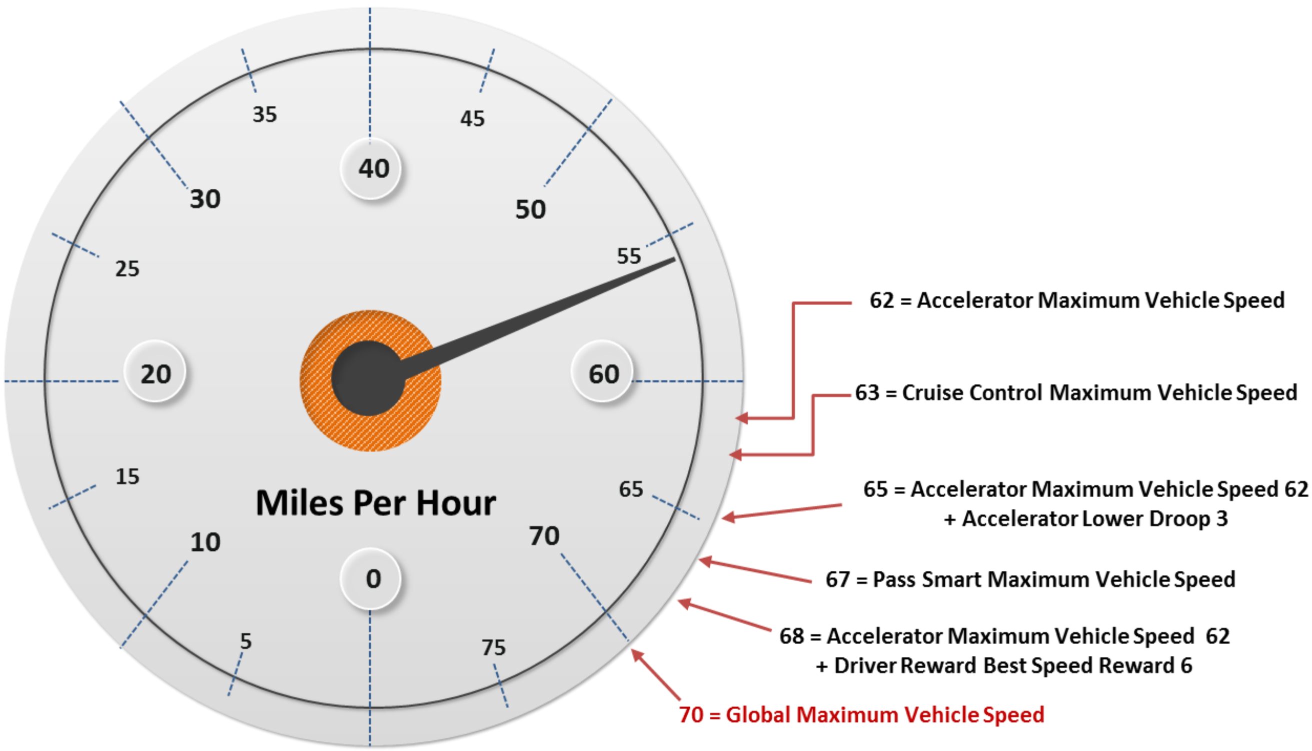
Once the top vehicle speed has been determined, a fleet must ensure that the vehicle is in top gear when it is traveling at its maximum speed. The Gear Down Protection parameter ensures that drivers cannot cruise in a lower gear setting while traveling at top vehicle speed, which would jeopardize overall fuel economy. The name “gear down protection” is occasionally misunderstood, and in reality has absolutely nothing to do with preventing down shifting.

Another parameter related to vehicle speeds which is sometimes misunderstood due to its name is that of Global Maximum Vehicle Speed. This is not a parameter to set the vehicle speed in other countries. It is an overall limit to what the vehicle can accomplish in terms of vehicle speeds, hence it is global in nature over all of the other parameters.

Finally, vehicle speed parameters can interact with the settings of parameters from other categories, such as idle reduction, to reward a fleet’s best drivers with higher speeds. For example, a driver who attains their fleet’s set targets of 7.0 MPG and 10% idle time, as recorded by the electronics in their engines, could activate a “Driver Reward Best Speed” parameter that raises their maximum speed by 2 MPH, or whatever value the fleet selects – in the case of the Cummins ISX engine, the parameter can be set all the way to 20 MPH above the Accelerator Maximum Vehicle Speed.

In terms of the physical specifications of the truck, aspects of the transmission, rear axle ratios and tires should all be selected with a consideration of whatever has been set as the vehicle’s top operating speeds in mind, in a variety of possible conditions, in order to create a vehicle that operates at the most fuel efficient engine RPM while still maintaining proper gradeability and startability.

Figure 7, below, illustrates how all of the parameters governing vehicle speed might be set at different levels. This illustration is not meant to show any recommendation for settings for an actual truck, but merely the range of speeds that the parameters might allow for.



NOTE: This is an example for illustrative purposes only: Many variations on this theme can be programmed

Figure 7: Vehicle Speed

2.1.2 Vehicle Configuration Parameters

As mentioned above, a fleet's chosen parameters should impact the physical specifications of their trucks. At the same time, one major category of the engine electronic parameters that can determine ultimate fuel economy – that of vehicle configuration parameters – will need to be set at the vehicle OEM factory to match the vehicle's componentry as built. This category includes parameters for recording transmission gear ratios, rear axle ratios, and tire revolutions per mile.

Because these will be specific for each custom model of truck, this report does not consider them in depth. But it is critical to know that if any of these physical components (tires being the most likely) are ever changed away from the original vehicle specification, the engine parameters must be reprogrammed to the new settings, such as the new revolutions per mile for tires. Failure to do so will result in not only an incorrect speedometer and odometer readings, but also impact the function of vehicle speed parameters, since the engine will be incorrectly calculating vehicle speed.

Trends around engine speeds and axle ratios exemplify this. When electronic engines were first introduced a 3.73:1 rear axle ratio was common for highway tractors cruising down the interstates at roughly 1500 RPM. As the industry continues to strive for fuel efficiency, engine operating speeds have been lowered thanks to the low-speed high-injection pressure characteristics of a high pressure common rail fuel system, and variable geometry turbochargers. Additionally, the reduction of friction inside the engine and lower parasitic loads from sources such as the oil and water pumps has assisted in lowering speeds, such that the most efficient operating point or "sweet spot" for big bore diesel engines has dropped to between 1150 and 1250 RPM, and it is reasonable to believe that these speeds will go even lower. The dark blue area of the engine map shown in Figure 8, from Volvo Truck, shows the operating area where the engine is most fuel efficient. This figure also demonstrates the move to faster rear axle ratios, characterized by the term Down-speeding in order to lower the engine speed while delivering acceptable vehicle operation.

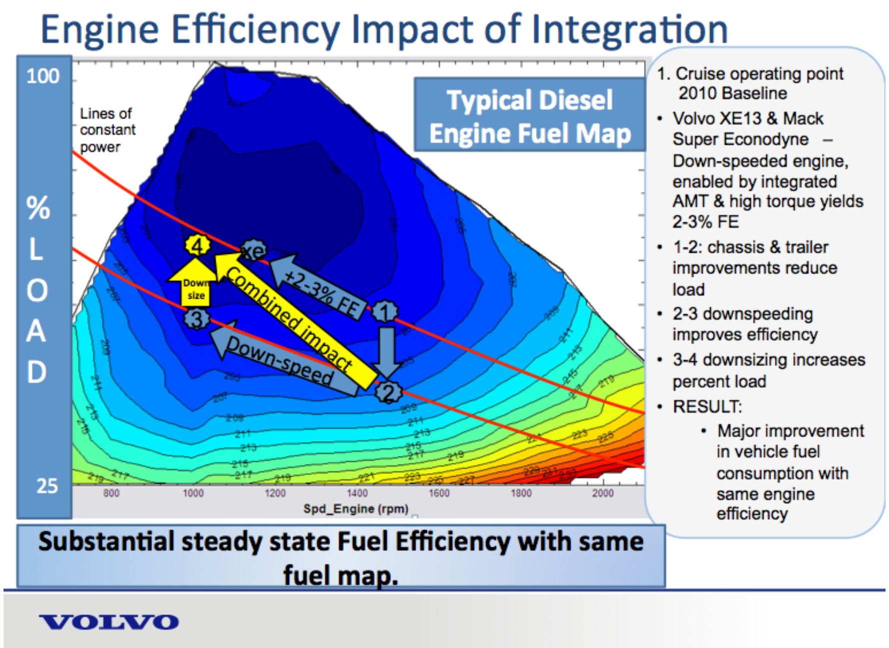


Figure 8: HD Diesel Engine "Sweet Spot" for Fuel Economy

Rear axles have changed alongside engine speeds, and the market now has offerings with ratios such as 2.64, 2.47, and 2.28, to match the engine speeds and transmission ratios. Figure 9 clearly shows the shift in rear axle ratios sold by Meritor over just the past four years. These various and progressive changes have meant that programmable parameters must also continue to change in areas such as progressive shift and gear down protection, among others. For fleets this means that the longer they keep their vehicles, the more variations of gearing that will be present in the fleet at any given time.

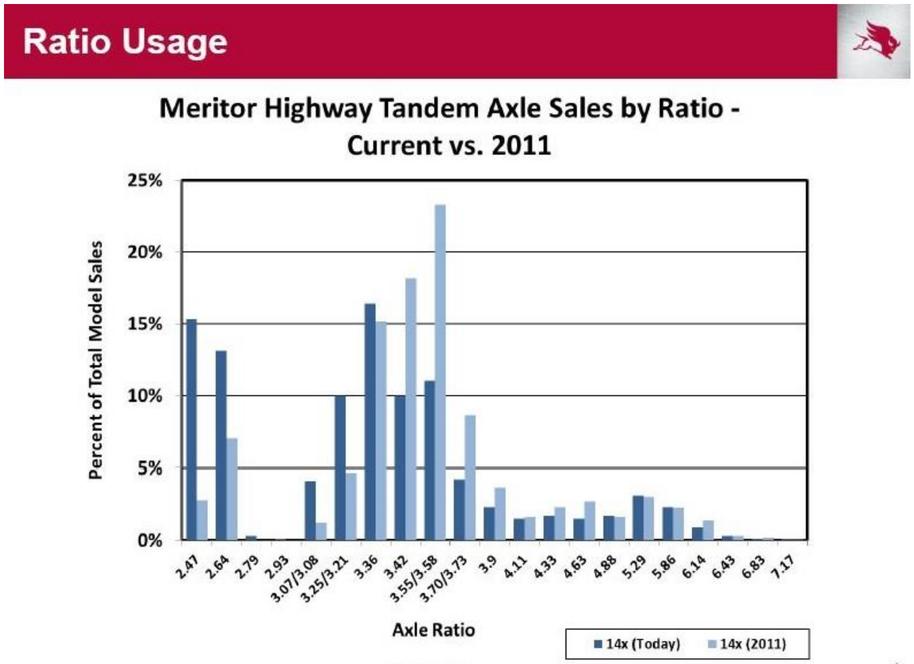


Figure 9: Move to Faster Rear Axles

Finally, no other parameter that has been included in this group for the sake of this report is the customer password(s). In some engines it may be several passwords with different levels of control. For instance there may be a password that allows Driver Rewards information to be reset, while a different password protects the actual parameters themselves.

2.1.3 Engine Speed (and/or Torque) Parameters

Limiting engine speed (and/or engine torque) based on road speed is another method of obtaining fuel savings from engine parameters. Likely the best-known such parameter is “Progressive Shifting,” which sets up boundaries to limit the engine’s RPMs at lower vehicle speeds in order to force an upshift into a more fuel efficient transmission gear for the given vehicle speed. Figure 10 illustrates how RPM limits can be programmed for various bands of road speed. As illustrated, some engines can be programmed to distinguish between heavy (high) loads and light (low) loads. “RSL” in this illustration from Navistar indicates the “Road Speed Limit” for this particular example.

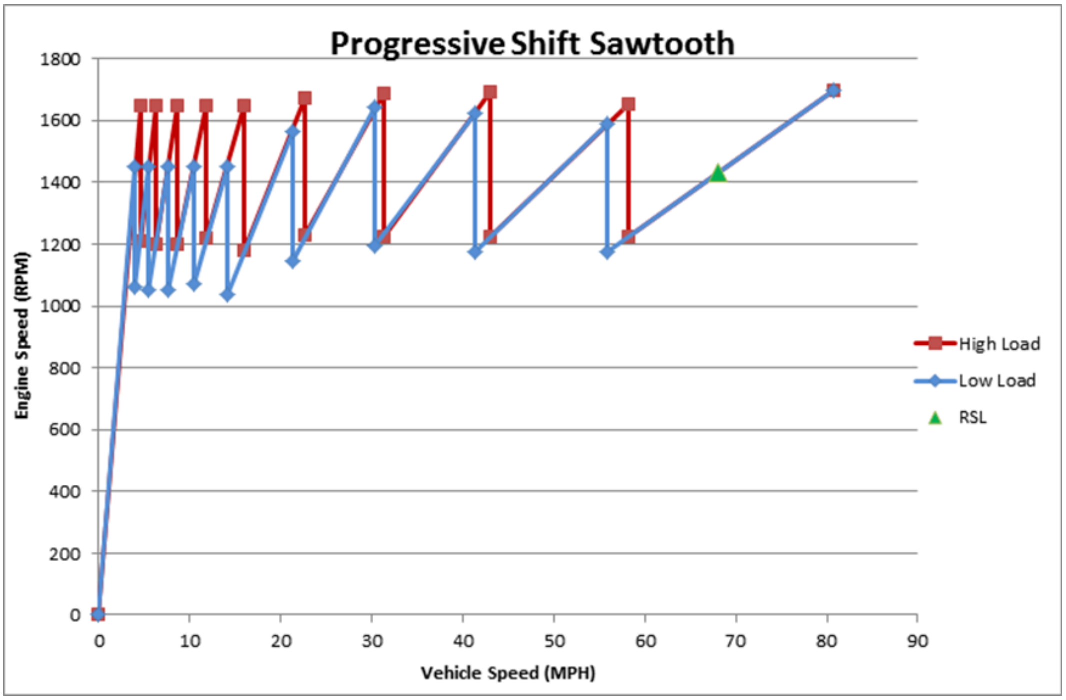


Figure 10: Progressive Shift Points

However, even Progressive Shifting, like Maximum Vehicle Speed, is actually a class of parameters unto itself within the broad category of parameters which optimize engine speed and torque. A fleet can expect to set roughly a dozen individual parameters to fully implement progressive shifting in some engines. One such parameter was in fact covered in the proceeding section – "Gear Down Protection," a parameter that controls engine speed in relation to vehicle speed. This overlap exemplifies the complexity and "shades of grey" a fleet faces when attempting to understand and optimize their full range of programmable parameters.

