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THE PROFIT MOTIVE
4 STEPS TO IMPROVING YOUR SHOP'S FRONT DESK SERVICE 8

ENDEAVOR BUSINESS MEDIA
SEPTEMBER 2020
VOL. 139, NO. 9 // MOTORAGE.COM

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X-431 Turbo

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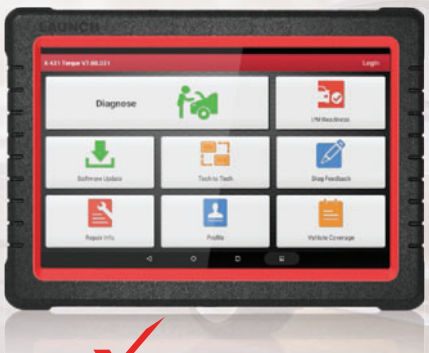

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Talk Shop Anytime

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OPERATIONS

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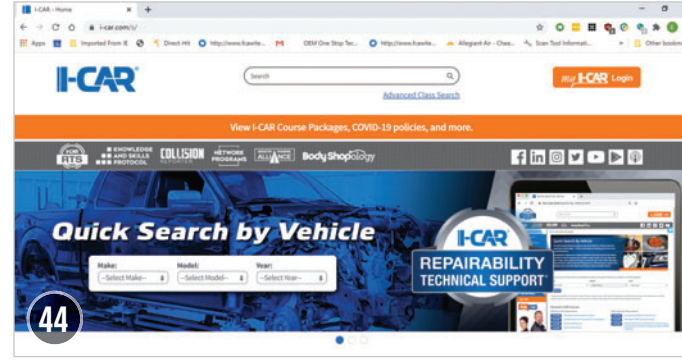

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TECHNICAL

IN EVERY ISSUE

VIDEO

A PEAK AT MOTOLOGIC

Get a introduced to the new MOTOLOGIC in this video. Watch at: ***MotorAge.com/SneakPeak***

WEB EXCLUSIVES // MOTORAGE.COM

CORRECTLY CALCULATE YOUR AVERAGE REPAIR ORDER

Does your Average Repair Order math work out the way you think it should? Double check your answers, and what you come up with might be wrong. That's why you need this first part of an exclusive series by John "JB" Burkhauser, the director of training at BOLT ON TECHNOLOGY. JB has insight into how you can correctly calculate your ARO — and how you can secure more work for the future, not just today. ARO is just one piece of the car count controversy that JB dives into. His article ties into why you want more vehicles: to have the chance to look at them and inspect them to find additional work to sell. This first piece in a two-part series is a must-read right now for all shop owners and managers. Discover how to get the vehicles you have moving down the right path in getting work approved now and more often.

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EVENTS

AAPEX 2020 IS GOING TO BE A VIRTUAL EXPERIENCE

MOTOR AGE WIRE REPORTS //

AAPEX 2020, scheduled for Nov. 3-5, 2020 at the Sands Expo and Caesars Forum Conference Center in Las Vegas, will not be held as an in-person tradeshow event this year due to the current state of the COVID-19 pandemic and related governmental prohibitions and restrictions on gatherings, businesses and travel.

Instead, AAPEX will provide a virtual/digital experience with many of the show's same elements presented digitally. AAPEX organizers walk us through the answers to some common questions to help attendees better understand what to expect with the virtual event set up and how to proceed.

Why did AAPEX move to a virtual event?

Given the state of Nevada's recently announced long-term mitigation strategy for the COVID-19 pandemic, which has indefinitely prohibited events with more than 50 participants, and the severe limitations on international and domestic travel imposed in connection with the pandemic, unfor-

>> CONTINUES ON PAGE 5

BREAKING NEWS

TRAINING

900+ INSTRUCTORS JOIN ASE VIRTUAL TRAINING COURSE

The ASE Virtual Instructor Conference was a huge success, as more than 900 instructors from across the country participated in the sold-out event. The conference was developed and conducted for high school and post-secondary instructors from automotive, truck and collision repair programs nationwide.

"We could not be happier with our first virtual training conference," said Mike Coley, president, ASE Education Foundation. "We had 1,000 instructors register for the event, the limit of the virtual platform, and more than 900 instructors participate in one or more sessions, a 150 percent increase over last year's record-setting attendance. Many thanks to the presenters who shared critical information that instructors could not get anywhere else, and

>> ASE CONTINUES ON PAGE 6

TRENDING

SNAP-ON 100TH EDITION ZEUS NOW AVAILABLE

The new 100th Edition ZEUS® Workstation allows techs the freedom to use the ZEUS diagnostic and information system, featuring exclusive Intelligent Diagnostics, throughout the service bay.
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HUNTER INTRODUCES AUTOCOMP ELITE

Hunter announced a new AutoComp Elite® family of on-car brake lathes. The new Digi-Cal, Standard and Base lathes are built from the same lathe body, but deliver different features and price points.
MOTORAGE.COM/LATHES

DANA LAUNCHES SPICER READYPAK

Dana Incorporated has introduced new Spicer ReadyPack™ preassembled kits for the most popular commercial vehicle driveshafts, coupling shafts and interaxle shafts.
MOTORAGE.COM/READY

MYASE DASHBOARD STREAMLINES OPTIONS

The National Institute for Automotive Service Excellence (ASE) plans has updated the myASE dashboard with new shopping, navigation and quick links, video tutorials and more.
MOTORAGE.COM/MYASE

BOLT ON RELEASES FOURTHGEAR

BOLT ON TECHNOLOGY, launched FourthGear, featuring Review Manager that will help shops boost their positive online customer feedback and raise their Google rankings.
MOTORAGE.COM/4THGEAR

>> AAPEX CONTINUED FROM PAGE 4

tunately, it is not possible for the traditional in-person event to proceed.

Will registered attendees get a refund? If yes, how will this work?

Yes, registered buyers will receive a refund. Refunds will be automatically processed within the next two weeks.

Does AAPEX anticipate returning to an in person show in 2021?

Yes, AAPEX 2021 is planned for November 2-4, 2021, at the Sands Expo and Caesars Forum Conference Center in Las Vegas.

What should attendees do who have purchased airline tickets?

Contact the airline directly for their individual policy details and options.

What should attendees who have reserved hotel rooms do to apply for refunds/credits?

If you booked a hotel room through AAPEX's official housing vendor On-Peak, your room will automatically be cancelled, and you will receive official confirmation within a week.

Will exhibitors get a refund?

Exhibitors can opt to get a refund or have monies applied to the 2021 event.

Will I have first right of refusal in 2021 for the sponsorship I booked this year?

Yes.

What should exhibitors do who have purchased airline tickets?

Contact your airline directly for their individual policy details and options.

What should exhibitors who have reserved hotel rooms do to apply for refunds/credits?

If you booked a hotel room through AAPEX's official housing vendor On-Peak, your room will automatically be cancelled, and you will receive official confirmation within a week.

Will this action affect seniority?

No, it will not.

What should exhibitors do if they have reserved spaces for hospitality events, receptions, dinners or other meetings and events within the Venetian, or other Las Vegas venues?

If you've booked space at a restaurant, hotel or other venue, contact them directly for information.

When will exhibit space/applications for AAPEX 2021 become available?

Exhibit space applications for AAPEX 2021 will be available November 16, 2020.

When will the virtual AAPEX event take place?

>> AAPEX CONTINUES ON PAGE 6

>> ASE CONTINUED FROM PAGE 4

Cengage who provided the registration and webinar technical support."

Educators who participated in the conference received a collective total of 5,700 hours of professional development training specifically geared to training programs coping with the effects of COVID-19. On average, each instructor participated in more than six hours of virtual training during the two days of the conference, all of which are applicable to the 20-hour annual training requirement.

The sessions covered a wide range of topics. Fernando Bleichmar, general manager of U.S. Higher Education and Skills for Cengage, gave the keynote address where he focused on macro trends in education. Toyota T-TEN instructors shared their Safe Lab plan, ASE staff discussed the impact of COVID-19 on program accreditation, and SkillsUSA showed how to develop students' employability skills. Instructors also heard about varied instructional models, how to engage distance learners and how to put work-based learning into action. Eight different publishers explored curriculum presentation in a virtual environment. Eric Chester, a noted speaker and author, delivered a closing speech that revealed keys to student motivation.

Instructors who were not able to attend the live conference will have the opportunity to view recorded sessions, download handouts and receive certificates of completion by visiting the Events section of the ASE Education Foundation website.

>> AAPEX CONTINUED FROM PAGE 5

The virtual event will be held the week of November 3, 2020 (during the originally planned, in-person event days).

If SEMA has a virtual event, will attendees be able to go to both the AAPEX and SEMA virtual events in the same way their badge gives them access to both shows?

There are no current plans to conduct a joint virtual event. If SEMA decides to hold a virtual event, it will be completely independent of AAPEX. Registration will be separate.

What will the virtual AAPEX event include?

Details of the virtual event were set to be announced in late August (after press time) to include exhibitor, sponsor, attendee, and registration information.

When will registration open for AAPEX's 2020 virtual event?

Registration opened Wednesday, August 19, 2020.

If an attendee is already registered for AAPEX, will they have to provide credentials again for the virtual event?

Registration will be separate.

For any additional questions reach out to Bill Glasgow, Jr. at billjr@aapexshow.com.

ASTE 2020 CANCELED, ASTE 2021 EXPECTED TO RETURN LARGER THAN LIFE

With safety as a top priority, the Independent Garage Owner's Association of North Carolina (IGONC) has decided the Automotive Service and Technology Expo (ASTE) will not happen in 2020.

Despite hopeful attitudes from event organizers and industry members, COVID-19 presents unignorable factors that will not allow ASTE 2020 to occur as planned. IGONC's decision was made based on gathering size restrictions imposed by North Carolina and the uncertainty of the timeline for the virus.

ASTE is the Southeast's largest aftermarket automotive show, and the 2021 expo will return as the largest installation yet. With an estimated 180 vendors and nearly 80 exhibitors, including Advance/Carquest and Tekmetric, ASTE 2021 will offer new excitement and opportunities for attendees. In a similar fashion to the 2019 expo, ASTE 2021 will continue the traditional ASTE Pizza Party and Casino Night, and commence with a banquet dinner including IGONC's Annual Induction of Officers and Awards Ceremony.