Note, however, that the specification of a tractor with an Automated Manual Transmission (AMT) can eliminate the need for managing most of the parameters within this category, as the transmission will take responsibility for shifting the gears in the most productive and efficient manner (unless the driver is allowed to operate the AMT in a manual mode). However, while AMTs can eliminate some of these engine parameters, some AMTs also introduce new parameters of their own, such as the ability to disable manual gear selection mode. On the other hand, if manual shift mode is kept available to the driver of an AMT-equipped truck, the progressive shifting parameter can still be utilized, though it will possibly be more difficult to set to ensure it does not interfere with the AMTs shift operation.

2.1.4 Idle Reduction Parameters

As outlined in a previous Trucking Efficiency Confidence Report, controlling idling costs is a significant challenge for fleets, though one which also offers substantial savings. Programmable engine parameters can play a major role in the various idle reduction strategies and technologies that fleets employ.

A partial list of the parameters available which impact idling in some way is found in Figure 11.

Feature/Parameter	Range	Default
Idle Engine Speed — Parameter	500 – 800 RPM	600 RPM
Idle Shutdown — Feature Option	Enable/Disable	Disable
Idle Shutdown Timer — Parameter	2 – 1,440 minutes	60 minutes
Idle Shutdown Manual Override — Feature Option	Enable/Disable	Disable
Idle Shutdown in PTO — Feature Option	Enable/Disable	Disable
Idle Shutdown PTO Load Override — Parameter	0 – 100%	10%
Idle Shutdown Ambient Air Temperature Override — Feature Option	Enable/Disable	Disable
Idle Shutdown Intermediate Ambient Air Temperature — Parameter	0 – 120° F	60° F
Idle Shutdown Hot Ambient Air Temperature — Parameter	0 – 120° F	85° F
Idle Shutdown Cold Ambient Air Temperature — Parameter	0 – 120° F	30° F
Idle Shutdown Hot Ambient Automatic Override — Feature Option	Enable/Disable	Disable
Idle Shutdown Manual Override Inhibit Zone — Feature Option	Enable/Disable	Disable

Figure 11: A Partial List of Idle Reduction Parameters

The most common parameter for controlling idling entails controlling the length of time that idling can last, and it is generally known as an "Idle Shutdown Timer" parameter. The Idle Shutdown Timer was offered for many years as an option on all electronic engines. Given ongoing legislative changes (discussed in an upcoming section of this report), some vehicles now come with the idle timer parameter permanently programmed to a 5 minute maximum, and cannot be reset.

Most engines also now have idle control parameters which set limits on when idling can occur based on outside ambient air temperature. Many idle laws are written with the understanding that idling without interruption is acceptable for running air conditioning when the ambient air is above a certain warm temperature, and likewise acceptable for heating when the outside temperature drops below a certain point. These parameters can actually become very complex, but Figure 12 below gives a general idea of the relationship between the three:

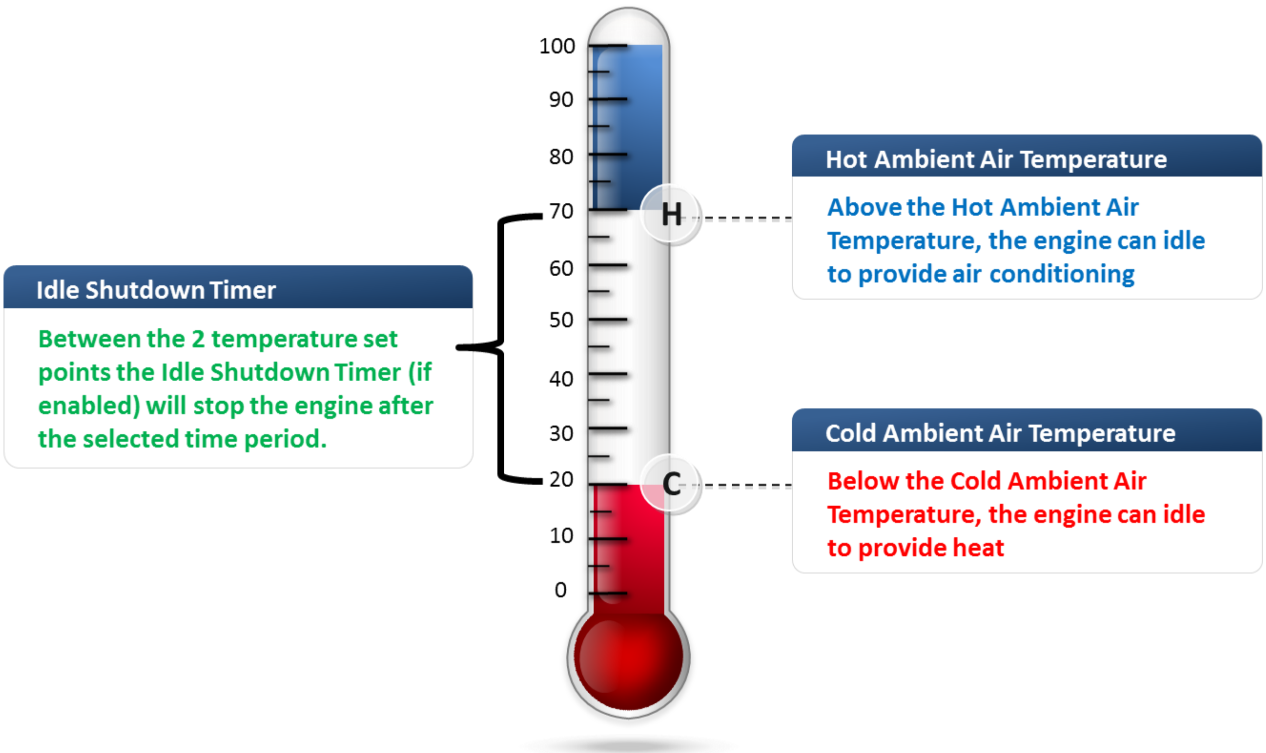


Figure 12: Idle Shutdown Ambient Air Temperatures

Given the different performance characteristics of idle reduction systems such as fuel operated heaters, diesel auxiliary power units (APUs), battery HVAC systems, and automatic engine start/stop systems, not to mention the different regional climates in which fleets operate, different fleet temperature settings will be required for these category of programmable parameters.

2.1.5 Driver Reward Parameters

This category of parameters exists to allow fleets to incentivize their drivers to attain and maintain a fleet's desired goals for idle time and fuel economy. Fleets not only set their goals, they also set the reward that a driver receives in terms of the additional speed that driver will be allowed to go above the fleet's overall maximum speed. Drivers see this as an advantage due to the fact that higher speeds get them home more quickly, and moreover due to that fact that most are paid by the mile and not by the hour. (Certainly this is not the only type of driver reward which can incentivize meeting MPG and idle goals). This parameter was already discussed briefly in the section on Vehicle Speeds, as it is certainly related to that category.

Though they vary from OEM to OEM, driver reward parameters generally entail a three-tiered system, which rates drivers according to:

1. Best (or Excellent) Level
2. Good Level
3. Expected Level

Each of these levels can be set with different stringencies for fuel economy (i.e. 7.8 MPG might equal "best" and 7.0 MPG might equal "good") and for idling times, and each of the levels can offer a different degree of reward in terms of the extra MPH a driver is allowed to go above the vehicles' speed limiting parameters. These systems are even capable of being programmed to penalize drivers who are not attaining the "Expected" levels.

There are many additional nuances and settings within the category of Driver Reward Parameters which can be programmed into an engine so that the truck will behave differently in different scenarios.

2.1.6 Miscellaneous MPG Parameters

There are a variety of other parameters that have at least some influence on driver behavior and fuel economy. For instance, one OEM offers a programmable option that will illuminate a light in the instrument cluster when the driver should make an upshift to better match RPM with road speed for fuel economy.

More commonly, depending on the engine model, one or more parameters focused on the operation of the engine brake may be available. Usually if an engine brake is set to the "on" position the engine brake will activate and begin to decelerate the vehicle once the accelerator pedal is released. A programmable parameter with a name such as "Service Brake Enable Engine Brakes" would change this, making it so that the engine brake will not activate until the service (air) brakes have also been applied by the driver through the brake pedal. This is thought to boost fuel economy by promoting coasting until the engine brake is actually desired and the vehicle must be slowed. Although this feature is set up slightly differently from one OEM to the next, any iteration of such a parameter would offer similar benefits.

Engines may also include parameters that govern the operation of the engine brake while in cruise control. Some engines can be programmed to enable the engine brake while in cruise control to limit how far in excess of the vehicle's maximum top speed can be obtained before the engine brake is activated to slow the vehicle. This feature provides the benefit of tighter control of overall vehicle speed going downhill, but does take away some of the fuel saving benefits a Class 8 tractor-trailer can enjoy thanks to gravity.

2.2 Programming Methods and Tools

After completing all of the work to select the appropriate settings for the various engine parameters, each new truck must be actually programmed with those settings. Programming can occur at the end of the truck assembly plant, at a truck dealership, or at another modification center where the OEM or the end user has authorized the performance of this service. Crucially, electronic engine parameters can be changed at any point during the service life of the truck.

There are several key participants in the successful implementation of programmable parameters including:

1. Fleet Management (Operations, Maintenance, Purchasing,)
2. Drivers
3. Dealership Sales
4. Engine & Vehicle OEM (may be one in the same or different)
5. Dealership Service
6. An approved Modification Center

Figure 13 illustrates the steps and participants involved in this continuous loop engine parameter optimization:

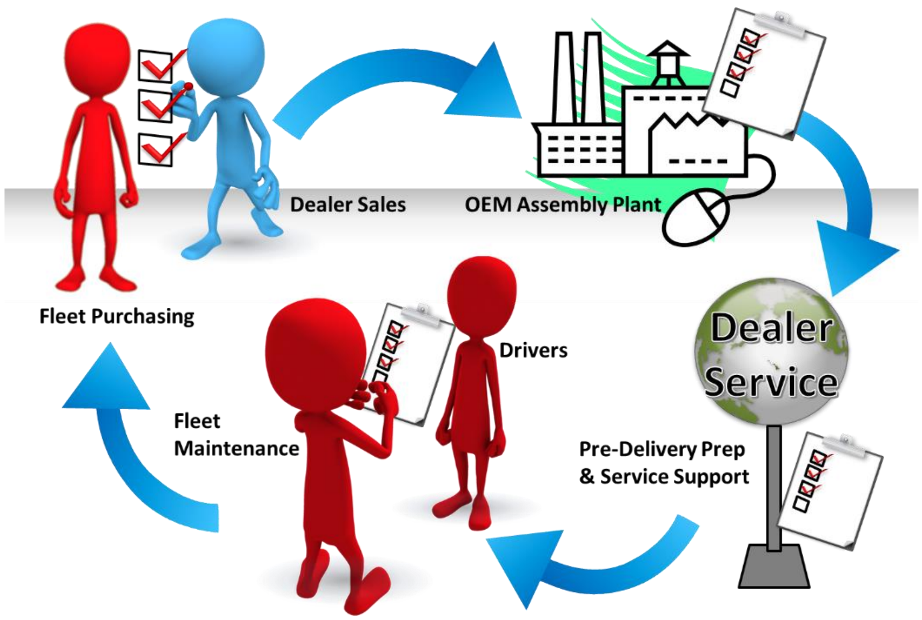


Figure 13: Participants in Engine Parameter Optimization

Once a fleet takes delivery of a vehicle, they can continue to make changes to the programmable parameters in one of two ways: they can purchase an electronic service tool and train someone to make the changes, or they can take the vehicle to a dealership that has the tools and expertise to make the changes for them.

Originally, in the 1980s, all interaction with these parameters was conducted through proprietary, dedicated, electronic service tools created by each of the engine manufacturers. Shortly thereafter the vehicle OEMs created production line programming systems to avoid the need to have a factory worker program numerous lines of parameters via an electronic service tool with a 100% accuracy rate. The OEMs' system became known to many as the Vehicle Electronics Programming System, or "VEPS." As the penetration of electronic engines (and the number of available parameters) grew substantially in the early 1990s, common platforms for service tools evolved, shortly followed by the introduction of the laptop computer as the service tool interface.

Today, engine parameters should ideally be managed as part of a continuous dialog, including training and systems support, from the OEMs to their dealerships. This interaction should then extend to the fleets, with the dealership taking the lead, supported by the relevant OEM. Internally, a fleet must have consensus around how the programmable parameters will govern the fleet's vehicles. All service personnel and drivers must then be trained so that they too understand what the electronic engine systems are doing and how they benefit everyone. Other participants in this system may include "modification centers" that take vehicles from the OEM production line and prep them for fleet delivery with decals, fire extinguishers, and in some cases engine parameter programming.

Along with all of these key actors, fleets require information tools to optimally select and manage their engines' programmable parameters. The following are three such tools, the last two of which were developed by the study team for this report.

2.2.1 OEM Software Tools

The vehicle OEMs offer fleets (and dealerships) very distinct software tools with which to order vehicles and select engine parameters. Some of those systems require the dealer sales person to convert the parameter name and desired setting through a look-up table into a sales code. Other systems require that a blank be filled in with an appropriate number for each parameter.

Just as every OEM offers its own ordering tool for specifying parameters on a new truck from a dealer, they all also offer their own variation of service tool which fleet's must use to maintain and manage parameters over the life of the truck.

Since every North American truck OEM offers Cummins engines in at least some of their model portfolio, the Cummins PowerSpec tool may be one of the more commonly referenced tools for engine parameters. Downloading this software should be highly useful for anyone looking to learn more details about programmable parameters; see the section entitled "Feature Descriptions" from the main menu, where a wide variety of information on all parameters, functionality and setting options is offered.

The names of the ordering and service tools names for each OEM are listed in Appendix B along with a contact point for any fleet that needs assistance in getting their parameters optimized to find support in doing so. They are also available as separate downloadable files on the website www.truckingefficiency.org.

2.2.2 Manufacturer Parameter Name Comparison Tool

Given the variation in parameter naming conventions between the engine manufacturers, this report contains a tool in Appendix C that compares the specific brand names of the various fuel economy parameters available from engine manufacturers. Software definitions are the true descriptions for these parameters, and the study team used the publicly-available documentation from OEMs, dealerships, and fleets to create this comparison. A detailed industry-wide effort at creating an exhaustive, regularly updated version of this tool would be extremely valuable towards the overall goal of improving the degree to which fleets are able to truly optimize their engine parameters for their own operations. This tool is also available as separate downloadable files on the website www.truckingefficiency.org. Disclaimer: this tool may not be 100% accurate, as the parameters of each OEM change over time.

2.3 Legislation and Programmable Parameters

Legislation has started to impact programmable parameters in at least two of their key categories of functionality: idle shutdown timers and maximum road speed limiters. Some examples for certain geographies are given below, but such legislation exists in many places across North America.

2.3.1 Idle Reduction

California has a five minute maximum idling law for vehicles with a GVWR over 14,000 pounds. Exemptions exist for certified clean idle engines, trucks with power take-off operation, engine temperatures below 60°F, and exhaust catalyst regeneration. Effective in 2008 the exemption for sleepers was eliminated. Also beginning in 2008 a new rule came into effect which mandates that unless a “Clean Idle” engine is purchased, a five minute maximum idle shutdown is to be “hard programmed” for all conditions and temperatures. A parameter that is hard programmed cannot be reset for the life of the truck and is explicitly tamper resistant. Details of these requirements are documented in in title 13, California code of regulations (CCR), section 1956.8(a)(6)(A) through (D).

2.3.2 Vehicle Speed

At the beginning of 2009 Ontario, Canada began enforcing legislation stating that all commercial vehicles must have a vehicle speed parameter set no higher than 105 KPH (65 MPH). Law enforcement officials can now connect a tool to any truck’s data link connector and confirm compliance. This legislation was enacted to reduce the fuel consumption of heavy trucks by roughly 100 million liters of diesel fuel per year, which would also avoid approximately 280,000 tonnes of greenhouse gas emissions. Effective with Canada’s 2014 greenhouse gas regulations, it is possible to earn credits by purchasing a truck with the speed limit hard programmed to below 65 MPH for the life of the vehicle.

2.4 Perspectives on Future Programmable Parameters

The number of parameters has grown significantly since they were first introduced in the mid-1980s. Every engine OEM that spoke to the study team for this report expects that the number will continue to increase as we move into the future, and moreover that ongoing developments in other aspects of truck design and operation will impact the way fleets should optimize their engine parameters.

Looking further to the future, as more new systems come onboard that interact with the engine, and vehicles gain features such as platooning, GPS (Global Positioning System)-based terrain controls, and lane departure systems, it is reasonable to expect innovative engine engineers to create new programmable parameters capable of improving fuel economy even further. For example, with respect to smart terrain controls, the introduction of such technologies will require the creation of parameters that not only enable and disable their various features, but also determine the delay times, speed differentials and fueling/braking rates applied by the terrain controls.

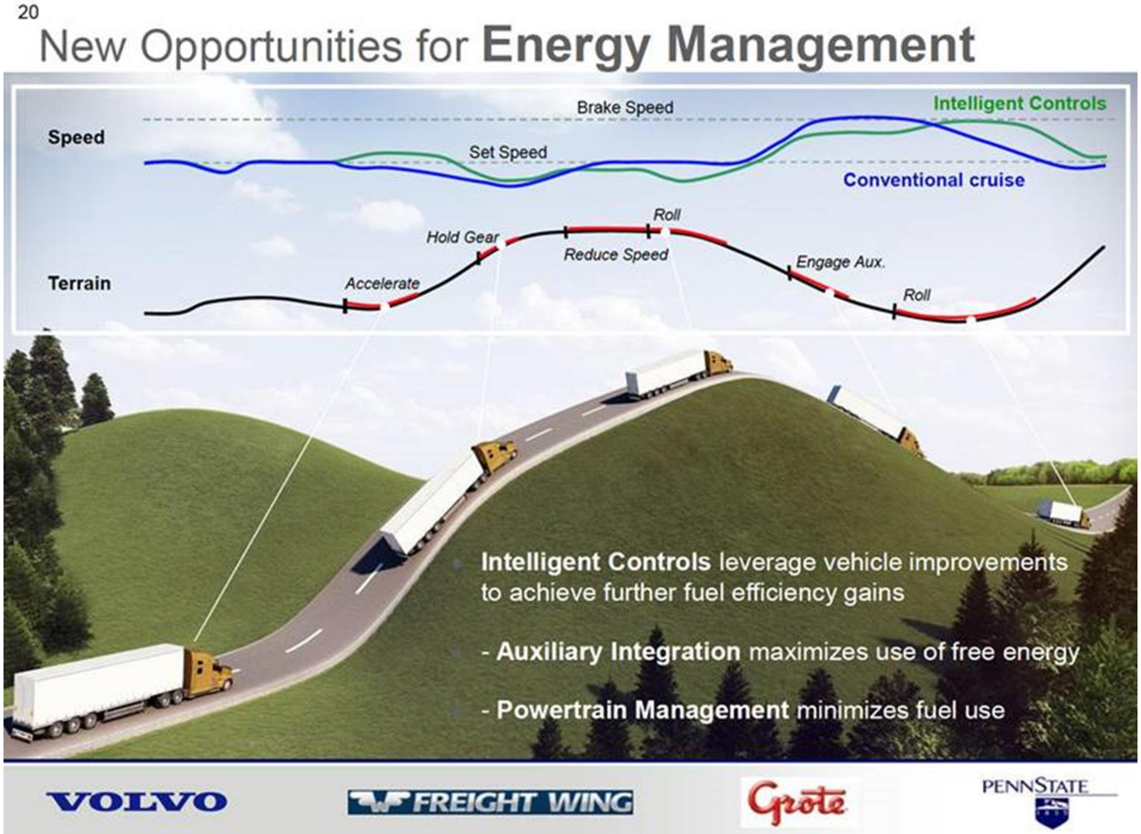


Figure 14: GPS Technologies for Vehicle Speed

Lane departure systems, which are growing in use and total vehicle integration, provide another example. Some fleets may choose to program their engines so that the cruise control will deactivate when the vehicle is deemed to be drifting in its lane. Others may feel that would be a nuisance, given that normal driving has some minor lane departures.

Finally, with regards to fuel economy, as the integration of GPS into overall vehicle operation becomes more and more prevalent it is possible that instead of selecting one top speed for a vehicle a fleet will be able to vary the vehicle's maximum speed with the actual speed limit of the road the truck is currently traveling. Some fleets may elect to match the maximum speed allowed on the given stretch of road, while others may feel their vehicles should travel several MPH lower than the speed limit. Still other fleets will have different rules that differentiate between interstates and state or city roads.

Overall however, telematics could and should be the next big jump in programmable parameter technology. The ability to monitor all of a truck's programmable settings without taking up a bay in the shop or even any technician time represent a major money savings for all fleets that utilize telematics. The more significant gains will come when parameters can be programmed wirelessly. Once such technologies are validated and introducing into commercial operation, fleets will find it much easier to test groups of vehicles with different parameters to determine maximally optimal settings for fuel economy see how much they can improve fuel economy. It is likely that one day soon fleets will change their settings based on their confidence in a given driver, or the route geography, or loads, or weather conditions. None of these options are reasonable today given the need to physically touch the vehicle to make the changes, but that limitation should be lifted in the very near future thanks to telematics.

3 Fuel Economy Benefits

In theory, programmable engine parameters should be far and away the most attractive pathway for a fleet to improve its fuel economy today. As opposed to nearly every other efficiency technology, electronic parameters weigh nothing, being simply software, and they cost nothing to adopt, as they are included in every engine made today. Plus, if set thoughtfully and correctly when the truck is purchased, they will require zero regular maintenance. No other technology that Trucking Efficiency has studied offers such significant cost savings with zero upfront cost and minimal management costs.

Given their long track-record in the industry, it is clear and well-proven that this technology can have a significant impact on fuel economy, among other areas of vehicle performance, particularly so when the parameters are not just set but are actually optimized. No testing was done in conjunction with this Confidence Report, although fleets and engine OEMs both provided insights into the fuel economy benefits offered by optimizing programmable parameters.

Specifically, engine manufacturers reported that when they sent one of their experts to a fleet to optimize the settings of parameters, they nearly always found fuel economy opportunities. One OEM reported a typical improvement of about 0.5 MPG, but for drivers with poor driving habits the results could be over 1 MPG. Another OEM reported typical improvements of 1% in fuel economy with 12% cited as the most extreme improvement produced from programmable parameter changes alone. A third OEM reported they monitor how much each fleet improves after a visit by their corporate team to adjust parameters and it usually ranges from 0.5 to 1 MPG improvement with their all-time record being a 1.7 MPG enhancement. Of these numbers, they estimate that about 70% of the improvement comes from the parameter setting optimization and 30% from additional driver training.

When NACFE fleets were asked about OEM support in optimizing their parameters, two fleets had enjoyed results of nearly 5% improvements in fuel economy. Others had accessed OEM support but seen little to no gains. One NACFE fleet noted an actual decrease in fuel economy after support from a consultant on engine parameters who was hired because the fleet was having difficulty getting an OEM to come in and support their efforts with parameters. In some extreme cases, gains to the MPGs of certain individual trucks of as great as 20% were reported to the study team.

The Michelin Fleet Forum produced a variety of different feedback points. On the low end were responses of no improvement while the high end was a report of 12% - 14% improvement in fuel economy. The most common answer was a 3 - 5% improvement from programmable parameter optimization.

In a final anecdote, an engine OEM shared an experience where engine repairs which mistakenly cleared parameters back to default settings resulted in a fuel economy loss of 2.5 MPG on those vehicles until the parameters were restored.

After assessing all of these insights together, the study team believes that fuel efficiency improvements on the order of 5-8% can be reached by optimizing engine parameters for fuel efficiency if a fleet is not currently utilizing these parameters at all, and instead is just operating their trucks with OEM default settings.

Meanwhile, fleets who are using default parameters on their new trucks may have improvements of 3-5% simply by setting parameters in a few key areas such as vehicle speed limiting and idle reduction.

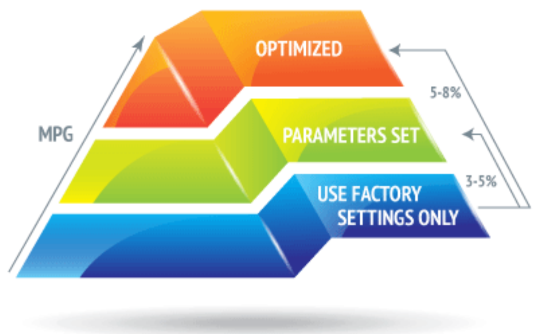


Figure 15: Fuel Economy via Parameter Setting

3.1 Additional Benefits of Optimized Parameters

While the primary motivation for optimizing engine parameters should be to meet a fleet's fuel economy goals, some of the categories of parameters covered in this report will also contribute to a fleet's ability to meet other targets, in particular safety and idling goals. Both safety and idling have been subject to increasing regulations and legislative standards lately, and both cost fleets money, in fuel, fines, maintenance, and downtime and repairs.

4 Challenge of Complexity

An overriding conclusion stands out from this research: that optimizing parameters is more complex than it needs to be. While the fuel economy benefits are great, the barrier of complexity at present may be greater. This Confidence Report untangles the complexity into eight discrete issues, which arise at three specific points during the process of optimization – understanding parameters, selecting and ordering parameters, and maintaining parameters. The eight elements of complexity are:

1. The large number of parameters
2. Interrelations between multiple parameters, and/or between parameters and other systems
3. Variation in OEM terminology and precise functionality
4. Variation in the tools dealers must use to set parameters on new trucks
5. Incorrect initial parameters settings
6. Lack of telematics for parameter maintenance
7. Negative reactions from drivers
8. Parameter records keeping

Some of these issues are quite straightforward, while others merit substantial discussion, given below.

4.1 Understanding Parameters

The first point in the optimization process is at the purely technical level, when a fleet is merely trying to understand parameters. Two challenges may arise at this point:

4.1.1 The large number of parameters

The sheer plethora of parameters available today requires extra effort to fully understand (and new ones are still being regularly created to take advantage of emerging technologies such as automated manual transmissions and global positioning).

4.1.2 Interrelations between multiple parameters, and/or between parameters and other systems on the truck

In order to *optimize* their parameters, fleets must understand how changing one parameter may necessitate a change in others, and will moreover need to tailor all of those parameters to the overall specifications of an individual truck, including its duty cycles, drivetrains, rear axle ratios, and additional installed technologies.

The example given in chapter 2 from the vehicle speed category demonstrates this issue. A fleet may set its “Accelerator Maximum Speed” as one value, but the settings assigned to other parameters such as “Accelerator Lower Droop” could make a vehicle’s actual maximum speed even higher under certain conditions. All of those conditions would need to be considered in order to ensure that the drivetrain gearing of a truck was specified to be able operate efficiently at the true highest speeds. Or in another example from the idle reduction category, the installation of something like a battery HVAC system would influence how idle-related parameters should be set. Extrapolating this sort of interrelatedness and cascading impact over hundreds of parameters makes the complexity of optimizing parameters quite clear.

4.2 Selecting and Ordering Parameters

The next step in the process comes once a fleet has determined the technical specifications and parameters desired for their new truck order, and must actually work with a dealer to select the right options from a particular OEM for delivery. The three challenges in the "new truck ordering" phase are:

4.2.1 Variation in OEM terminology and precise functionality

Each engine OEM has its own terminology and brand names for their parameters, and even some slight differences in how they function. Even within a single OEM there will be differences from one engine model to the next. To make matters worse, the majority of fleets have multiple years and models of engines in active operation, sometimes from multiple OEMs.