IGONC is also excited to announce that there will be two ASTE events taking place in 2021. The fall expo will resume as expected and will be preceded by a new spring event. IGONC hosting two events will ensure that ASTE 2021 will return larger than life.

IGONC Executive Director Tricia Sauls states, "As ASTE grows and gains national following, we want to provide a safe and fun experience for all participants, which isn't feasible this year. We are working with current and new vendors and repair shops to expand ASTE and provide an educational, fun event at a very cost-effective price. We are excited and expect the ASTE 2021 will be bigger and better than ever."

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Four steps to improving your shop's front desk service

Practice makes perfect when honing their skills and abilities

We have all witnessed increases and decreases in our average repair orders over the years. Customer service and selling are greatly affected by a person's emotional state of mind and them sticking to procedures consistently. Let's listen to ATI Performance Coach Mike Haley share how he teaches these skills so shop owners can manage their front desk service folks.

Have you ever read or watched stories on top athletes and wondered what makes them the best? There is obviously their natural talents. Some of us will never dunk a basketball no matter how hard we train. But when you compare similar body structures and talent, what is it that separates the good from the great? Putting the sheer willingness to be the best aside, what separates the good from the great is the amount of preparation.

I am a football fan. I played up until my abilities were no longer appreciated (community college) and knew playing in the pros was never going to happen. I felt I had the physical features and mentality to play at that level, but I was missing something the pros had. I grew up like most of us, playing in the backyard or in the street with the neighborhood kids. Then I joined a local rec league with my friends. The coaches were volunteers who also enjoyed the game and played high school ball.

PUTTING THE SHEER WILLINGNESS TO BE THE BEST ASIDE, WHAT SEPARATES THE GOOD FROM THE GREAT IS THE AMOUNT OF PREPARATION.

Then high school came and there was more emphasis put on the game and your play. You were not guaranteed playing time and/or the ability to play the position you wanted. You had to earn your spot and playing time, which meant getting into the weight room and working out with your quarterback if you were a receiver, or center if you were a kicker. But after practice, we had plenty of distractions. No one explained to me that if I wanted to be the best I would need to put in the extra time and effort to learn all there is to my position. I went to practice, did the required weightlifting, and was at the film study on Monday after games. What I realize now is that I met the minimum requirement and was only doing what everyone else was doing. I did nothing to separate myself from everyone else.

In the NFL, the games are sixty minutes. But the actual play time of the game itself is 11 minutes. By position the actual play time is somewhere between four to six minutes. So how much time do the pros spend practicing for their four to six minutes of play time? The typical NFL team spends 44 hours a week with scheduled practices. The players will then spend additional hours with film study and physical therapy. So it's safe to say the typical pro football player spends more than 50 hours a week on his craft to play four to six minutes a week. How much do you and your team practice at the service desk in preparation for your game day? How do we expect our service desk to be the best when we give them virtually no practice or film time to hone their skills?

We do not have 50 hours a week to train. We do, however, have precious minutes in our week to train, practice and provide feedback to our employees. If we follow a few simple steps, I believe we can drastically improve our performance at the service desk.

Step 1. Set the expectations. The employees need to know your Standard Operating Procedures (SOPs). From the greeting to the good-bye and everything

in between. If you have multiple employees doing it the way they want to do it, you are guaranteed inconsistency in your performance.

Step 2. Practice together with employees. Have morning huddles prior to opening, or weekly meetings with your staff. Take a few minutes to practice with your team to help them become more comfortable and fluid interacting with customers.

Most customers are going to ask two questions: how much and how long? I am always amazed how these questions will still catch employees by surprise and they are not able to respond immediately and confidently. I think of this scenario like driving a car. Remember the first time you drove a car? How acutely aware you were of every detail? You steered the car neatly between the lines, making sure you drove the speed limit, and kept a safe distance from other cars. Now you do not even pay attention to the route you took home. It's committed to memory. Take time to role play and practice overcoming common objections, and know selling features and benefits to help improve your employees' conversion rate and improve their CSI.

Step 3. Study the experts. You don't have to reinvent the wheel when it comes to sales techniques for your shop. There are just shy of three million YouTube videos on "how to sell." These are quick videos on how to become a better salesperson from some of the top salespeople in their industry. Also send your employees to vendor-sponsored class to learn more about the features and benefits of what they are selling. ATI's CEO Chris "Chubby" Frederick Sr. used to hold a sales training class every Monday for shop owners when he was involved in running the day-to-day of the company. They benefited greatly, and now most are among of the top shops in the nation.

Step 4. Perform observations. Just as football players have stats to track and evaluate performance, you should do the same when observing service desk performance. To do this, I recommend using my Sales Management Checklist. Ensure that service desk employees are following your shop's procedures as intended and provide instant feedback if needed to improve.

I always tried to perform two observations a week per service writer. We always have a discovery that changes our process, policy or introduces technology. These improvements made us better at our job and also put the owner at ease that the desk is running the same, whether they were physically at the service desk or not.

Recognize that most people want to be the best at what they do, and it's your job to provide them with the knowledge and tools to become just that. The keys to achieving greatness and peak performance is to set expectations, practice often, study the experts and observe results. To help them stay on track and stay the best shop in their area, we have shop owners follow the ATI Sales Management Checklist. Get a copy of the checklist to use in your shop at *www.ationlinetraining.com/2020-09* for a limited time.

CHRIS "CHUBBY" FREDERICK is the CEO and founder of the Automotive Training Institute. ATI's 130 full-time associates train and coach more than 1,700 shop owners every week across North America to drive profits and dreams home to their families. Our 32 full-time Certified Performance coaches have helped our members earn over ONE BILLION DOLLARS in return on their coaching investment since ATI was founded. This month's article was written with the help of ATI Performance Coach Mike Haley.
chubby@autotraining.net

DON'T HIT THE "EASY" BUTTON

How to turn price shoppers into loyal customers

DAVID ROGERS // Contributing Editor

The "easy" button in auto repair shops is the "create estimate" button in the point of sale system. Making this single click probably does more to cost your business than any other action you can take.

I know this is a strong statement right out of the blocks, but hear me out.

If an employee is actively sabotaging your business, you're bound to find out, replace the employee and create policies to prevent it from happening again. You can't fire the "create estimate" button, but you can make a choice to use it or not.

But the "create estimate" button is an accepted part of a point of sale. It seems innocuous. It feels harmless to push. What's the worst thing that could happen?

I'm here to tell you that pushing that button whenever a price shopper calls your shop is — in nearly every circumstance — not what the customer needs, not what your shop wants and will not create more sales, strengthen the relationship or help anybody on either side of the call.

The worst thing that could happen is you waste time creating the estimate and the customer doesn't take your offer. Or worse, get the customer to bite on the lowball offer and throw good money after potentially misguided advice. Neither is a particularly great result.

In our shop, the "create estimate" option might as well not exist, because our team has a proven method for dealing with price shoppers on the phone. The first step of which is to remember that they're not really looking for a price.

Cars > money

It's true; price is not the answer. Ignore all your instincts, because they're not looking for you to lowball them. They don't need or even want to find the least expensive shop.

That price shopper simply doesn't know what else to ask.

You know it and I know it, but I'll say

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it out loud anyway: automotive repair isn't a commodity. If you are buying a pair of Levi's 501 jeans, you can call around, provide measurements and confidently get an apples-to-apples comparison.

But repairing a car isn't the same as buying a pair of jeans. And treating it that way creates the wrong expectation. When you push the "create estimate" button and create a quote, when you lowball the offer, cut profits and quote the cheapest parts, all in an effort to get them through the door the first time, you make that transaction about money. The next time that customer needs a repair, they'll go through the same process. After all, there's nothing to separate you from every other repair shop — you confirmed that belief when you created that estimate and gave that quote.

And that's the best-case scenario. In all likelihood, you'll be lowballed by somebody else and have to void yet another estimate from your point of sale system.

When a customer doesn't know how else to tell repair shops apart, they ask about price. After all, they've seen the nightly news reports about shady shops running scams. Customers are led to believe every shop is out to get them, so why not get away for as little money as possible?

Which is why our service advisors know the first job is to educate the customer. When a caller asks for a price, we know the customer doesn't know how else to tell shops apart; the best thing we can do to help them is give them the tools needed to make the best decision for their vehicle. It's as simple as, "If you'll give me five minutes, I'll give you better questions to ask so you can make the best decision for yourself and your family."

And just like that, you've changed the conversation. Without even using the words, you said, "We care more about you than the money."

Perfecting trust

What comes next, of course, is unique to your shop. What sets you apart? What are your distinct and meaningful differences?

My shop has been serving our community for more than 45 years, which immediately sets us apart. We have excellent BBB and AAA ratings. And, we stand behind our work with a strong nationwide warranty.

The last item is particularly important, because customers don't seek perfect repairs. Parts fail and problems happen, and customers understand this reality. They do expect perfect trust, though. You can't control the failures, but you can control how you deal with them. Our warranty is a critical part of representing that to our customers.

But what sets my shop apart isn't nearly as important as what sets yours apart. Do you know what makes your shop unique? Have you thought about it?

Once you know how to set yourself apart, get this on a card and put it by the phone in your shop. Nobody has a perfect memory and trying to memorize your unique and meaningful differences is an invitation to forget a critical bullet point at a key moment.

Actions speak louder than rote estimates

Of course, bullet points can only do so much, because your tone does all of the work for you. When the customer asks for a quote, if you sound too busy — if you sigh, if you give any indication they're not important — the relationship is dead on arrival.

Which is really part of the bigger picture here and the reason why you shouldn't give quotes. The reason why you should educate customers even though you might lose the sale from some price shoppers. The reason why spending time with the customer like this is all the same. You have to be the people you say you're going to be.

When you make that card with a few statements about why your shop stands apart from others and put it by the phone, when you teach customers how and why to make a decision about their vehicle, what you do is show them you care. You demonstrate through your actions that you're not just after their money.