The cell phone analogy is again apt – by and large all smart phones have the same capabilities of texting, taking photos, surfing the web, and using aps, but there are different manufacturers (Samsung, Apple, Motorola), different operating systems (Android, Windows, Apple), and different models (iPhone 4, iPhone 5, Galaxy, Droid), all within unique interfaces and names for their proprietary functions that a user must understand.

4.2.2 Variation in ordering tools

The tools and methods that dealers must use to communicate a fleet's desired parameter settings for a new vehicle order to the OEM vary greatly between one OEM and the next. Some tools such as the Cummins PowerSpec software have extensive guides on parameter definitions, modes of operation, and default settings. Some of the other tools available today appear to be less detailed, but given that they are proprietary and require training to use this report will not attempt a comparison.

It is notable that some vehicle ordering systems allow the dealership salesperson to directly enter a numerical value into an electronic template for each parameter desired, while others require the salesperson to use a table provided by the OEM to convert the desired value for a given parameter into a sales code which can then be entered into the vehicle ordering system.

It also appears that some parameters have limited selection options in the dealer's sales tool, when in reality they are not as restricted when they are accessed using the service department's diagnostic and programming system. For example, the study team saw listed sales options for one engine's idle temperature parameters that were limited to 5 degree increments, but the engine could in fact be adjustment by single degrees using the service department's tools.

Finally, even dealers who are well-versed in how to use the parameter selection tool may falter including parameter optimization in their sales-pitches. By their very nature parameters are an integral part of an engine controller, are so they are not always a focus area for new truck specifying and procurement. There is little chance that an opposing salesperson will challenge that they can set up parameters better than whatever a fleet may be currently implementing. Because programmable parameters are "free," it is quite likely that little time is spent discussing how to optimize the "investment" made in them. And since they are integrated and have no weight, there is no reason to have a discussion on whether to take them off of a vehicle to see how the truck runs without them.

4.2.3 Incorrect initial parameters settings

Even once a fleet has chosen their parameters and a dealer salesperson has placed the order, it was made apparent in the industry interviews conducted during this research that there are persistent issues with the parameters for a new truck being set incorrectly or incompletely by any one of a few different actors who may be responsible for doing so.

Discussions with fleets and engine manufacturers have revealed that there are at least four reasons that programmable parameters may not be set to the values at which a fleet believes they should be set. The vast majority of issues fall into one of the first two categories, which are both unintentional.

1. Vehicle OEM failed to properly or fully program the vehicle to desired values on or after the production line
2. Service work on the vehicle that changed or eliminated the fleet's settings from the ECM
3. Tampering with the settings by either a driver or a mechanic

While gathering input for this report, some fleet professionals mentioned receiving a vehicle that was not properly programmed at the vehicle OEM's factory. To counteract this, some dealers check that the vehicle is programmed to the customer's desires during their vehicle prep procedures. Many fleets also reported that they spot check new vehicles to see that they are programmed to their specifications. At least one vehicle OEM appears to require either the dealer or fleet to program every new vehicle with the fleet's password since it is not an option that can be requested for vehicle assembly plant programming on normal orders.

4.3 Maintaining Parameters

The third point of complexity in the process occurs even after a fleet has placed its new trucks into operation with the desired initial parameters set properly. Three challenges are preventing fleets today from accomplishing the ongoing parameter management required to achieve true optimization:

4.3.1 Lack of telematics and variation in service tools

Changes in duty cycles or even insights from new truck performance data may indicate that a certain parameter should be altered on a group of trucks. But right now changing parameters requires someone physically connecting with the truck – which can be a time-consuming task for a large fleet. Telematics technology which allows for parameters to be updated remotely would be a true game changer.

At present, the tools for programming an individual vehicle's engine after it is in operation also vary depending on the brand of the engine. Some OEMs allow fleet maintenance staff to change parameters with in-house tools, but at least one brand of engine requires taking a download from the engine, sending it to the engine OEM with the desired parameter settings, and then uploading a new file from the OEM onto the engine.

The current state of maintenance technology means that there are indirect costs to using and optimizing programmable parameters. For one, they cannot be validated or reprogrammed without electronic hardware (service tool or laptop) with which to access the electronics on the engine via a data link. Furthermore it takes a well-trained staff to know how to change the parameters at all, and even more extensive training for them to know how to set them for optimal fleet productivity. These service tools and training add costs to fleet budgets.

4.3.2 Negative reactions from drivers

As a general rule, drivers do not like being restricted in the way they operate a commercial vehicle, and electronic engine parameters, particularly those which can improve fuel economy, will do just that. Although advances in things like password protection for engine parameters has limited this, instances of drivers or maintenance technicians subverting or tampering with parameters were reported in the interviews and surveys conducted for this Confidence Report. Even if they are not able to physically tamper with the parameters, drivers who feel negatively about parameters may otherwise not drive as efficiently, not treat their trucks with as much respect, or experience higher driver turn-over rates.

Fleets must consciously include engine parameters in driver training and other communications with drivers to explain how engine parameters actually function, and to obtain buy-in from their drivers. For example, data often demonstrates that capping a vehicle's maximum speed actually raises its overall average speed, or otherwise does not measurably impact drive time – but this is counterintuitive. Moreover, optimized fuel economy and profitable operations allow for better driver pay and performances. Some fleets provide monetary bonuses for safe driving, fuel efficient driving, reduced idle time or all three. Driver reward programmable parameters an additional pathway for incentivizing good driving.

The challenge of optimizing fuel economy via parameters is not always an issue of older experienced drivers that can drive with maximum efficiency versus younger inexperience drivers that are not as well disciplined. The combination of lower engine operating RPMs on new engines, better cab/sleeper interior noise reduction, quieter engine operation, and driver hearing loss can mean that an experienced driver (who shifts based on their hearing) is actually operating in higher engine RPMs than would be ideal for maximal fuel economy. As one OEM employee stated: "engines used to scream at the drivers, but now they whisper."

Overall, parameters provide boundaries of operation to assist drivers in becoming fuel efficient and profitable employees for their company. With proper settings and training, the parameters play a significant role in establishing a fence to keep operations within a desired area of performance. Like any other actual fence, the parameters need to be monitored to ensure that no one has broken the fence, whether intentionally or unintentionally.

4.3.3 Parameter records maintenance

Technology for keeping records of parameter settings is highly scattershot at present. If programmable parameters are to truly be optimized for fuel efficiency, it is critically important that fleets keep records of how parameters were initially set on a given truck model and of any changes that were later made to them, so that the effects of the parameters on fuel consumption can be understood. Record keeping is equally critical in the unlikely-but-not-impossible case that maintenance or systems failure cause the settings to be erased.

While programmable parameters cost nothing to adopt as a technology for improving fuel efficiency, they do entail a managerial cost within a fleet's operations. A fleet will need to first asses its duty cycles to determine the right settings of engine parameters for their trucks, and will also need to meticulously record how those parameters are to be set. Then, in order to fully obtain the fuel economy gains offered by parameters, fleets will need to reevaluate and even perhaps experiment a bit in order to determine the optimal settings for their trucks, diligently recording all changes to the factory originals as they are made. Plus, as the overall componentry of trucks continues to evolve, more and more parameters will be introduced, while the optimal settings for existing parameters may change. Given that is it unlikely that any fleet will ever have a full suite of identical and brand new trucks at any one time, a fleet will also need to determine the best parameters and maintain unique records for each of the different makes and generations of engines and vehicles they operate.

Finding a method that works for your fleet and management team can be a challenge. Many fleets use a "template" to assign identical parameter settings to every group of identical vehicles purchased. A sample template for fuel economy parameters is shown in Figure 16.

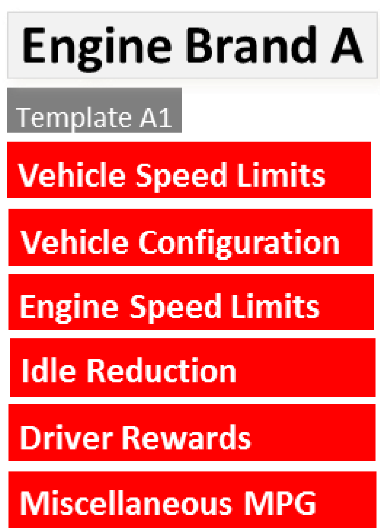


Figure 16: Sample Template of Parameters by Categories

If another brand of engine is added to the fleet, or even another model from the same OEM, a second template will need to be created, ideally one with as many identical settings to the first template as possible. For instance, a fleet may add diesel APUs to their specifications for a new group of sleeper tractors. This would likely require them to alter the parameters within the Idle Reduction category, doing things like raising the Hot Ambient Air Temperature parameter lowering the Cold Ambient Air Temperature one, in order to ensure that more of the HVAC burden is shunted to the new APU rather than placed on the main engine. Another example would be for a fleet transitioning to Automated Manual Transmissions, which would necessitate changing their parameters from the Engine Speed category, in order to place more responsibility for optimized shifting onto the AMT. Figure 17 is an example of what the full suite of templates for a fleet who owns two or three models of engines from three different OEMs could look like, though an actual template would go into much more detail regarding specific parameters in each of these general categories and the settings that they should be assigned.

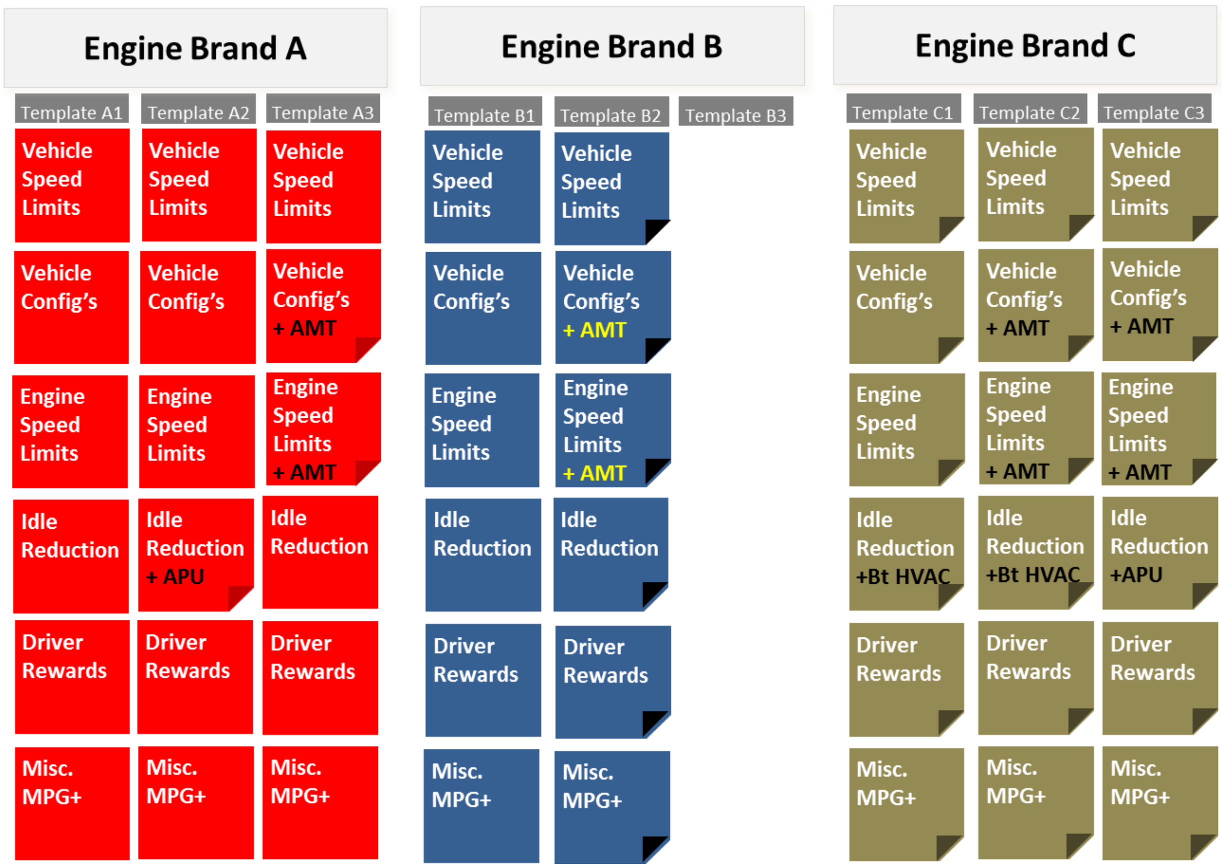


Figure 17: Multiple Templates When Adding a Few Features

One very large fleet reported that they now have 50 templates for one engine OEM and 30 templates for a second. Additionally, one of the engine OEMs reported that they had recently worked with a large fleet to consolidate down to just 28 templates for their engines, with significant differences still required from one generation of their engines to another.

An oft-overlooked challenge occurs when fleet acquisitions and/or mergers require the integration of another fleet's programmable parameters. Given the sheer number of programmable parameters it is unlikely that any two fleets have many of their parameters set to the same values. Accelerator Maximum Vehicle Speed is obviously one of the first parameters to standardize in such a situation, but beyond that fleet's will need to fully understand the specifications of these new trucks, from vehicle ages to rear axle ratios to idle reduction systems, to make sure that parameters from progressive shifting to gear down protection to minimum and maximum temperatures and more can be set correctly.

Another reason why good records keeping on parameters is so critical is that although instances of complete or even partial ECM failure are uncommon, when they do occur, all of that engine's programmable parameters must be reentered. In a best case scenario, it may have been possible to download the parameters from the ECM before replacement. In a worst case scenario, the parameters will need to be reset from scratch, which will require either good fleet records on how the parameters are to be set, or an identical vintage vehicle from which to copy parameter settings. Fleets that implement strategies for recording their parameter settings *as they change over time* will avoid problems in these instances. While many fleets retain vehicle production records, using these as a reference to replace failed ECM data will only work if none of the truck's parameter settings have been modified in the interim.