Chances are, no other shop has ever taken the time to show the customer they're cared about. That's why they're searching around, asking the wrong questions in the first place. They need that connection. They need that care. And if you take the time, there's a good chance you'll become the trusted shop for them.

And if not? If they were only chasing price? So much the better. That customer was never going to value your relationship, and you remained committed to doing what is best for your business in the long run. You're both better off, and there's no estimate work order to void from your system.

If you've made it this far, it's clear you're the kind of shop owner who values transparency, who cares about customers and who understands the importance of setting expectations and delivering on what you promise. To help you expand that care and commitment to other areas of the advising process, head to explore2.shop4d.com/podcast-how-to-deal-with-price-shoppers/ to download a free podcast to help you apply this same education to advising customers about preventive maintenance.

DAVID ROGERS is chief operating officer of Keller Bros. Inc., president of Auto Profit Masters and president of Shop 4D, the industry's first Artificial Intelligence (AI) -enabled, self-learning system for proactively managing repairs, customers, marketing, profits and employees. Reach David via email at *contact@shop4d.com,* toll-free at 1-866-826-7911, or *online at https://shop4d.com/.*

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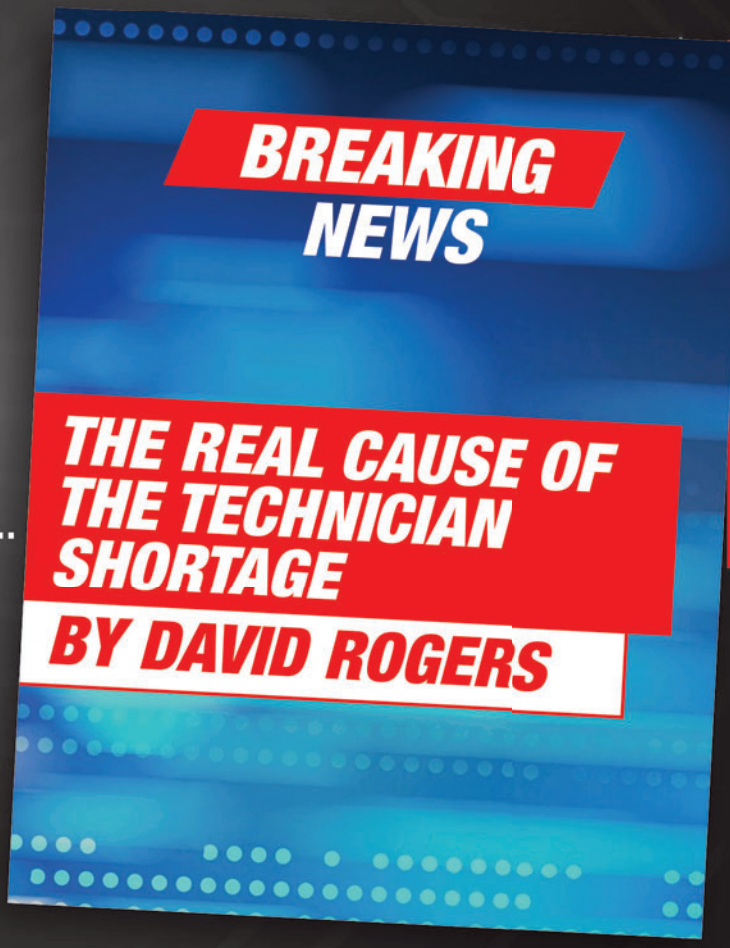

"I'm more efficient, which means more hours in the day to work and allows me to make more money!"

Scott L.
Lead Tech

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How COVID-19 has created just the latest challenge

Technology, evolving consumer habits were upended with the pandemic

Everyone is aware that vehicle technology and business trends are moving forward at a constant pace. Things are changing so fast, in fact, that many automotive repair shops have had to devise strategies to help them keep up.

The same can be said for the jobber business, where electrification, alternate fuels and vehicle automation are causing incredible parts proliferation, forcing stores to rethink their approaches to inventory management and customer service.

Technological advances will continue to change the dynamics, look and day-to-day operation of aftermarket businesses. To succeed, repair shops and parts stores alike must have a plan for adapting to the latest developments.

But no one anticipated the kind of rapid and revolutionary changes that a global pandemic would bring. COVID-19 forced overnight changes at the shop and jobber level, prompting a complete realignment of business priorities faster than new technology ever could.

In the past few months, we've seen a complete redesign of the consumer experience at repair and service shops:

- Touchless drop-off of vehicles
- Vehicle pick-up and drop-off at client homes and businesses
- Fewer chances to chat with clients face to face
- The complete sanitization of keys and vehicles before they come into the bay
- A second sanitization before these are returned to the client
- Complete rearrangement of the shop interior to ensure physical distancing
- Extensive use of personal protective equipment by staff
- Thorough and frequent cleaning of public areas, surfaces and hands
- Potential deterioration in staff morale as employees try to maintain productivity while being distracted by concerns for their own families, and looming over everything:
- The consequences to the shop if even one staff member is infected with COVID-19

TO SUCCEED, REPAIR SHOPS AND PARTS STORES ALIKE MUST HAVE A PLAN FOR ADAPTING TO THE LATEST DEVELOPMENTS. QUOTE COLUMN OPERATIONS OPERATIONS

These issues are stressful to shop owners across the country. Given the situation, it would be understandable if relations with suppliers are occasionally strained or tempers occasionally flare. Shops have had to start working in "emergency mode."

Managers and owners should bear in mind, however, that jobbers are also facing market uncertainties, and have had to retrain their staff and reassess their protocols in order to meet the needs of their clients.

Among the challenges they've faced in recent months:

- Shops that insist parts are dropped off outside the shop in a secure but

THE LASTING EFFECTS OF COVID-19

SCOTT LUCKETT // Contributing Editor

Recently I participated in an Auto Care Association webinar along with a panel of industry analysts discussing the lasting impacts of COVID-19 on the aftermarket. There were many valuable insights shared, but I want to focus on the changes that will resonate for years and account for lasting change in 1) the level of digital commerce and 2) the new business models for automotive service shops.

For the past year or more, I have enjoyed a wonderful partnership and friendship with Jon Hedges. Jon and Julie Hedges operate a digital marketing practice in Hudson, Ohio. Jon has always been fascinated by all things "internet." And since the pandemic arrived on the scene, Hedges and Company has offered up some meaningful data about the growth of digital sales channels in a range of industry categories. We look forward to the weekly blog from Hedges & Company as a measure of how far up eCommerce sales are going to go and where the sales growth will level off.

With stay-at-home orders in place across the country earlier this year, it was no surprise that miles traveled hit an historic low in April and online purchases reached for the sky. Continue at **MotorAge.com/LastingEffect.**

touchless way
- Confirming that all deliveries are made to the client's satisfaction with minimal face-to-face contact
- Operating a staff that still has to venture out into the field for sales and detailing visits in a time of social distancing
- Keeping counter teams safe and informed about COVID-19 transmission
- Maintaining the trust of wholesale clients when low-grade paranoia about health safety infects every personal interaction.

COVID-19 has brought an incredible level of complexity to routine transactions.

As stress levels rise, let's all take a deep breath, acknowledge what an unusual situation we find ourselves in, and calmly consider the best path forward.

Jobbers might want to ask themselves what they offer their best customers that other jobbers don't or simply can't offer. Understanding their clients' businesses, of course, is key to meeting needs. Do they fully grasp each shop's circumstances and vision? Can they offer competitive advantages to help client businesses grow profitably?

Meanwhile, shops need to redefine the added value they bring to their clients. What makes them the best service outlet for their customers' vehicles?

Professional shops and jobber businesses want to do business that offers clear profitability, not just volume sales. That is true today, and will probably be even truer tomorrow. Our industry is getting too complicated to rely on low-margin sales. This only creates volume, not profit. Everyone ends up working too hard for very little money.

In repair shops and jobber stores alike, we want to work smarter. Relying on the way things have always been done in the past is a recipe to failure.

COVID-19 has shown all of us how fast business conditions can change. Look at the fantastic response you've done of negotiating these difficult times. Now apply the same kind of ambition and innovation to the other challenges in our industry.

Change is not an option. Today's entrepreneurship and leadership will help you capture tomorrow's business. Failure to change is not an alternative.

BOB GREENWOOD, AMAM, is president and CEO of Automotive Aftermarket E-Learning Centre Ltd. (AAEC), which provides business management resources for the automotive aftermarket. Bob has more than 36 years of business management experience and is one of 150 worldwide AMi-approved instructors.
greenwood@aaec.ca

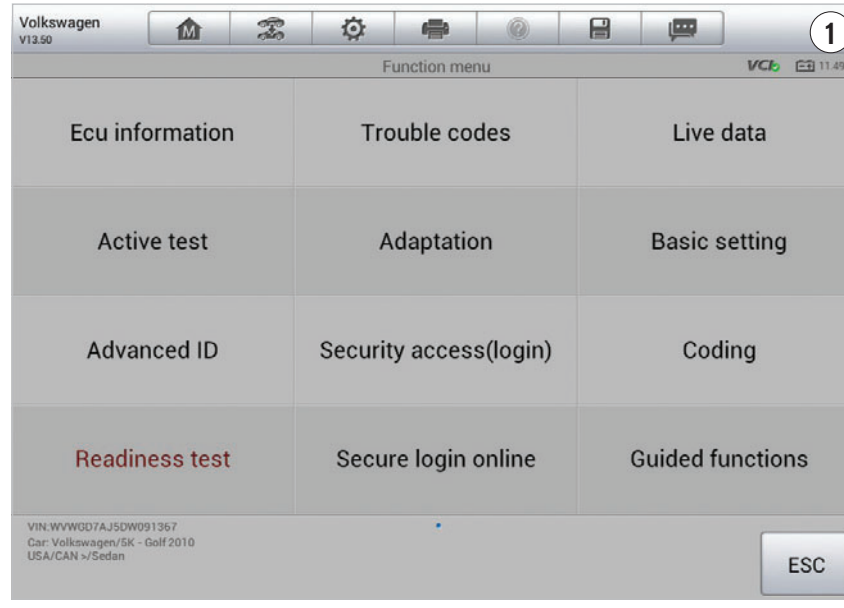
A LOOK AT EUROPEAN CASE STUDIES

LEARN HOW DIAGNOSTIC CHALLENGES PRESENTED BY TWO VOLKSWAGENS AND A BMW WERE SOLVED AFTER TAKING UNEXPECTED TURNS

G. JERRY TRUGLIA // Contributing Editor

We begin our European case studies with a 2004 VW Jetta 2.0L at 161K miles. It came in with the complaint of an illuminated Check Engine light. We follow our usual game plan with a customer Q&A session to find out when the Jetta owner first noticed any symptoms, along with trying to find out when the Check Engine light illuminated. Our diagnosis started with a visual check followed by a scan of the vehicle's systems that uncovered two DTCs. The DTCs that were revealed were P0140 (HO2S2 Oxygen Sensor Heater Circuit, Bank 1 Sensor 2 No Activity) and the dreaded P0420 (Catalyst Efficiency Below Threshold Bank 1). We now had enough data to formulate a game plan.