Finally, good parameters record keeping is a guard against tampering. Fleets need to also be vigilant for other tampering beyond the programmed parameter values. It is possible to tamper with programmable parameters by changing the sensors which engine electronics use to monitor the performance and external environment of the vehicle. It is possible to move the ambient air temperature sensors into a position, say under the hood or near the exhaust, where excessive heat will trick the engine controls to allow unlimited idling. It is also possible to tamper with a vehicle's speed sensors to alter the signal the engine uses to determine the road speed of the vehicle.

Advancements in password protection for programmable parameters have largely put a stop to tampering, but some fleets reported that they still struggle with it. Parameters governing the Accelerator Maximum Vehicle Speed are most commonly changes, as drivers may wish to go faster than the fleet allows. Several fleets reported spot checking this setting to ensure it had not been altered. Fleets should be aware though that there are other ways to subvert these limits which would not be detected by a simple spot check of the parameter itself. For instance, it may be possible to alter other parameters, such as the Driver Rewards parameters, to enable the vehicle to go faster than the fleet's maximum speed. Therefore changes to any of the parameter settings should require both a programming tool and the fleet's password, which should be kept as confidential as possible.

5 Interview Perspectives: Original Equipment Manufacturers

The study team's conversations with the engine OEMs provided substantial insight into why programmable parameters are so complex to create and maintain. First of all, heavy trucks can last for a long time, meaning there are still trucks from the 1980s equipped with the very first sets of electronic controls in operation and requiring occasional support today. Volvo determined that they currently have 12 variations of ECMs in the field, Cummins reported 10 and Detroit and Navistar both reported seven generations/variations. Available engine parameters have not only grown in number in the interim years, but in some cases have also changed names or evolved entirely, as truck systems become more interrelated. Within the engine OEMs, it appears that engineers and marketing personnel have the most control over the names given to new parameters.

The challenge for an engine OEM goes far beyond the development and validation of the parameters within the ECM itself. They must also create the sales and marketing materials that explain the parameters to dealers and fleets, the software tools used to enter parameters when a truck is sold, and the service/diagnostic tools and supporting diagnostic troubleshooting materials for the life of the truck. They may even need to play some role in driver training, as this is tightly intertwined with the operational functionality of some of the programmable parameters.

Starting on the front end with sales, the study team found some very different approaches to handling programmable parameters among the engine and vehicle OEMs. The Cummins PowerSpec software is available at no cost for anyone to download to their computer, and this software has detailed definitions of the parameters for all current Cummins engines as well as some of the more recent past generations of Cummins engines. When a PowerSpec installation is licensed via Cummins, the computer on which it is downloaded becomes capable of programming a Cummins engine via an additional adaptor cable. At this point in time, however, none of the vehicle OEMs can download parameters directly from the PowerSpec tool into their vehicle sales ordering tool. And the vertically OEM integrated sales software systems are not publically available so little could be gleaned on these systems for this report.

The study team asked Engine OEMs to gauge which actors along the value chain of a truck's sale and operation seemed to possess a detailed knowledge of programmable parameters. They reported that company distribution centers and national account managers appear to be the last of highly trained parameter experts on the sales side. They also reported that detailed knowledge of parameters is frequently stronger on the service channel side, since those personnel are more likely to have the actual equipment to program a vehicle and therefore experience programming parameters. Obviously there are variations in understanding throughout all companies, so each fleet will need to seek the best support they can find. Each OEM appears to have at least someone in an "Applications Engineering" role who can make customer visits to optimize parameter settings post-purchase. But such teams were minimally staffed and really only have the bandwidth to support a small number of customer fleets. As more fleets investigate and ultimately demand the optimization of their engine parameters, it is the study team's belief the OEMs will respond by increasing the staff resources devoted to this.

One OEM reported they offer live on site training classes in parameter settings and service tools but require at least eight participants to cover travel costs. This typically requires the dealer to invite fleet personnel and others to get enough students.

Overall, each of the OEMs that agreed to discuss parameters with the study team talked about their success with customers in the field, and some of the results cited in Chapter 3's section on "Fuel Economy Testing" may be seen as proof of their success.

6 Interview Perspectives: Dealership Sales Staff

This is the first time that Trucking Efficiency has consulted directly with dealer sales personnel to get their insights for a Confidence Report.

The salesperson at the dealership is an often missed player in conversations on the adoption of new technologies, as they do in fact play a role in the process. Salespeople must understand new technologies well enough to explain their operation to fleets, and more importantly to communicate their value. They must also learn how to correctly specify the technology for inclusion on a new truck order.

A common thread heard in the interviews with deal sales personnel was that programmable parameters are a particularly challenging technology for which to steer fleets in the right direction due the sheer numbers of terms given to those settings by the various OEMs. It was also brought up several times that fleet customers have been known to work with the dealer salesperson to select the right vehicle drivetrain for a given maximum operating speed that they have decided to program into their engines, but then upon delivery will set the maximum vehicle speed higher than what was previously discussed, potentially decreasing the overall performance of their truck.

The dealer sales personnel all reported to the study team that the most common parameters such as Accelerator Maximum Vehicle Speed, Cruise Control Maximum Vehicle Speed, and Idle Shutdown Timer were understood by their customers already. On the other hand, they find fleets to be generally confused in conversions around newer or more obscure parameters, such as Droop Settings, among many others.

When asked how they set the programmable engine parameters in a new vehicle order for an existing fleet customer, half of the sales people responded that would contact the customer to make sure they had the most recent settings. Other responses included that they would use the settings from the fleet's previous order, or that they would just using the default settings due to the limited functionality of their sales tools. In this last case, the responsibility for optimizing the parameters would fall on the service department. Two of the sales people reported that they had different levels of programming capabilities depending on whether the engine they were selling was their own vertically integrated engine (in which case they had more parameters they could set) or was the Cummins engines (which has fewer parameters for them to set). Interestingly, in both cases the dealership ordering software could not take a customer's password information and set the password at the factory. This shortcoming places responsibility to set the password at the dealership for all new vehicles.

Only one of the sales people could actually change parameter settings on a real truck themselves. All of the others relied completely on their service department teammates to handle all customer parameter programming needs.

Three-fourths of the sales people have worked with a customer on optimizing the parameter settings on a vehicle and being aware of the performance results. Anecdotally, one interview respondent told of a fleet vehicle that was only getting 4 MPG due to the driver not being in top gear at highway speeds, and achieving and improvement to 6.5 MPG simply by programming the Gear Down Protection parameter. Another related having programmed the Progressive Shifting parameters for a fleet and thereby improving fuel economy by 0.2 MPG. And a third reported experiencing 0.5 MPG improvements simply optimizing the parameters.

7 Interview Perspectives: Fleets

Trucking Efficiency conducted confidential, over-the-phone interviews with nine NACFE-affiliated large fleets, all of whom had significant experience with the optimization of programmable engine parameters. Insights from medium and smaller fleets were garnered via an online collaboration with the Michelin Fleet Forum; forty-five fleets participated in that survey, of which forty-one had first-hand knowledge of parameter settings and processes.

All surveyed fleets were asked about their respective use of fuel economy related programmable engine parameters. Fleets in the Michelin Fleet Forum with less than 50 vehicles were considered to be the "small fleets" and any fleet with 50 or more vehicles was classified as a "large fleet." Fleets with NACFE affiliation who granted a live phone interview, all of which were large fleets, are referred to as "NACFE fleets." Figure 18 displays the percentage of each group that is using the various programmable parameters related to fuel economy.

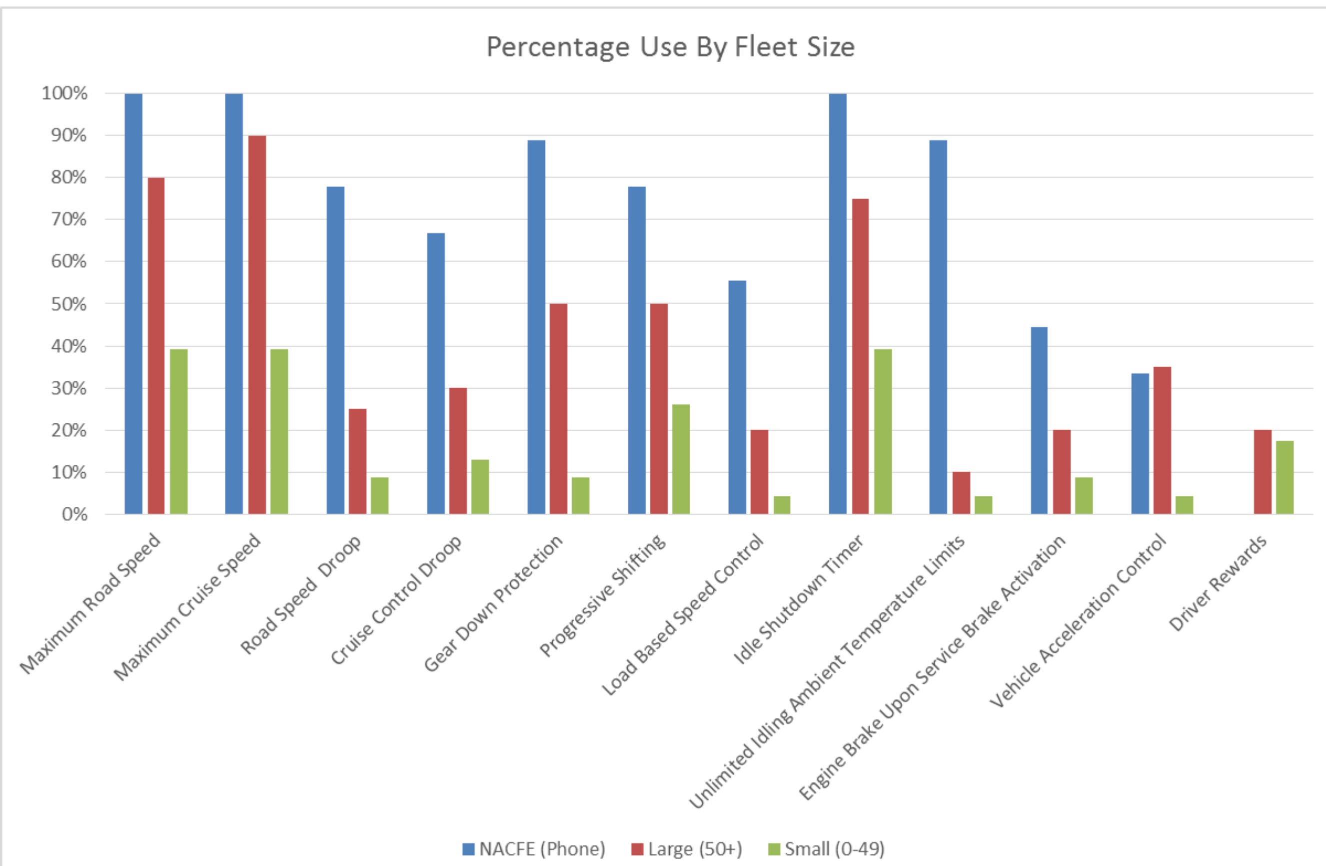


Figure 18: Parameter Use

As shown, all three groups self-reported using the Accelerator Maximum Vehicle Speed, Cruise Control Maximum Vehicle Speed, and Idle Shutdown Timer parameters at the high rates, though the NACFE fleets use these three parameter groups more than twice as often as the small fleets.

The NACFE fleets in fact implement the majority of these parameters at very high percentages. Interviews reveled that their reasons for reporting lower adoption rates of a few of the parameters were generally either:

1. The parameter not being available from all OEMs (Load Based Speed Control and Engine Brake Upon Service Brake Activation both fit this category)
2. There are other features that minimize the need for the parameters (for examples AMTs can supplant Progressive Shifting)

The Driver Rewards parameters were not utilized by any of the NACFE fleets spoken to for this report. The general consensus among these fleets was that offering even the best drivers higher speeds was counterproductive to an overall pursuit of optimal fuel economy and fuel efficient driving techniques.

The features with the highest deviation between the NACFE fleets and the smaller fleets are the Unlimited Idling Ambient Temperature Limits. Unfortunately, since the Michelin Fleet Forum participants reported via an on-line survey there was no chance to ask follow-up questions to understand why their usage of these parameters is so low.

7.1 NACFE Fleet Interviews

Nine large fleets, several of whom are NACFE members, committed their time to participate in a personal phone interview with the study team on programmable parameters.

These fleets were asked about the mix of each of the different class 8 engines within their fleet, so that if anything irregular or outstanding surfaced in the findings the study team could check to see if a certain brand of engine might behind that outlier. The question about engine mix revealed that nearly all of the fleets were operating at least three different brands of engines simultaneously, and that some had four or more – one fleet reported having a full seven brands of engines in operation. It follows, and was confirmed in the interviews, that these fleets are experiencing a good deal of confusion around the different programmable parameter features and terminology offered by each of the engine OEMs, as no two are alike. One fleet reported specifically that they do not use a particular feature because not all of their engines have that feature, and they do not want a discrepancy in a function, such as how the engine brake engages in one truck compared to the other, to cause confusion for any of their drivers.

Seven of the nine fleets stated that making any changes to their programmable parameter settings was either difficult or extremely difficult. One fleet that relies on contract maintenance support reported that it took 12 months to get all of their vehicles programmed with a new maximum vehicle speed limit. Other challenges that were noted included:

- It is extremely difficult to physically connect with thousands of trucks
- Not all service locations have a service person that is software knowledgeable

Only one of the fleets reported wanting to have all of their trucks, whatever the model or engine, set to the same parameters. This would not be a good choice for most fleets, especially those with a range of truck model years in their fleet, as newer trucks tend to have different optimal engine speeds and therefore different transmission gear ratios and rear axle ratios.

Some fleets reported developing different parameter templates to meet other differences among their trucks, such as:

- Setting team vehicles with a higher maximum road speed than single driver tractors
- Setting idle shutdown temperature limits differently, to match the performance capabilities of different types of idle reduction systems (fuel operated heater only, APU, Battery HVAC, etc.)

When asked about the challenges that can arise after fleet mergers and acquisitions, there was general agreement that it was extremely difficult to get any newly acquired vehicles programmed to match the rest of the fleet. Not only do all of the challenges cited in the last two paragraphs arise, but new vehicles may have features such as gearing combination not seen in the rest of the fleet, so brand new templates will need to be developed which will allow those trucks to meet fleet fuel economy goals. Two fleets admitted that this situation was found to be so difficult that they had either sold the newly acquired vehicles out of the fleet or just left them alone without any changes.

When asked about their fleet's procedures for maintaining records of their electronic engine parameters the answers varied widely. One fleet keeps a 3-ring binder on each and every vehicle which includes the programmable parameter settings. Others had spreadsheets, and others had nothing documented at all. Many of the fleets do attempt to monitor that the settings on vehicles are as they should be. Some spot check upon new vehicle delivery, after finding that at least two vehicle OEMs completely missed programming the parameters at the assembly plant. Others spot check parameters during service work or preventative maintenance. Fleets also use telematics and driving reports from the engines to spot drivers that have been operating outside of their parameter settings. Most fleets state that they now change these fuel economy parameters less than once per year.

All of the fleets expressed a strong desire for the industry to develop a telematics system that could at least report back on parameter settings, ideally be able to reprogram the parameters remotely, as needed. According to fleets, such technologies would offer benefits including:

1. Enabling spot checks and facilitating of wholesale changes
2. Saving shop bay time as well as technician time, both of which are more expensive compared to a business analyst in an office using telematics
3. Making changes to parameters would be much easier and faster, with no shop time required
4. Ability to adjust settings as the driver gains experience, and possibly also based on the truck's location, neither of which are currently possible
5. Ensure all vehicles are operating with optimized parameters, and obtain higher quality data about various parameters' effectiveness

The only concern expressed was that telematics providers might charge high prices for such programming.

When asked about tampering several fleets reported some incidents with maximum speed settings or vehicle sensors being altered, but by and large found that tampering occurs at low rates today.

Several fleets mentioned the terminology challenge when asked for any open ended comments. One sees this as a strong need at vocational training schools. Another commented that he now has a request for common terms on all Request for Proposals on all new truck orders. Fleets also requested a downloadable file and a comparison tool to know if any settings do not match the desired settings. They complained that the dealerships are not well trained when it comes to parameters, and in any case that dealerships lack a master file saved in their system with version controls.

7.2 Fleet Forum Internet Survey

In conjunction with Michelin, NACFE and the study team surveyed the 200-plus members of Michelin's Fleet Forum to learn about how these fleets manage their parameter settings. The survey was available online to members of the Fleet Forum from November 6, 2014 until November 20, 2014. A total of 45 fleets responded to the survey, though not every question was answered on every survey.

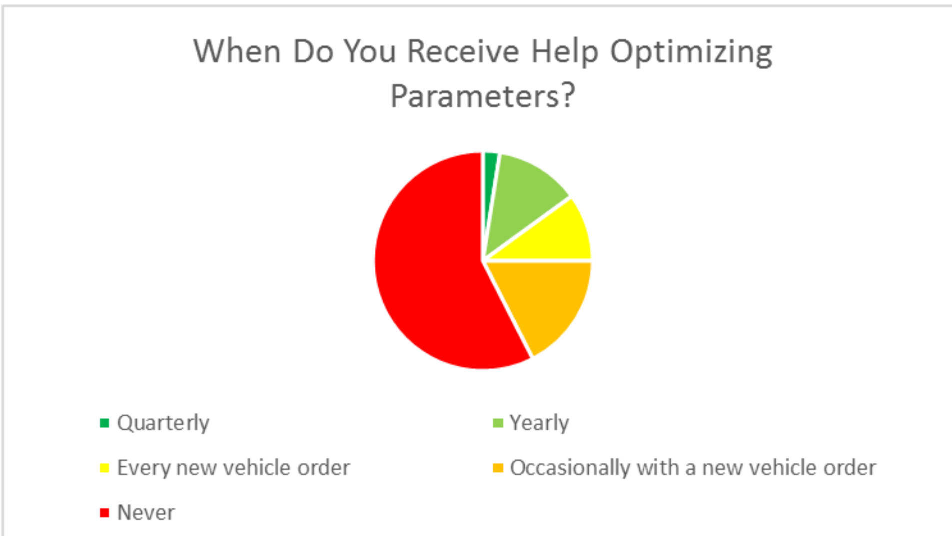


Figure 19: Frequency of Help

One of the most striking findings regards when fleets receive support with optimizing their parameters. More than half of the fleets responded that they had never been given any help from their dealerships or their engine or vehicle OEMs in optimization. Roughly a quarter of the fleets received support at least occasionally when placing new orders. The most startling response was "bought a new truck in May and have not been informed of any of the values discussed in this survey unfortunately."

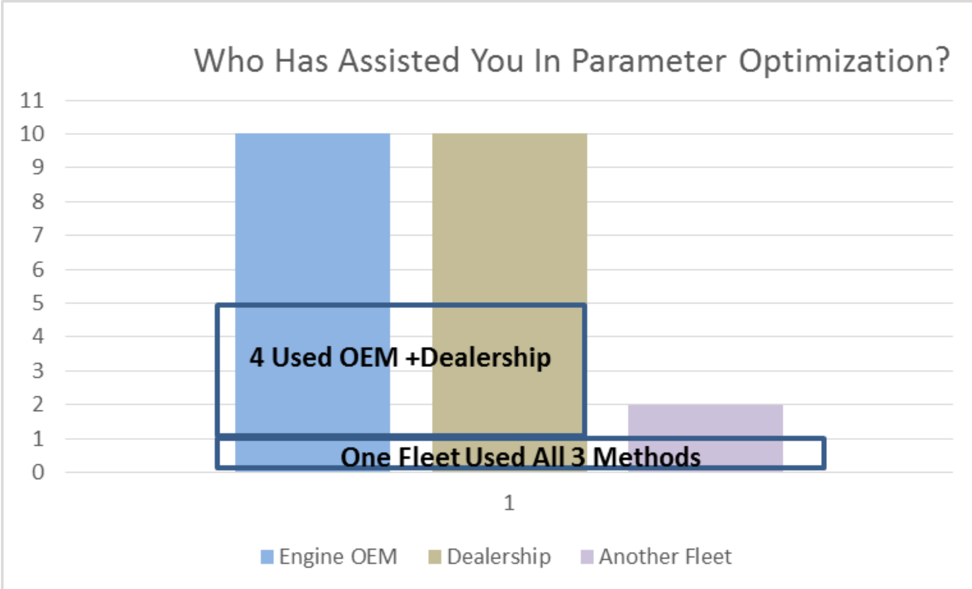


Figure 20: Help in Setting Parameters

A follow-up question found that the source of any optimization support is evenly split between truck dealerships and engine OEMs, with several fleets using both. A pair of fleets also reported using a peer from another fleet to help optimize their settings.

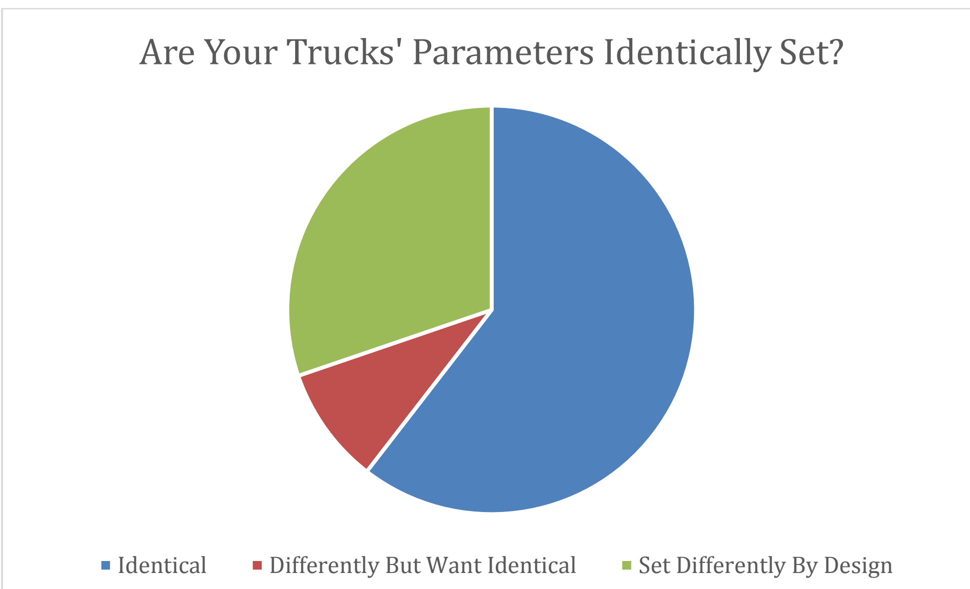


Figure 21: Percent with Trucks Identically Set

The majority of surveyed Michelin Fleet Forum fleets have their parameters set identically. This may be more common in fleets that utilizer fewer of the available parameters to manage their tractors. For instance, if only the vehicle's maximum speed, maximum cruise speed, and idle shutdown timer are set at all, differences between the engine sweet spots, drivetrain gearing, and idle reduction systems of the various trucks in a fleet will not need to be accounted for.

Fleets were also asked how often they changed any of the parameters, and the results in the following chart show that the parameters are rarely if ever changed.

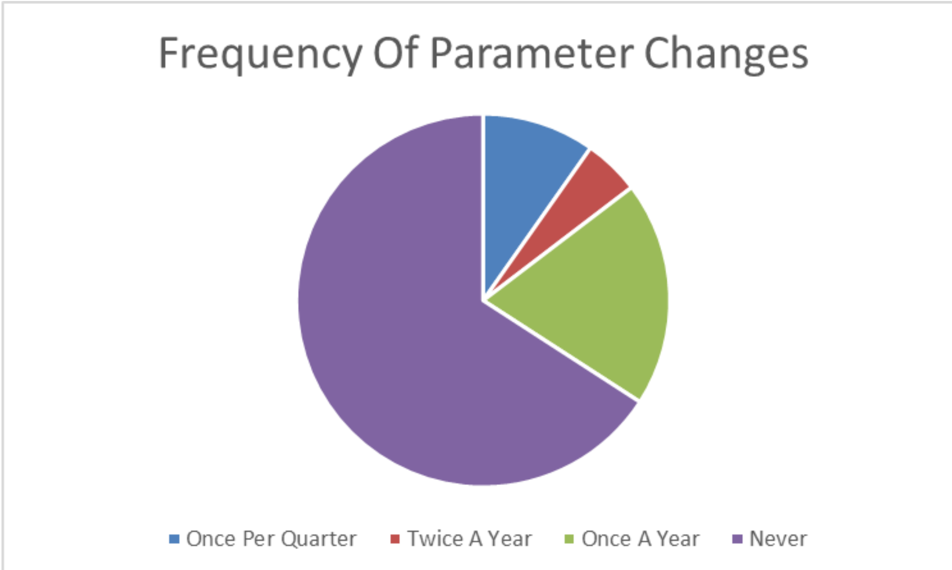


Figure 22: Frequency of Changes

When asked about how difficult it is to change parameters, the Michelin fleets reported finding it less than the NACFE fleets. This may be a result of fleet size, as the NACFE fleets will need to touch much larger numbers of individual vehicles to implement any changes. One Michelin fleet responded that "some engines are much easier to set parameters than others - some engines are much more time consuming and difficult."

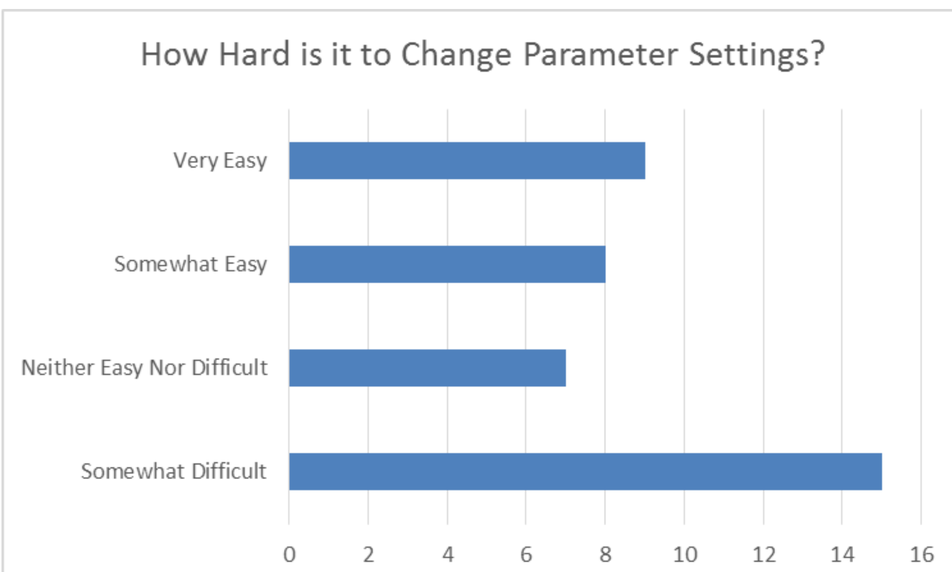


Figure 23: Difficulty in Changing

Given that there is presently a debate within the industry around whether the parameter for maximum cruise control speed should be set to a higher, lower, or the same value as the parameter for maximum accelerator speed, the fleets Michelin were asked where they set those values. Most of the Michelin Forum fleets had the two parameters set to identical speeds, but a few set them differently.