The next step was to measure the O_2 sensor heater circuit, where we found both good voltage and ground reference. This concluded that there was a problem internally with the sensor. To confirm that the sensor was the issue, we connected an Ohm meter to check for resistance on the heater circuit. The results of the Ohm test revealed a reading of OL (infinite resistance/open circuit), confirming that the sensor was bad. After completing our testing, we called the vehicle owner and explained that the first course of action to repair this VW was to replace the O_2 sensor. This would be followed by clearing the DTCs, setting monitors and test driving the vehicle. The results after a couple of test drives were that the MIL stayed off and all monitors were ready.



It is important to make sure that the monitors are ready to confirm your repair. Many techs do not understand how important monitors are. When a monitor is not ready, you do not know if you've fixed the drivability problem on the vehicle. On Audi/VW products (and a few other OEs), you can run the monitors to ready right from your scan tool to check the vehicle systems out faster (**Figure 1**). I usually recommend performing this step so a test drive can illuminate the MIL quicker, confirming if the vehicle repair was successful or not. On this Jetta, the vehicle was indeed repaired since the MIL stayed off.

The customer was happy and drove away, but it would not be the last time that we see this VW. At 165K miles, the vehicle returned with the MIL illuminated again and a Jetta owner who was not sure that we had repaired the Jetta correctly. We explained that we would diagnose the vehicle and if the same DTC for the O_2 heater circuit was the cause of the illuminated Check Engine light, we would repair the vehicle, free of charge.

Don't you just love it? Once you touch it, some customers want you to

PHOTOS: G. JERRY TRUGLIA

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- Had limited inventory of key tools and equipment?
- Lost access to inventory of specific brands or fitments?
- Increased prices to cover expenses on their end?

The Current Aftermarket State

8.8%
Total Aftermarket Parts Sales Declining*

But there's good news!

$281 billion in 2020 to $314 billion in 2021
Growth of total light duty aftermarket sales*

80%
Auto parts orders still placed over the phone – an inefficient and costly approach**

eCommerce is GROWING!
An online revenue from eCommerce transactions for parts and accessories the week of April 26-May 2 had a 67% increase from the first week of March.***

* 2020 Joint Channel Forecast Model produced jointly by the Automotive Aftermarket Suppliers Association (AASA) and the Auto Care Association
**https://www.searchautoparts.com/aftermarket-business/automotive-aftermarket-technology/partstech-streamlines-ordering-process
***The Hedges & Company survey, https://www.searchautoparts.com/aftermarket-business/automotive-aftermarket-technology/online-aftermarket-sales-explode-%E2%80%94-good-way

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Go mobile
Use your mobile device that can be connected freely to alternative suppliers like eBay Motors to find parts quickly.

Partner, partner, partner
Find someone in another area of the country you can work with to buy parts from to expand your base.

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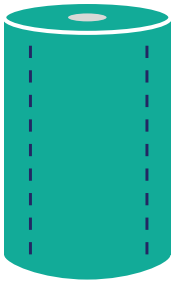
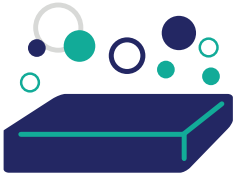
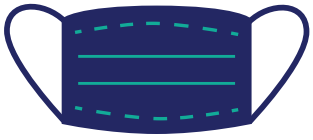
That phrase has taken on a different meaning in 2020.
But if you're looking for more ways to add efficient purchases to your shop, look to eBay Motors for additional options to buy product. Utilize shipping and other discounts applied when you order in bulk. Plus, save an unnecessary trip to the store – ***find the shop supplies you need on eBay.***

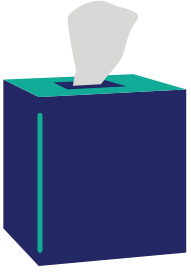

Paper towels


Soap


Hand sanitizer


Bottled water


Face masks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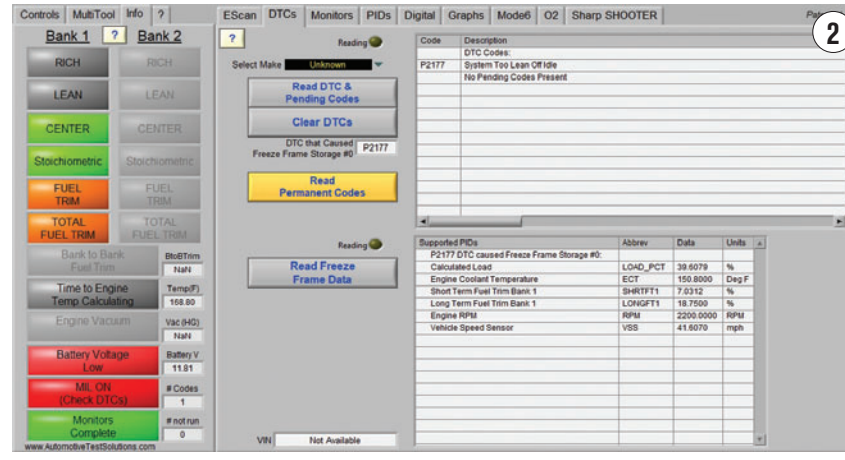
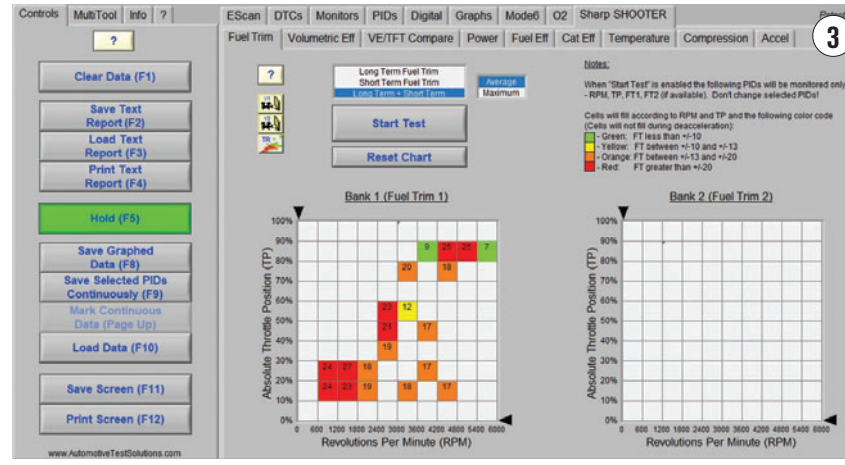
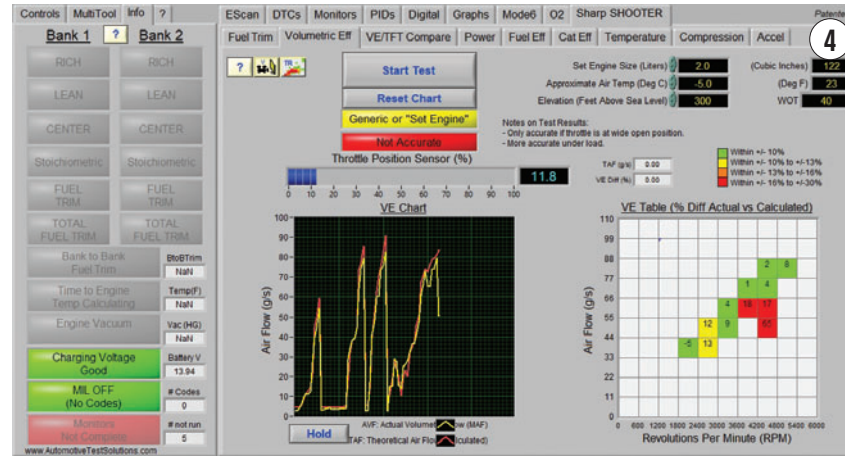
own it and repair everything for free.

Following a complete vehicle scan, we uncovered a P2177 (System Too Lean Off Idle) that could mean that the engine has a fuel delivery problem (**Figure 2**). The first place to start is by checking the fuel trim numbers. If you don't own an ATS EScan than you not only need to look at fuel trim numbers, but you need to find out what fuel cell the DTC has set in. Since we do have the EScan, it's easy for us to identify what fuel cell the problem is occurring in. If the fuel trim block numbers are high/positive at the lower end, then it's a vacuum-related problem. If it's high at the top of the chart, the problem is fuel delivery (that could be a clogged filter, voltage drop on the fuel pump circuit or a bad fuel pump). If neither one of these exist and the chart has high fuel trim numbers from bottom to top, then the problem is a load sensor (**Figure 3**).

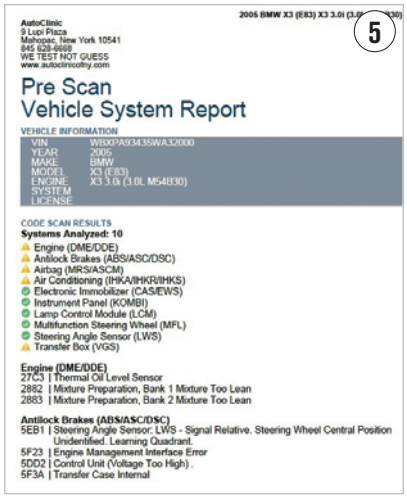
Jettas use an MAF sensor, so the next logical test to perform would be an MAF sensor volumetric efficiency test (VE test). On the EScan, we selected the VE test and ran it, confirming that the MAF sensor had an issue (**Figure 4**). The MAF sensor on this engine cannot be cleaned, so the only path of repair would be to recommend a rebuilt or new MAF sensor. I am not a fan of the rebuilt sensor, since many of them will not perform correctly (we learned by experience). After we printed out and provided the test results to the VW owner, she understood and gave us the OK to repair the vehicle. That old saying "paper sells" is true. We always provide a printout or electronic copy of the diagnostic report so the vehicle owner can see the before and after difference. In this case, it helped keep the Jetta owner calm, rather than her blaming us for not diagnosing and repairing her vehicle properly.







With that out of the way, we still needed to explain that a 165K mile vehicle will have parts that have worn or gone bad. Since this VW engine had a lean condition, there was a chance that the P2177 (System Too Lean Off Idle) could cause a very rich mixture, taking the catalytic converter over the edge and illuminating the Check Engine light (again, setting a P0420 DTC). Luckily for this Jetta owner, after the MAF sensor replacement and a couple of road tests, the VW was DTC-free.



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2005 BMW X3 (E83) X3 3.0i (3.0L M54B30)

5

Pre Scan
Vehicle System Report

VEHICLE INFORMATION

VIN	WB5XPA9345WA32000
YEAR	2005
MAKE	BMW
MODEL	X3 (E83)
ENGINE	X3 3.0i (3.0L M54B30)
SYSTEM	
LICENSE	

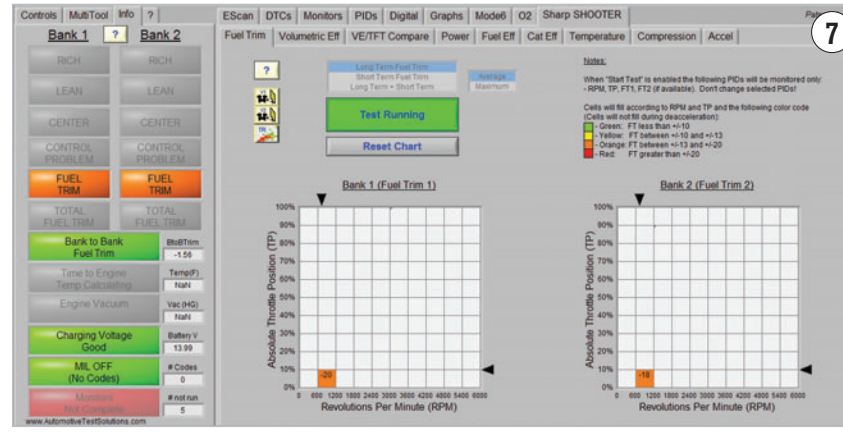
CODE SCAN RESULTS
Systems Analyzed: 10

- Engine (DME/DDE)
- Antilock Brakes (ABS/ASC/DSC)
- Airbag (MRS/ASCM)
- Air Conditioning (IHKA/IHKR/IHKS)
- Electronic Immobilizer (CAS/EWS)
- Instrument Panel (KOMBI)
- Lamp Control Module (LCM)
- Multifunction Steering Wheel (MFL)
- Steering Angle Sensor (LWS)
- Transfer Box (VGS)

Engine (DME/DDE)
27C3 | Thermal Oil Level Sensor
2882 | Mixture Preparation, Bank 1 Mixture Too Lean
2883 | Mixture Preparation, Bank 2 Mixture Too Lean

Antilock Brakes (ABS/ASC/DSC)
5EB1 | Steering Angle Sensor: LWS - Signal Relative. Steering Wheel Central Position Unidentified. Learning Quadrant.
5F23 | Engine Management Interface Error
5DD2 | Control Unit (Voltage Too High) .
5F3A | Transfer Case Internal

6



7

A 2005 BMW X3- MIL/misfire

A 2005 BMW X3 3.0L at 178K miles came in with a complaint of a check engine light illuminated and an engine misfire. This "Bimmer" was in bad shape, but we were told only to diagnose and repair the engine misfire. We followed the X3 owner's wishes and concentrated on the problem at hand. After we spoke to the X3 owner, we were as much in the dark about the problem on this X3 as we were before we asked him. Our game plan on this vehicle would be to perform a visual inspection and follow-up with a complete system scan. The visual inspection provided us with an abundant amount of problem areas, such as:

- exceptionally low engine oil
- missing air filter
- loose spark plugs
- missing passenger seat
- metal-to-metal front brakes

The interior of this BMW resembled a garbage dumpster (debris everywhere) along with dirty windows (that I could barely see out of) and a messed up clutch pedal (it was missing the rubber pad and exhibited a noise with the pedal depressed). The first thought that came to my mind was "do I really want to work on this car?" After some more thought, I realized that this sloppy mess is not the type of vehicle we work on at our shop, AutoClinic. I had to come to the reality that the vehicle owner was the son of my HVAC guy. I could not be rude, so as all good techs must do, I just had to get over it and move on to diagnosing and repairing this mess.

After we got over the condition that this vehicle was in, we started diagnosis by scanning the vehicle with our AutoLogic. We then switched over to the Snap-on ZEUS scan tool. As can be seen in **Figure 5**, the following DTCs in the Engine controller (DME/DDE), were uncovered:

- 27C3 (Thermal Oil Level Sensor)
- 2882 (Mixture Preparation, Bank 1 Mixture Too Lean)
- 2883 (Mixture Preparation, Bank 2 Mixture Too Lean)

There were DTCs found in other systems such as antilock brakes, airbags, AC and transfer case, but we were only concerned with the engine issues. My technician, Franklin, took the next step by looking up all the information associated with the oil sensor, before moving on to the lean condition. Franklin already knew that the engine oil level was low, so he added the correct amount to protect the engine and eliminate the possible cause of the oil level sensor fault.

As you can imagine, the problem was not solved yet. Through testing, Franklin came to the conclusion that the oil level sensor was defective. He ordered the oil level sensor and when it arrived, installed it. This solved the oil level DTC issue. Franklin was now able to move on to the lean condition issue. Using the EScan by ATS (**Figure 6**), he found the fuel trims were substantially off from normal. As you can see, the

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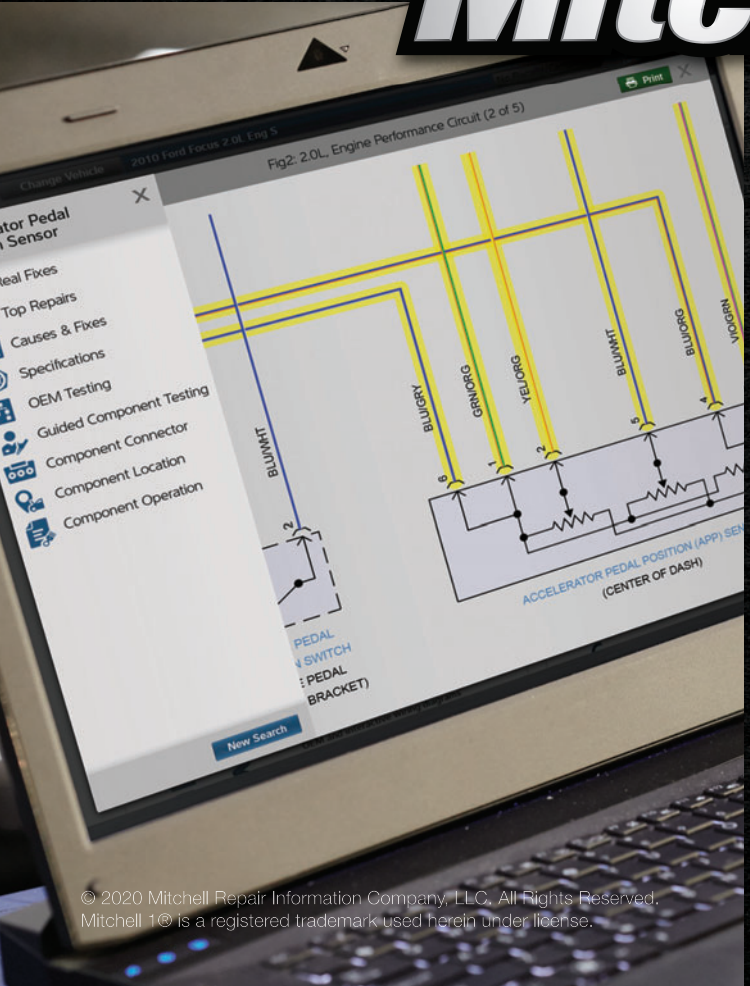

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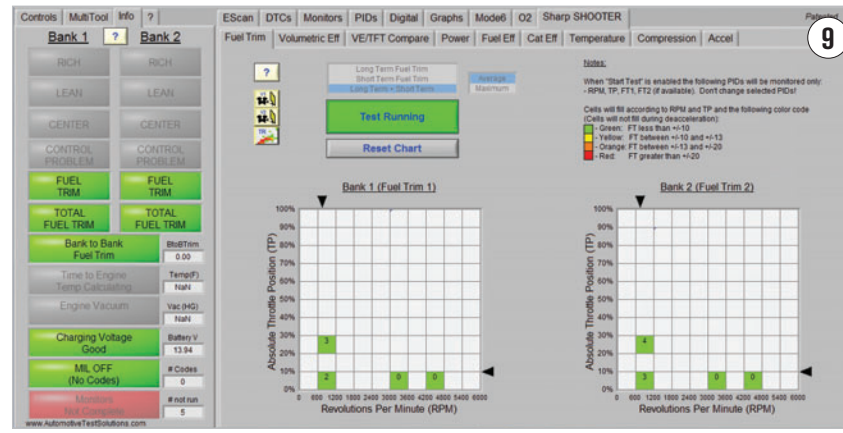
chart indicated high positive numbers, from the bottom of the chart to the mid-level. If this engine was running better, it would have revved higher and the fuel trim cells would've populated the chart to the top, rather than just the middle. Franklin asked me what I thought of the readings, and I confirmed his diagnosis of a bad load sensor.