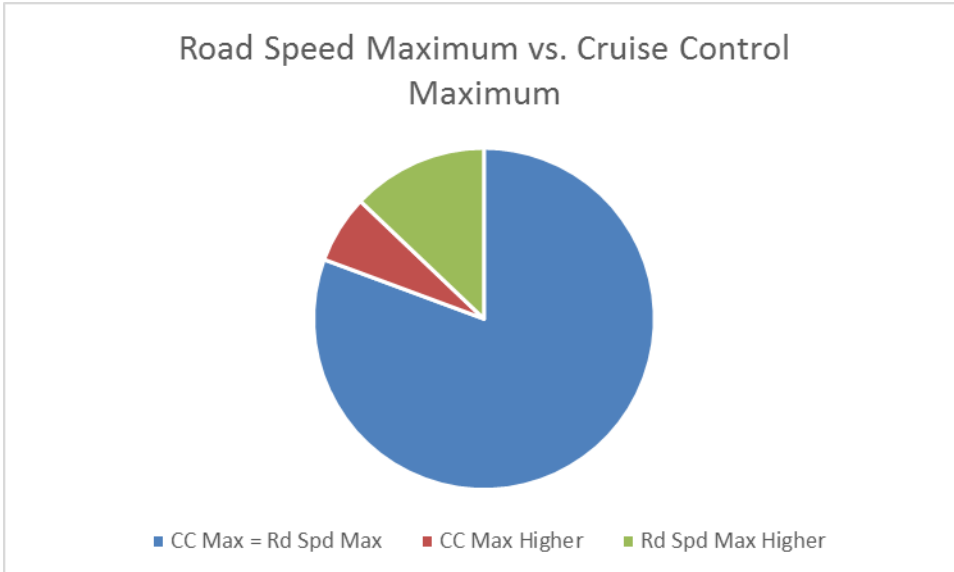


Figure 24: Maximum Speed Settings

Finally, when asked about whether they would benefit from the introduction of telematics to manage engine parameters, some of these fleets indicated that they had little need for such technologies as they either do not use telematics generally, or else never change any of the parameters. One fleet stated that "Security is a serious issue I have with this option." But other fleets saw significant opportunities in telematics systems. One stated "Being able to modify parameters according to driver behavior real time, whether that is with reward or discipline, would help our fuel economy."

8 Conclusions and Recommendations

By the close of this research one of Trucking Efficiency's initial hypotheses about engine parameters had been resoundingly confirmed, namely, that many people in the industry understand the basic concept of using this technology to control certain aspects of vehicle operation, but that it is much harder to find people who are comfortable truly optimizing those parameters to obtain their full potential impact on fuel economy.

Along with this observation, three top level conclusions are evident in this body of research:

8.1 Conclusions

8.1.1 This Is More Complex Than It Needs To Be.

The optimization of fuel economy parameters is made difficult for fleets today by the sheer plethora of parameters available, the wide variation in the terminology and brand names used by the various engine OEMs, and the need to tailor parameters to the overall specifications of a truck, including its drivetrains, rear axle ratios, and additional installed technologies.

This report found that fuel-economy-related parameters can be broken down into six categories according to the aspect of fuel use the parameters address, though there is some overlap between them.

It is understandable that the OEMs did not and could not work together on their confidential software development. On the other hand when Accelerator Maximum Vehicle Speed (Cummins), Max Road Speed (Detroit), Customer Vehicle Limiting Speed (Mack), Max Accelerator Vehicle Speed (Navistar), and Maximum Accelerator Pedal Vehicle Speed (PACCAR) all mean the same thing there is now unnecessary complexity in the marketplace. The time has come to help fleets and dealership personnel alike by standardizing terminology whenever possible. Two of the OEMs made comments to this nature from our discussions.

8.1.2 Programmable Parameters Enhance Fuel Economy.

The study team believes that a fleet which is not currently utilizing programmable parameters at all, and rather is simply leaving their trucks set with OEM defaults, could obtain fuel efficiency improvements on the order of 5-8% by tailoring their parameters to their operations. Meanwhile, fleets may have improvements of 3-5% simply by setting parameters in a few key areas such as vehicle speed limiting and idle reduction. But it appears only large fleets have worked to optimize their settings.

Survey feedback indicates that large fleets appear to have achieved more optimization in their parameter settings. This may well be a result of more sensitivity to fuel costs as well as more support from the OEM representatives. Smaller fleets could well benefit from similar approaches whether supported by the OEMs or some well-trained dealership representatives.

8.1.3 Processes must be in place to manage these parameters.

Its key for fleets to have processes around the management of their programmable parameters to ensure they are operating as expected, and OEMs and dealers can each play a role in this. Fleets create templates, but they might have up to like 80 of them for different engines, plus different model years, plus different features a truck might have like APUs, transmissions etc.

With these conclusions in mind, the following are some recommendations for each of three groups involved; fleets, suppliers (OEMs), and dealerships.

8.2 Recommendations for Fleets

If you are not currently optimizing your programmable engine parameters for fuel economy, do so. The interviews, surveys, and Trucking Efficiency Workshops conducted for this Confidence Report provided numerous insights into how fleets handle their programmable parameters. Certain best practices clearly emerged:

8.2.1 Record keeping of parameter settings

One fleet interviewed has a three ring binder for *every* vehicle and every binder includes the list of parameter settings for that vehicle. Another fleet keeps their parameter settings on a thumb drive stored in their vault. If either of these fleets experienced an engine ECM that was destroyed, they could replace it with the same parameters it previously was running. If there was a lawsuit and the fleet was asked to show their settings, they would have records to do so.

Determine how parameter settings are to be documented and make sure the system is working in day to day operations. Does it capture changes recommended when new orders are made? Does it force thought about whether existing vehicles should be reprogrammed to have the same settings? Does the dealer always discuss these settings before ordering more vehicles to insure any improvements the fleet has found are rolled into the specifications for future vehicles? If the engine ECM suffers a complete failure can a replacement module be set to the exact same settings as the failed unit? The answer might not be templates as discussed in this report, but some method of control is highly recommended.

8.2.2 Create “parameter Templates” that cover a group of similarly specified trucks

One major fleet recently worked with their engine supplier and created over two dozen templates that cover all of their vehicles. Groups may differ by age, powertrain gearing and idle reduction system at a minimum. Make sure the parameter templates clearly call out the different aspects of the vehicle specifications that make the templates different from each other. Keep these files in a safe place electronically where they can be accessed as required.

8.2.3 Pilot review (or spec review) time with OEM to discuss parameter settings

At a workshop, one of the major fleets stated they have purposefully changed the agenda whenever meeting with OEM representatives at pilot or spec reviews. Now much more time is spent reviewing all parameter settings and less time is spent on the not nearly as critical items such as interior trim details. The parameters can make a large difference in fuel economy and operations, so focus on them whenever experts on parameters are available in the room.

If a fleet finds parameters to be confusing or challenging in any way they should be spending more time in conversation with their dealer and OEM. When OEM experts are present, such as order reviews or pilot reviews, it is time to have these discussions. When an OEM representative at a NACFE workshop was asked about the typical length of time fleets wanted to talk about parameters during a pilot review, the response was "anywhere from no discussion at all to a 45 minute discussion."

For fleets that desire more training on parameters, it is highly recommended to contact both the appropriate dealership as well as the engine OEM for support. As an interim step, the Cummins PowerSpec system is available to anyone to download from the web. It provided detailed information on parameters.

8.2.4 Parameter verification checks to ensure vehicles are set as desired

Many of the fleets stated during the survey that they spot check the parameter settings upon delivery as well as periodically throughout the vehicle's lifetime, especially at PM intervals.

8.2.5 Read or write tools to use with parameters

Some fleets are very well equipped with proper service tools and trained technicians to validate programmable parameter settings as desired, as well as reprogramming them if tampering has occurred or the fleet operational strategy has forced vehicles to be reprogrammed.

8.2.6 Protect passwords

Both fleet managers and dealer sales people reported that vehicles returned for trade-in frequently still had the fleet password active in the truck. While it is possible for at least some brands of engines to be erased via special passwords; that is not always what is happening. In many cases someone (dealership or used truck center) will call a friend at the fleet to ask for their parameter password to reprogram the engine for the next customer. Trust is great, but this is also an opportunity for your fleet's password to get into the wrong hands. Fleets with the best procedures erase the password before the truck leaves their lot. Trade-ins should not have your password on them. Passwords should not be given out widely over the phone.

8.3 Recommendations for Suppliers

Fleet frustrations with parameter names and terminology was expressed loudly, clearly, and frequently in the study teams' interviews. Degrees of differences due to intellectual property concerns are understandable and may be unavoidable, but greater commonality in nomenclature and naming conventions than what exists today would be very beneficial to the customer base. Engine manufacturers could provide an improved level of understanding and communications in the field if the names for common parameters between the different engine manufacturers were the same. Granted, given the software infrastructure already in place at each OEM (on-board vehicle/engine software, sales software, order management data, service tool software and training materials), streamlining terms would not be a simple task, nor will it be simple to convince executives to undertake such an overhaul, given that the returns on this investment will be seen by the fleets who are thereby more easily able to optimize their parameters. Nonetheless, the study team recommends that creation of an industry-wide group to create recommended practices, before too many more parameters are created and implemented without guidelines. One fleet stated that making the change to common names would be very similar to the industry's conversion to HD-OBD (common Heavy Duty On-Board Diagnostics) since "you will have to relearn a few things but you will only have to do it once."

The development of telematics service tools by the OEMs was desired by many of the fleets surveyed. At a minimum, such telematics should be able to read existing parameters to validate settings. The ideal telematics-based tool would give fleets the ability to program parameters via wirelessly, removing the need to touch the trucks in a service bay, which requires time to coordinate the work and the time of the service technicians. Several hints were dropped that this capability may not be far off for some manufacturers.

Dealer sales personnel also appear to need additional training and technical support from OEMs on programmable parameters, especially if the number of parameters continues to increase. OEMs could perhaps accomplish this with additional training or more support engineers, or give them additional time to support dealers in providing fleets with the greatest available fuel economy opportunities from optimized programmable parameters.

Fleets can use additional help from OEMs in managing their parameters over a span of engine generations, variety of engine makes, and generations of vehicles. A software tool to manage templates would be a marketplace advantage for any OEM willing to develop such data. It would have far more value if it could handle parameters from other OEMs as well. Additionally, a feature that allows entire vehicle parameter sets to be compared would be extremely valuable to fleets.

Although not investigated as part of this report, it appears that all of the OEM systems have one generic set of defaults for programmable parameters. It may be helpful to both dealer sales personnel and to fleets if different sets of default values were made available to differentiate between different vehicle applications.

8.4 Recommendations for Dealers

Dealerships must provide their sales staff with strong training on programmable parameters as this is key to helping providing the best guidance to your customer base. Dealer guidelines on parameters should be available on-demand, online, and quite possibly also shared directly with customers. The effectiveness of this training will increase with strong support from other sales and service personnel at the dealership, as well as support-as-required from the engine OEM.

Dealers should ensure that all parameter optimization processes start with educated discussions of gearing. The right gearing is determined by the fleet's desired operations, and encompasses engine sweet spots, transmission ratios, rear axle ratios, tire sizes, and programmable parameters. A failure to consider *any* one of these areas can and will result in vehicles that do not achieve optimal fuel economy. Customers that don't fully comprehend the implications of the interrelations between vehicle and engine configurations, programmable parameters, and fuel economy, need all of the visual aids, training materials, and software simulations that can be provided.

An OEM representative shared that the very best of dealer sales people will actually ride in a customer's truck for a while to understand how that customer wants their vehicle to operate, as you first have to know everything that the customer already knows if you want to become even more knowledgeable than your customers.

8.5 Confidence Matrix

A Confidence Matrix (Figure 25) is a diagram used to inform fleets of Trucking Efficiency's overall confidence in the technology being studied and the currently available performance data of that technology as compared to the payback a fleet should expect to receive from the technology.

This report finds that programmable engine parameters are proven to provide payback to those fleets that use them wisely – that is, who make a concentrated effort to optimize them on new trucks and then to manage them over the life of the truck Depending on where the fleet is in its current operations, paybacks can be rapid and significant for those that have not previously focused on this area. This report, unlike previous Confidence Report, does not provide a payback calculator, since programmable parameters have no direct upfront cost. The only "cost" of parameter optimization is the time and effort required to understand today's complex parameter options and tools, and to maintain good records of fleet activities relating to parameters.

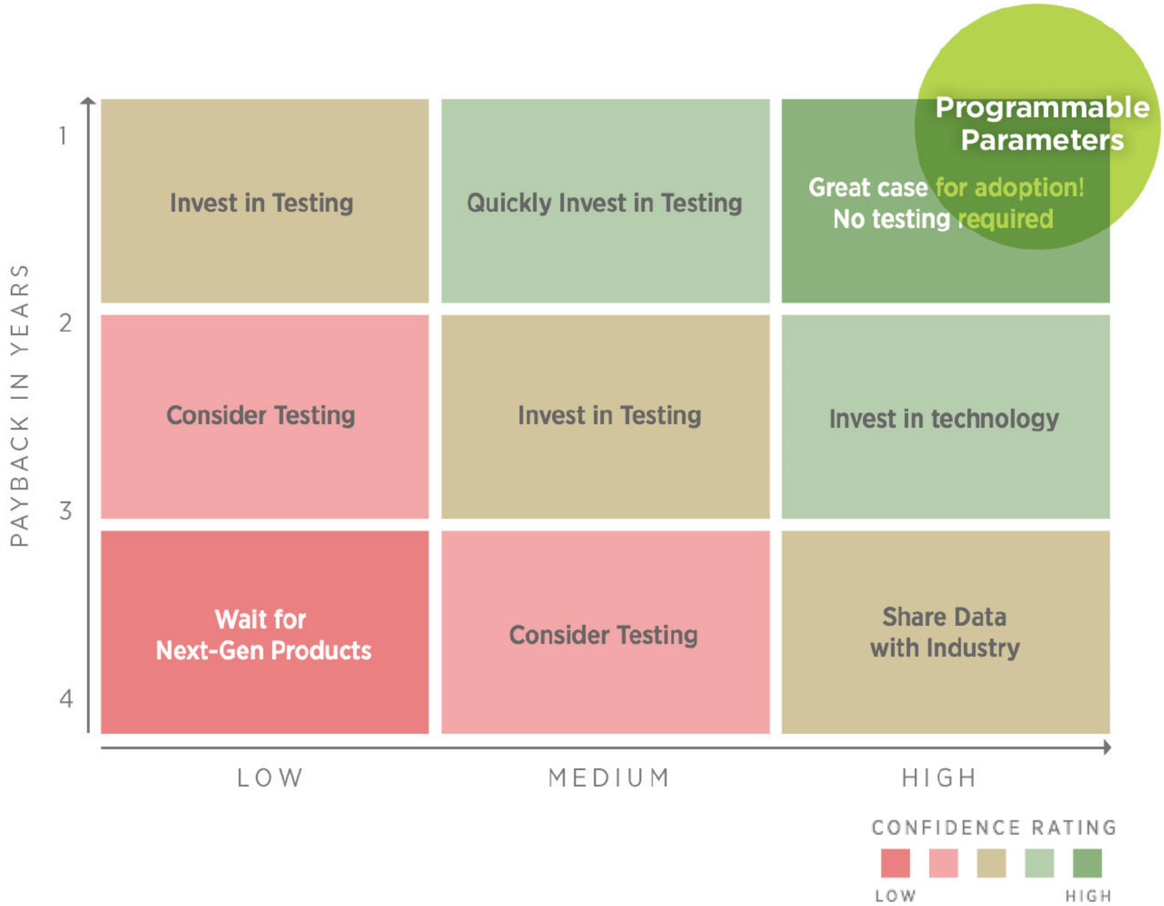


Figure 25: Confidence Rating on Optimizing Engine Parameters

Appendix A: References

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Appendix B: Manufacturer Summaries