I called the customer up and told them that we were far from done with diagnosing the engine problem, but that we needed to start by replacing the MAF sensor. With the X3 owner's approval, we ordered and installed a new MAF and rechecked the engine's performance and fuel trim readings. As a result of the check, we found a reading of -20 and -18 fuel trim (at idle) that went away while we increased the load on the engine. The results confirmed that the replacement load sensor fixed the high positive fuel trim number (that we had before), but why did the computer command such negative numbers after the repair?

We thought that we would reset the adaptive fuel trim and take the vehicle for a good test drive. When we returned to the shop, the fuel trim numbers were still a very negative number but only at idle. When fuel trim numbers are commanded negative, it usually means that there is an unwanted fuel source (such as leaking injectors, high fuel pressure, EVAP purge issue, contaminated engine oil, E85 issue or other).

Franklin and I check everything and came up empty. We needed to regroup and try to figure out what is causing the -20 and -18 fuel trim readings (**Figure 7**). When both banks of trim are affected, there has to be a common point, so we decided to smoke-test the engine to see if there were any leaks. You won't believe what we came up with! We found a dipstick seal that was leaking (at the base of the oil tube) and contaminated engine oil



(**Figure 8**). We installed a new dipstick o-ring, changed the engine oil and filter, reset the additive fuel trim and test drove the vehicle.

When we returned, we connected the EScan and checked the fuel trim reading again. We found that the BMW was now back to a normal under all operating conditions (**Figure 9**). Now, at least the engine of this X3 was running as designed. There was still other worked that needed to be completed to get this pile of junk back to normal.

2006 VW GTI 2.0L turbo-MIL

Our next vehicle was the complete opposite of the X3. This 2006 VW GTI 2.0L turbo with 46K miles is just one of five vehicles that this customer owns. Let me tell you that this GTI looks better than when the vehicle was purchased new. All of her vehicles are very well taken care of and are a pleasure to work on. Any time there is even a minor issue on the vehicle, the owner is right on top of it and brings it in for repair.

This visit to the shop was for concern of an illuminated Check Engine light and her (2,000 miles or less) synthetic oil and filter change. We started by following our normal diagnostic plan and asked when she first noticed the Check Engine light. We inquired if she just refueled the vehicle or if there was there something else done that could have caused the problem. We connected our EScan and found a P0301 along with the associated Freeze Frame data. We found all of the System Readiness Monitors in a "Ready" state (**Figure 10**).

Examining Freeze Frame data provided us with the information on when the P0301 had occurred. The engine temperature was at 50 degrees Fahrenheit with an engine RPM of 1185. Since the engine was not currently misfiring, we needed to duplicate the problem. With Freeze Frame info, we knew that we had to have the engine cooled down to check for the misfire, since none were present with the en-

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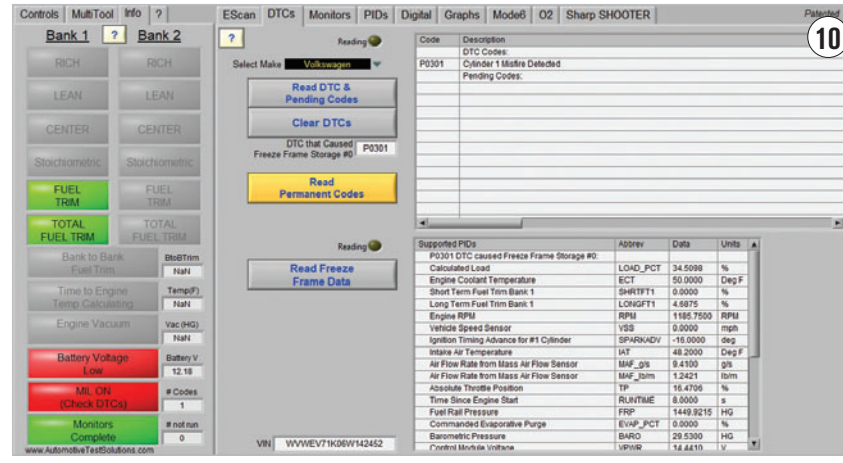
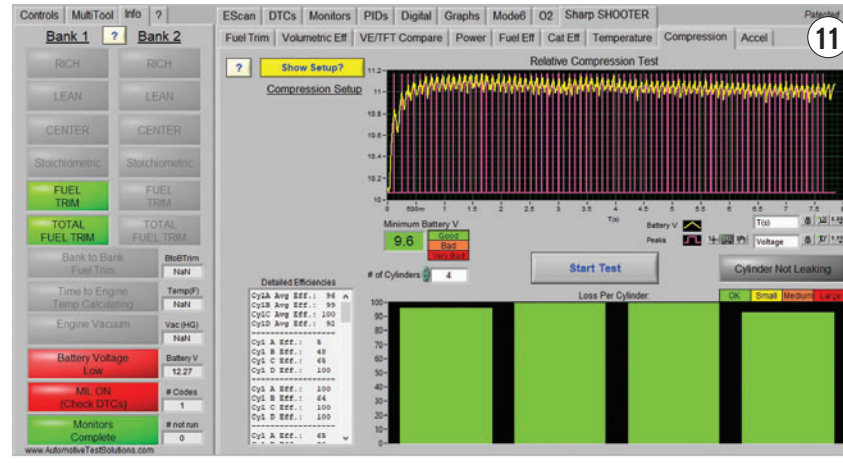
gine at operating temperture. We left the vehicle outside overnight and made sure that we would have all our tools ready when we started the engine up in the morning. The tools we would use were the EScan and the GTC505 ignition tester.

We unlocked the vehicle, popped the hood, connected the scan tool and fired the engine up. Our patience in waiting until the engine was cold paid off. The engine started to misfire for us. To rule out a mechanical fault condition, we ran a Relative Compression test on the EScan (**Figure 11**). Next, Bill powered up the GTC505 and started testing the ignition system, finding that the #1 cylinder was misfiring when the engine was cold. Bill removed the coil and spark plug only to find that there was some carbon on the spark plug electrode. He advised the vehicle owner to perform a GDI (Gasoline Direct Injection system) cleaning, since the spark plug tested good. This was determined by moving the plug to another cylinder that was not misfiring.





The customer decided that she would take the VW and drive it to see if there would still be an issue. We were surprised by her decision considering she always wants her vehicles in "tip-top" shape! We cleared the DTC and had her drive the vehicle, asking her to return in a couple of weeks. Upon the VW's return, we connected the scan tool and found that there were no DTCs or pending DTCs and all monitors were ready.

We assumed that the misfire was caused by the carbon build-up that affected the number1 cylinder only when cold. The problem cleared up when Bill removed the spark plug to check for an issue before installing a pressure transducer for a compression test. The results of the in-cylinder transducer test did not reveal any mechanical problem so that only left one thing to check. We had to wait until the engine cooled down before using our video scope so we would not fog the lens or ruin the video inspection camera. The inspection with the video camera uncovered heavy carbon build-up that we have seen before on other GDI engines (especially Audi and VW). With the video screen shots, we explained to the owner that a GDI fuel system cleaning was needed to prevent the engine from misfiring in the future. The owner (for some unknown reason) decided not to perform the cleaning at this time. Again, we were a bit taken aback by this decision. Maybe it was because of the pandemic and that she had just had us perform two clutch replacements (one on this GTI and the other on her Audi). Anyway, we are still waiting for the MIL to illuminate again (since theses 2.0L turbo tend to build up carbon up and cause misfires). Only time will tell, but I'll bet that this VW will be back with an issue soon!

I hope these few European case studies shed some light on helping you diagnose problem vehicles. Remember no professional team plays a game without a game plan, and neither should you.

G. JERRY TRUGLIA, ASE World Class Triple Master Technician Auto, Truck & School Bus, L1, L3, F1, A9, X1 C1, is president of Technicians Service Training and a nationally recognized trainer/author. He founded TST to bring affordable training to fellow techs and owners.
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LIGHTING THE WAY

NEW TECHNOLOGIES CONTINUE TO HELP IMPROVE SAFETY

TRACY MARTIN // Contributing Editor

It wouldn't surprise anyone that about half of deadly automobile accidents occur during nighttime hours. What is not common knowledge is that driving at night only accounts for 25 percent of overall traffic in the U.S. It's intuitive that when driving in the dark, if one can't see another vehicle, animal, pedestrian or curve in the road, bad things can happen. Seeing the road ahead at night has been a challenge since the advent of the automobile. Just as the automobile has evolved, so too, have the lighting systems that provide the means to see danger while navigating highways in the dark.

THIS 2018 NISSAN MAXIMA USES OLD AND NEW LIGHTING TECHNOLOGY. The low beams have a modern projector headlight (right) and the high beam uses a reflector, a component that's been around for more than 100 years. Both beams use halogen bulbs.

History

Headlight technology has followed the same path as the development of the automobile. When cars were first introduced, there was no precedent as to how they were designed, built and what technology could be used to solve engineering challenges. Consider the early systems used to deliver fuel to internal combustion engines. One of the first (in the year 1875) was the rotary-brush "Atomizer," where a pully-driven, rotating brush swept gasoline from a reservoir throwing it into a pipe, and suction from the engine's pistons drew fuel/air into the combustion chamber. This idea and others gave birth to the carburetor that, in some form, was in use from 1882 to the mid-1980s. Then electronic fuel injection was widely introduced, eventually replacing the carburetor.

As you will see, automotive headlight technology has followed a similar trajectory: lots of "weird" ideas were tried in the beginning and distilled down to the most practical solution, remaining the same for more than 50 years. Then, with advances in electronics, the technology undergoes radical changes. We'll take a look back at the early headlight, or headlamp technology; the current systems in use today and cutting-edge headlights of the near future.

Used on carriages drawn by horses and early automobiles, oil, kerosene and acetylene types of lamps provided lighting. Acetylene was the superior light source, but using it was not exactly convenient. To turn on the lamp, one had to open a supply valve, open the cover of the lamp and light a match to ignite the acetylene. Acetylene gas was produced in a tank (not part of the lamp) divided into two sections that had to be filled with calcium carbide and water before using the vehicle. During winter months, alcohol had to be added to the water to keep it from freezing.

PHOTO: MARELLI AUTOMOTIVE LIGHTING

THE FIRST AUTOMOTIVE HEADLIGHT BULB WITH TWO FILAMENTS was developed by Bosch in 1919. This 1924 advertisement for an OSRAM Bilux bulb clearly shows the two filaments. "Für Auto-Beleuchtung" translates from German to "For Auto Lighting."

In 1912, Cadillac used one of the first electric headlamps for autos. An electric light bulb was used in place of an open flame and located between a polished reflector and glass lens. This design was flawed, as the reflector quickly rusted (since the lamp was not sealed) causing the light to become dimmer and forming a halo-effect around the light, which blinded oncoming cars.

For electric automotive lighting to operate, a DC generator (dynamo) was required. The Cadillac Model 30 and Rolls-Royce Silver Ghost (premium cars) were some of the first automobiles that could produce the electricity needed to support electric headlights. It wasn't until the introduction of the electric starter (on the Model T) where a battery charged by a dynamo was widely used to power automotive lighting.

PHOTOS: TRACY MARTIN

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By the 1920s, batteries were in use in a majority of cars, providing power for electric headlamps.

With more cars on the road, driving at night became problematic because the headlights from oncoming cars would blind their drivers. The "dipped-beam," aka passing, low or meeting beam, provided drivers a way to direct headlight illumination away from oncoming traffic. In 1919, "dip" headlamps were made available as Bosch offered the first two-filament bulb (incorporating both low and high beam functions). Dip switches to control high and low beam operations were typically located on the dashboard and it took until 1927 for the foot-operated dimmer switch to be widely used.

Lighting sources

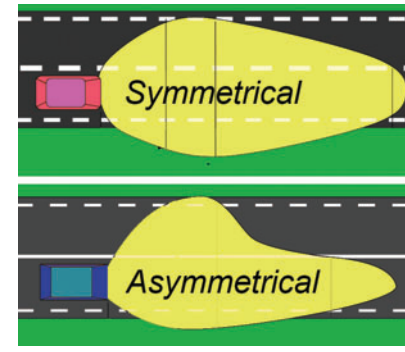
To address the problem with rusting lighting reflectors, the sealed beam headlight was introduced in 1936. If the light burned out or was damaged, the entire non-repairable unit had to be replaced. Sealed beams used two filaments (one for high- and one for low-beam operation). In 1940, the U.S. government mandated the use of sealed-beam headlamps on all vehicles and refused to change this requirement for more than 45 years, despite the continuous development of superior lighting technology in Europe.

By 1950, cars were traveling at higher rates of speeds, posing a problem at night, as headlight beams did not project far enough ahead for safe driving. To address this issue, the asymmetrical beam was introduced, in which the lens of the headlight illuminated only the lane of the road that the vehicle was driving on. The resulting beam pattern was light focused lower towards oncoming cars and higher to the right of the road, projecting the light a greater distance.

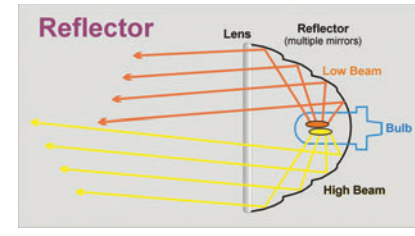
Hella, a German company, introduced the halogen headlamp in 1962. Light efficiency was one and a half times greater than previous lighting and service life was doubled. Other benefits include lower heat emission and the light could be made in a variety of shapes. Rectangular shaped headlamps were approved for use in the U.S. in 1974 and by 1979 the majority of new cars sold in the U.S. were equipped with either round or square halogen sealed beams.

HID (high-intensity discharge) headlamps were first used on the 1991 BMW 7 Series. HID lamps have no filaments, but use a high-voltage arc that emits light in an atmosphere of inert gas. HID metal halide lamps have been around for a while and are used to provide general lighting in parking lots and along highways. These lights have a long warm-up time and won't work for automotive use. HID bulbs designed for cars are filled with xenon gas that reduces start-up time. To ignite the arc, a high starting voltage (18,000v to 30,000v) is required and supplied by ballast and ignitor that controls current sent to the bulb. Once the arc is operating, it requires less or the same amount of electrical energy as halogen-type bulbs while providing more light. Another advantage is the longevity of HID bulbs that typically last around 2,000 hours, versus halogen bulbs that only last 450 to 1,000 hours.

A recent innovation in automotive lighting is the light-emitting diode or LED. An LED light uses a semiconductor light source that emits light when current flows through it. LEDs are solid-state electronics with no components that wear out (like bulb filaments used in halogen lights or tungsten electrodes in HID bulbs). Unlike halogen lights that have an average service life of around 500 hours, LEDs can be used for around 8,000 hours. The use of LEDs as a light source saves money for consumers, as



BEFORE 1950, HEADLIGHTS PRODUCED A SYMMETRICAL LIGHT PATTERN that tended to blind drivers of oncoming cars. The asymmetrical beam creates a pocket where light is directed down and away from other drivers.



WITH THE LOW BEAM IN OPERATION, light (orange arrows) from the bulb shines upward, bounces off the reflector and is directed downward onto the road. The high beam filament (yellow) directs the light down, where it bounces off the reflector creating a light pattern that lights up the road further ahead than the low beam.

LED replacement is no longer a maintenance cost. This is especially helpful on many late-model vehicles where replacing a headlight bulb requires disassembling the entire front of the car to gain access to the bulb.

In addition, LED-illuminated headlights are 80 percent efficient in light production and only waste 20 percent of electrical energy to heat. Halogen lights invert this energy use, as they waste 80 percent of their supplied electrical energy and only use 20 percent to produce light. Adding to their longevity and versatility, LEDs are highly resistant to vibration and can be used in physically smaller headlight assemblies.

In the U.S., the 1986 Chevrolet Corvette used the first LED in its center high-mounted stop lamp. The first

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use of LEDs for headlights was in Europe on the Audi R8 where low and high beams (along with parking lights and front turn signals) used LED light sources. In 2009, LEDs were used in headlights in the US on the Lexus LX 600h. It featured LED low beams and side marker lamps. In the same year, the Cadillac Escalade Platinum used LEDs for the low and high beams, as well as for position and side marker lamps.

Introduced on the 2014 BMW i8 and Audi R8 LMX, lasers are one of the latest light source innovations for headlamps. In operation, three diodes project a blue-colored laser beam into a prism that focuses the three beams into one. The single-beam passes through a phosphorous lens that changes the blue light to white, where it bounces off a reflector, directing the beam onto the road. In 2018, the trend to miniaturization lighting components, resulted in deploying a much smaller laser module powered by just one high-power laser diode on the BMW8.

With nearly double the projected lighting distance of LEDs (around 6,500 feet) and being 30 percent more efficient, laser-sourced headlights could be the future of automotive lighting technology. Laser diodes are 10 times smaller than conventional LEDs and help to reduce weight and installation space inside a headlamp. Using a laser light source, the size of the reflector surface can be reduced by a factor of up to 10 versus the same headlamp using LEDs.

Currently, laser headlights for BMW and Audi models add $8,000 to $12,000 to the price of the car. Even for these expensive cars, this is a rather pricey option, so it will take time for laser headlight technology to be affordable on mainstream automobiles. In October 2018, the National Highway Traffic Safety Administration (NHTSA) issued a notice of proposed rulemaking that would allow for better headlights including laser technology. Don't expect to see laser headlights on U.S. roads for a few years, as they will have to undergo testing to be approved and it will take some time to fit them to U.S. production-spec vehicles.

Reflector vs. Projector

Reflector and projector are the two types of headlight housings used in the US. Reflectors used for automotive lighting have been in existence for more than 120 years. In operation, a light source is located near the focus of the reflector. The reflector bounces the light through a lens where it is dispersed onto the road.

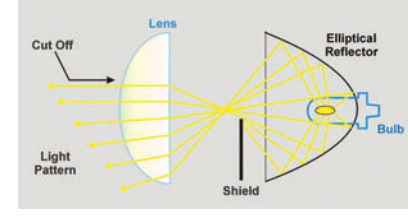
The pattern of light output is designed into the optics of the reflector instead of the lens. Many reflectors are a parabola that is U-shaped, symmetrical, and provides a basis for more complex shapes. Modern reflectors have many individual segments and complex contours. Each segment is designed so that its cumulative effect outputs the designed light distribution pattern. On newer headlamps, optics molded into the headlight lens refract, or shift some of the light sideways and vertically, further directing the light distribution pattern.

Reflectors that use a two-filament bulb operate as follows. Light from the low-beam filament bounces off the reflector that directs it down onto the road. When the high-beam filament is operating (low-beam filament is off), the light source position is shifted, causing light to bounce off different segments of the reflector's surface, creating a light pattern that shines more upward. On some bulbs, a shield is used to keep light from the high-beam filament from projecting towards sections of the reflector.

Commonly made of compression, or injection-molded plastic, modern reflectors use a surface where vapor-deposited aluminum provides a highly reflective surface. Extremely tight tolerances are maintained in the design and production of these complex-reflector headlights. The halogen light bulbs are also made to exacting tolerances, regarding where the filament or light source is placed. Aftermarket HID (and to a lesser extent LED bulb replacement) for lighting may not position the light source in the same location as stock bulbs. This can cause variations in the light pattern and direction of light output. When aftermarket lighting kits are installed in a vehicle, the lamps must be re-aimed to compensate for this variation.

The first projector type of headlights was used by Chrysler in 1969. Projector lights use a light source (bulb, HID or LED) placed between a reflector and lens. The elliptical-shaped reflector surrounds the light source and focuses its light on a single point about an inch ahead of the light. A shield is located between the bulb and lens,

THIS REFLECTOR TYPE OF HEADLIGHT FROM A 2014 FORD F-150 has complex multiple surfaces that create a designed light pattern on the road. A single, two-filament halogen bulb is used for low and high beam operation.



PROJECTOR HEADLAMPS USE AN ELLIPTICAL REFLECTOR that focuses light in front of the bulb. An internal shield blocks some of the reflected light and produces a sharp light beam cut off before the light passes through the lens.