CUMMINS		
Ordering Tools	PowerSpec	
Service Tools	Insite	(also PowerSpec if licensed & data cable equipped)
Contact	Jason Owens	Customer Performance Technical Manager – jason.owens@cummins.com
FREIGHTLINER		
Ordering Tools	Spec Pro & Spec Manager	
Service Tools	Diagnostic Link	
Contact	Victor Meloche	Manager, Technical Sales - victor.meloche@daimler.com
KENWORTH		
Ordering Tools	Prospector	
Service Tools	DAVIE & ESA	
Contact	Applications Support	425-828-5999
MACK		
Ordering Tools	MACKTRAQ	
Service Tools	VCADS PC	
Contact	Joe Scarnecchia	National Accounts Powertrain Sales Manager - joseph.scarnecchia@macktrucks.com
NAVISTAR		
Ordering Tools	Sales Tools & TCAPE	
Service Tools	Service Maxx	
Contact	Aaron Peterson	Chief Performance Engineer - aaron.peterson@navistar.com
PETERBILT		
Ordering Tools	Prospector	
Service Tools	DAVIE & ESA	
Contact	Applications Support	PBDivision.Applications@paccar.com 940-591-4096
VOLVO		
Ordering Tools	TM2	
Service Tools	PPT	
Contact	Customer Support	1-800-525-6586

Note: This is an initial NACFE comparison of parameter names, additional in depth analysis with the OEMs is required to know that these parameters match. **9-Feb-15**

	Cummins	Detroit	Mack	Navistar	PACCAR	Volvo
Vehicle Speed Limits	Accelerator Maximum Vehicle Speed	Max Road Speed	Customer Vehicle Limiting Speed	Max Accelerator Vehicle Speed	Maximum Accelerator Pedal Vehicle Speed	
Vehicle Speed Limits	Global Maximum Vehicle Speed	Absolute Max Veh Speed			Maximum Vehicle Speed – vehicle speed limiter	
Vehicle Speed Limits	Gear Down Protection - Feature Option		Lower Gear Vehicle Limiting Speed Feature Activation	Gear Down Protection	SCM: Gear Down Protection	
Vehicle Speed Limits			Lower Gear Vehicle Limiting Speed			
Vehicle Speed Limits	Gear Down Protection Heavy Load Vehicle Speed			Top Gear Minus 1 - Heavy Load Speed		
Vehicle Speed Limits				Top Gear Minus 2 - Heavy Load Speed		
Vehicle Speed Limits	Gear Down Protection Light Load Vehicle Speed			Top Gear Minus 1 - Light Load Speed		
Vehicle Speed Limits				Top Gear Minus 2 - Light Load Speed		
Vehicle Speed Limits		Torque Factor Gear Down Protect				
Vehicle Speed Limits		Torque Factor High Gear Power				
Vehicle Speed Limits	PowerSpec Gear Down Protection Auto-Calculate - Feature Option					
Vehicle Speed Limits	Cruise Control Enable - Feature Option			Cruise Control Enable		
Vehicle Speed Limits	Cruise Control Maximum Vehicle Speed	Max Cruise Set Speed	CC Max Set Speed	Max Cruise Control Vehicle Speed	Maximum CC set speed	
Vehicle Speed Limits		Min Cruise Set Speed low	CC Min Set Speed	Min Cruise Control Vehicle Speed	Minimum speed that CC may be enabled	
Vehicle Speed Limits					Min Speed to Automatically Turn Cruise Control On	
Vehicle Speed Limits	Cruise Control Auto Resume	Enable Cruise Auto Resume	CC Autoresume with Clutch			
Vehicle Speed Limits			Cruise n' Brake Engagement Delay		Delay in Engine Brake Activation with Brake Pedal Depressed	
Vehicle Speed Limits	Cruise Control Save Set Speed - Feature Option					
Vehicle Speed Limits	Cruise Control Lower Droop					

	Cummins	Detroit	Mack	Navistar	PACCAR	Volvo
Vehicle Speed Limits	Cruise Control Upper Droop					
Vehicle Speed Limits		Pass Smart		Vehicle Speed Limiter Override		
Vehicle Speed Limits	Reserve Speed Increase Delta	PS Pass Speed Increment		VSLO Speed Increment		
Vehicle Speed Limits		PS Pass Speed Duration		VSLO Maximum Activation Time		
Vehicle Speed Limits	Reserve Speed Maximum Distance					
Vehicle Speed Limits		PS Pass Speed Interval		Time Interval To Reset VSLO		
Vehicle Speed Limits				VLSO Time Duration Source		
Vehicle Configuration	ECM Master Password			Customer Password		
Vehicle Configuration	ECM Reset Password					
Vehicle Configuration	ECM Adjustment Password					
Vehicle Configuration	Vehicle Setup Rear Axle Ratio	Axle Ratio		Rear Axle Ratio		
Vehicle Configuration	Vehicle Setup Transmission Top Gear Ratio	Top Gear Ratio		Top Gear Ratio		
Vehicle Configuration	Vehicle Setup Transmission One Gear Down Ratio	Second Highest Gear Ratio		Gear Ratio of Top Gear Minus 1		
Vehicle Configuration				Gear Ratio of Top Gear Minus 2		
Vehicle Configuration	Vehicle Setup Tire Revolutions Per Distance	Tire Revs per Unit Distance		Tire Revs per Mile		
Vehicle Configuration	Vehicle Setup Transmission # of Tailshaft Teeth	Number of Output Shaft Teeth				
Vehicle Configuration	Vehicle Speed Sensor(VSS) Type	Vehicle Speed Sensor				
Vehicle Configuration	Vehicle Setup Application Type					
Engine Speed / Torque Limits		Progressive Shift Enable		Progressive shift enable	SCM: Progressive Shift	
Engine Speed / Torque Limits				Low gear ratio break point		
Engine Speed / Torque Limits				High gear ratio break point		

	Cummins	Detroit	Mack	Navistar	PACCAR	Volvo
Engine Speed / Torque Limits		PS Low Gear 1 Max RPM Limit		Low gear engine speed limit		
Engine Speed / Torque Limits		PS Low Gear 1 Max Vehicle Spd		Low gear speed limit		
Engine Speed / Torque Limits		PS Low Gear 1 RPM Limit				
Engine Speed / Torque Limits		PS High Gear RPM Limit		High gear engine speed limit		
Engine Speed / Torque Limits		PS High Gear On Vehicle Spd				
Engine Speed / Torque Limits				High gear engine speed range		
Engine Speed / Torque Limits		PS Low Gear 2 Max RPM Limit				
Engine Speed / Torque Limits		PS Low Gear 2 Max Vehicle Spd				
Engine Speed / Torque Limits		PS Low Gear 2 RPM Limit				
Engine Speed / Torque Limits	Load Based Speed Control			RPM Minimum Progressive Shift Gear Ratio		
Engine Speed / Torque Limits	High Engine Speed Breakpoint					
Engine Speed / Torque Limits	Low Engine Speed Breakpoint					
Engine Speed / Torque Limits	Vehicle Acceleration Management					
Engine Speed / Torque Limits	Acceleration Limit #1					
Engine Speed / Torque Limits	Acceleration Limit #2					
Engine Speed / Torque Limits	Speed threshold #1					
Engine Speed / Torque Limits	Speed threshold#2					
Engine Speed / Torque Limits	Smart Torque 2 enable					
Engine Speed / Torque Limits	Powertrain protection					
Engine Speed / Torque Limits	PTP Max torque at 0 VSS					
Engine Speed / Torque Limits	PTP Max allowable driveshaft / axle torque					

	Cummins	Detroit	Mack	Navistar	PACCAR	Volvo
Idle Reduction	Idle Engine Speed			Idle Engine Speed	Engine idle speed	
Idle Reduction	Idle Shutdown - Feature Option	Enable Idle Shutdown	Idle Shutdown Feature Activation	Idle Shutdown Mode	Engine Idle Shutdown Timer Enabled	
Idle Reduction	Idle Shutdown Timer		Idle Shutdown Time	Idle Shutdown Time with Park Brake Set	Timer Setting Non-PTO Mode w/Park Brake Set	
Idle Reduction		Enable Idle Shutdown		Idle Shutdown Time with Park Brake Released	Timer Setting Non-PTO Mode wo/Park Brake Set	
Idle Reduction			Idle Shutdown Warning Time		EIST Time for Shutdown Warning	
Idle Reduction			Idle Shutdown Warning Temp			
Idle Reduction			Idle Shutdown Warmup Timer			
Idle Reduction	Idle Shutdown Manual Override - Feature Option			Latched Driver Override Enable		
Idle Reduction					Enable Accelerator Pedal Reset	
Idle Reduction					Enable Clutch Pedal Reset	
Idle Reduction					Enable Park Brake Reset	
Idle Reduction					Enable Service Brake Reset	
Idle Reduction	Idle Shutdown in PTO	Enable PTO Shutdown			EIST - PTO Mode Overrule	
Idle Reduction	Idle Shutdown Percentage PTO Load Override					
Idle Reduction	Idle Shutdown Ambient Air Temperature Override - Feature Option	Ambient Air Temp Sensor Enable			EIST - Ambient Temperature Overrule	
Idle Reduction	Idle Shutdown Intermediate Ambient Air Temperature			Intermediate Ambient Air Temperature		
Idle Reduction	Idle Shutdown Hot Ambient Air Temperature	Hi Amb Air Override Temp		Max Ambient Air Temp for Idle Shutdown	High Temperature Ambient Overrule	
Idle Reduction	Idle Shutdown Cold Ambient Air Temperature - Parameter	Lo Amb Air Override Temp			Low Ambient Temperature Overrule	
Idle Reduction	Idle Shutdown Hot Ambient Automatic Override - Feature Option					
Idle Reduction	Idle Shutdown Manual Override Inhibit Zone - Feature Option					
Driver Rewards	Driver Reward Enable	Fuel Economy Incentive Enable	Fuel Economy Incentive Mode Selection (enable)	Driver Reward Enable		
Driver Rewards	Driver Reward Expected Fuel Economy Standard	FEI Minimum Fuel Economy	FEI Penalty Target Fuel Economy	Fuel Economy - Expected Level		

	Cummins	Detroit	Mack	Navistar	PACCAR	Volvo
Driver Rewards	Driver Reward Penalty Speed		FEI Penalty Vehicle Speed Decrease	VS Limit Decrement - Penalty Level		
Driver Rewards	Driver Reward Good Fuel Economy Standard		FEI Reward Target Fuel Economy	Fuel Economy - Good Level		
Driver Rewards	Driver Reward Best Fuel Economy Standard			Fuel Economy - Excellent Level		
Driver Rewards	Driver Reward Expected Idle Standard			Percent Idle Time - Expected Level		
Driver Rewards	Driver Reward Good Idle Standard			Percent Idle Time - Good Level		
Driver Rewards	Driver Reward Best Idle Standard			Percent Idle Time - Excellent Level		
Driver Rewards	Driver Reward Speed Reward Mode					
Driver Rewards	Driver Reward Expected Speed Reward			VS Limit Increment - Expected Level		
Driver Rewards	Driver Reward Good Speed Reward	FEI Max Vehicle Speed Reward	FEI Reward Vehicle Speed Increase	VS Limit Increment - Good Level		
Driver Rewards	Driver Reward Best Speed Reward			VS Limit Increment - Excellent Level		
Driver Rewards		FEI Use Trip Mileage	FEI Distance Calculation Interval			
Driver Rewards		FEI Conversion Factor				
Driver Rewards		CDR mode				
Driver Rewards		CDR Reset Frequency				
Driver Rewards		Top Gear Max CDR incentive				
Driver Rewards		Max CDR incentive for CC				
Miscellaneous	Engine Brake Cruise Control Activation	Cruise Control Enable Eng Brk		Retarder Mode	MX Retarder State Cruise Control On	
Miscellaneous	Cruise Control Speed Delta for Minimum Engine Brake	Low Eng Brk Max Cruise RSL Spd		Minimum Vehicle Speed For Retarder		
Miscellaneous	Cruise Control Speed Delta for Maximum Engine Brake	Hi Eng Brk Max Cruise RSL Spd		Cruise Control Retarder High Speed		
Miscellaneous						
Miscellaneous						
Miscellaneous		Eng Brk Stage On Service Brake				

	Cummins	Detroit	Mack	Navistar	PACCAR	Volvo
Miscellaneous		Service Brk Enable Eng Brakes				
Miscellaneous				Delay After Throttle Pedal Released		
Miscellaneous				Delay After Brake Pedal Pressed		
Miscellaneous		Enable eCoast (Detroit Transmission)				
Miscellaneous	Engine brake delay (up to 3 seconds)				Allow Multi-Torque Only When Cruise is Active	
Miscellaneous	Engine brake min vehicle speed			Upshift Indicator		
Miscellaneous	Adaptive Cruise Control - Feature Option					
Miscellaneous		Predictive Cruise Control Eng Brake Mode				
Miscellaneous		Predictive Cruise Control Lower Veh Spd Limit				
Miscellaneous		Predictive Cruise Control RSL Mode				