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and the top edge of the shield provides the light beam cutoff. This concentrated light is then dispersed by a lens into a tight beam focused on the road. The tightly controlled light pattern of a projector beam headlight increases its range and brightness and reduces glare for oncoming vehicles. Modern condenser lenses incorporate optical features specifically designed to direct some light upward towards reflective overhead road signs.

In some applications, the shield can be lowered by a solenoid to provide high-beam operation. This type of projector light is known as BiXenon (HID) or BiHalogen. If the cutoff shield is fixed in the light path, separate headlamps are required for high-beam operation.

Headlight controls

Auto-on headlights used to only be available on high-end cars, but that has changed and today they can be found on many vehicles regardless of price. One of the earliest types of automatic headlamp was the Twilight Sentinel, which was featured on Cadillac, Buick and some Chrysler cars in 1964. In operation, auto headlight systems use a photoelectric sensor mounted on top of the dash or the windshield near the rearview mirror. With the light switch in the "auto" position and twilight conditions, the system turned on the headlights. On current systems, ambient light-sensitivity is usually fixed by the manufacturer, but some systems allow drivers to adjust when the lights come on. In most states, rain, snow or other weather conditions require that headlights be on while driving. It's a mixed bag whether a particular auto-on system will react appropriately to weather conditions, and drivers might have to manually turn on their headlights.

Automatic, or auto-dim, high-beams are different than auto-on headlights in that they switch from high to low beams when an oncoming vehicle or a vehicle in front of a car is detected. Some systems combine auto-on and auto-dimming into one control. The idea isn't new and has been around since the 1950s. General Motor's Autronic Eye and GuideMatic are some early examples of the technology. Today, the auto high-beam function is driver-selectable, where the driver keeps the high-beam switch in the on position and activates a second control for the auto-dimming function. Mounted on or near the rearview mirror, a forward-facing camera detects oncoming headlights, taillights as well as streetlights (or other illumination) that indicates high-beam operation is not required. When these lights are detected, the systems switch the high-beam headlights off, and back on again once the lights disappear from the camera's view.

Some recent examples of this technology are Ford's Auto High-Beam Headlamps that use a windshield-mounted camera to detect other vehicles. The high beams automatically turn on during nighttime hours at speeds above 25 miles per hour and dim automatically when an oncoming vehicle is detected. This system is available on some 2020 Ford models. Chevy's IntelliBeam is a similar system and is part of their Enhanced Driver Alert package, first available on 2016 Chevy Tahoe and other models. In Europe, selective high beam, or glare-free high beam designs, are legal and can be accomplished either by swiveling the light source downward or in the case of an LED light source, switching off specific LED chips that create a gap in the light pattern to reduce glare.

The future of headlights

Imagine a headlight that could be used in high-beam mode continually and never have to be dimmed, no matter traffic conditions. The same headlight could also project images, text and symbols onto the road's surface to warn drivers of upcoming hazards. This functionality would seem to describe something from a sci-fi movie, but is instead technology developed by Marelli Automotive Lighting. First introduced on the 2018 Mercedes-Benz Maybach S 560 4MATIC, their h-Digi® system marks the first time Digital Micromirror Device technology has been used in an automotive application.

One of the most significant features of the system is its ability to use light as a communication tool by projecting an image onto the roadway. High-definition (HD) image projections can include vehicle guidelines, weather warnings, speed limit changes, construction zone cautions, pedestrian and animal warnings. After input from onboard sensors and computer analysis of driving situations, images are auto-

PHOTO: MARELLI AUTOMOTIVE LIGHTING

2018 MARELLI AUTOMOTIVE LIGHTING developed the first high-resolution projector-type headlamp. The headlight uses a device with 1.3 million digital micro-mirrors placed a small 0.55" screen to project light and images onto the roadway.

PHOTO: THE DAIMLER GROUP

DIGITAL HEADLIGHTS ON THIS MERCEDES-MAYBACH S-CLASS SEDAN can project an image onto the roadway to warn drivers of hazards. A few possible images are displayed at the bottom of the photograph.

matically projected directly in front of the vehicle. The goal of the projections in the driver's line of sight is to inform and/or warn them without distraction. Studies have shown that roadway projections are faster and less distracting at conveying information to drivers than a heads-up windshield display.

The technology not only increases safety and comfort in human-driven vehicles, but it will also play a role in semi-autonomous and autonomous vehicle development. More robust image projection is possible when leveraging vehicle-to-infrastructure (V2I) technology, increasing the types of messages that can be conveyed, i.e., four-way stop ahead, crosswalk symbols, railroad crossing and many others.

Another outstanding feature of the h-Digi headlight is its ability to eliminate glare for other drivers. Glare from headlights of oncoming vehicles causes significant driver stress and distraction at best and temporary blindness at worst. The problem of glare is multiplied when high beams are used. Although high beams are a nuisance to other drivers, they are beneficial on narrow, curvy and poorly lit highways, especially in rural areas where wildlife routinely leaps onto the road. According to NHTSA, glare is not often reported as a cause of accidents. However, hundreds of fatal nighttime crashes attribute glare as a contributing factor.

The h-Digi system solves the problem of glare by disabling light that would normally illuminate on-coming drivers or vehicles being followed in the same lane. This takes place in real-time, as the system tracks the movement of oncoming vehicles and places a moving shadow where the vehicle is on the roadway. The view from the vehicle with the h-Digi headlights is that the high-beam is on all the time, lighting up the road far ahead.

PHOTO: MARELLI AUTOMOTIVE LIGHTING

USING VEHICLE-TO-INFRASTRUCTURE (V2I) TECHNOLOGY, the h-Digi headlight system can project an image onto the road warning drivers of construction zones. Projections can also provide messages about weather conditions, pedestrians or curves in the road.

Inside the h-Digi headlight, the module is a microchip with 1.3 million micro-reflectors. With two headlights, a vehicle would have a total of 2.6 million

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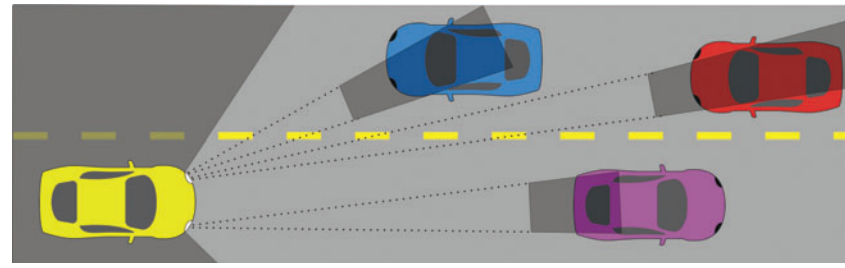
reflectors. Onboard cameras and sensor systems detect other road users, and a computer evaluates the data in milliseconds, providing headlamp commands for the best possible adaption of light distribution and/or image projection, for all situations. Each of the micro-mirror elements is approximately 10-microns in size or 1/1,000,000 of a meter (.00004 inches). These small mirrors can be individually controlled by moving them back and forth between two positions, on or off. Each mirror's flip-over movement generates a pixel of the projected light or image.

Micro-mirror switching frequencies of a few hundred Hertz (cycles per second) are used to modulate the 1.3 million pixels to project an image, light up the road, or even play a video. The visual matrix generated is uniformly illuminated by high-current LEDs and projected onto the street within milliseconds, employing a multi-level lens system. With HD resolution and precision computer control (of more than a million beams of light), high-beams can be left on continuously, as their light is selectively directed onto the road and avoids oncoming vehicles. This creates completely new possibilities of dynamic light distribution during driving as well as the projection of text or graphics. In 2020, *Automotive News* named Marelli Automotive Lighting a PACE Award winner for their work on the h-Digi headlight. The PACE Awards honor superior innovation, technological advancement, and business performance among automotive suppliers.

Conclusion

Just as the latest driver-assist technology (like automatic braking, stay-in-lane or pedestrian warning systems) use an array of cameras and sensors, future high-tech headlight systems use this same technology and will present a challenge for independent repair shops.



THE H-DIGI HEADLIGHT CREATES A MOVING SHADOW (LIGHT GAP) that keeps oncoming traffic from being blinded by high beam operation. The high beams can be left on continuously with this technology. As illustrated in the graphic, multiple gaps are possible.

In the future, replacing a headlight bulb will become a rare occurrence, as these new systems will likely use LED or laser technology having a service life lasting longer than a vehicle is on the road! The bulb as a separate replacement part will become a repair of the past and instead bulb replacement will turn into a "lighting module" replacement.

Parking lot speed fender benders that damage headlight components will still offer plenty of opportunities to service headlights. After bodywork, paint, and installation of a new headlight assembly are completed, instead of replacing a $20 bulb, a new headlight module would be required that could cost thousands of dollars. Also, auto-leveling headlight systems, windshield-mounted cameras, lidar, radar and other sensors will have to be calibrated and/or initialized, using a scan tool to communicate with the vehicle's body control module (BCM) to enable headlamps to operate properly.

While cutting-edge headlamp technology like the Marelli Automotive Lighting h-Digi system is currently found only on high-end vehicles like the 2018 Mercedes-Benz Maybach (a $170,000 car), Mercedes-Benz S-Class Fast Lane and Audi e-Tron, these systems will eventually trickle down to less expensive models. As new lighting technology proves that it truly offers superior lighting for drivers, reduces accidents and saves lives, it's not far-fetched that in the future they could

PHOTO: MARELLI AUTOMOTIVE LIGHTING

THE MARELLI AUTOMOTIVE LIGHTING H-DIGI LIGHTING MODULE uses three high-current LEDs as a light source illuminating 1.3 million mirrors that can be individually controlled to project light or an image onto the roadway.

be mandated in some form by the U.S. Department of Transportation for all vehicles sold in the United States.

Smart headlights that track oncoming vehicles at night (creating moving shadows to eliminate glare and project warning images on the road) are just part of the never-ending technological innovations and will affect independent repair shops and the technicians that work in them.

TRACY MARTIN has covered the powersports industries since 1998. He is also the author of six Motorbooks Workshop Series books published by the Quarto Publishing Group and is a regular contributor for *Motor Age*.
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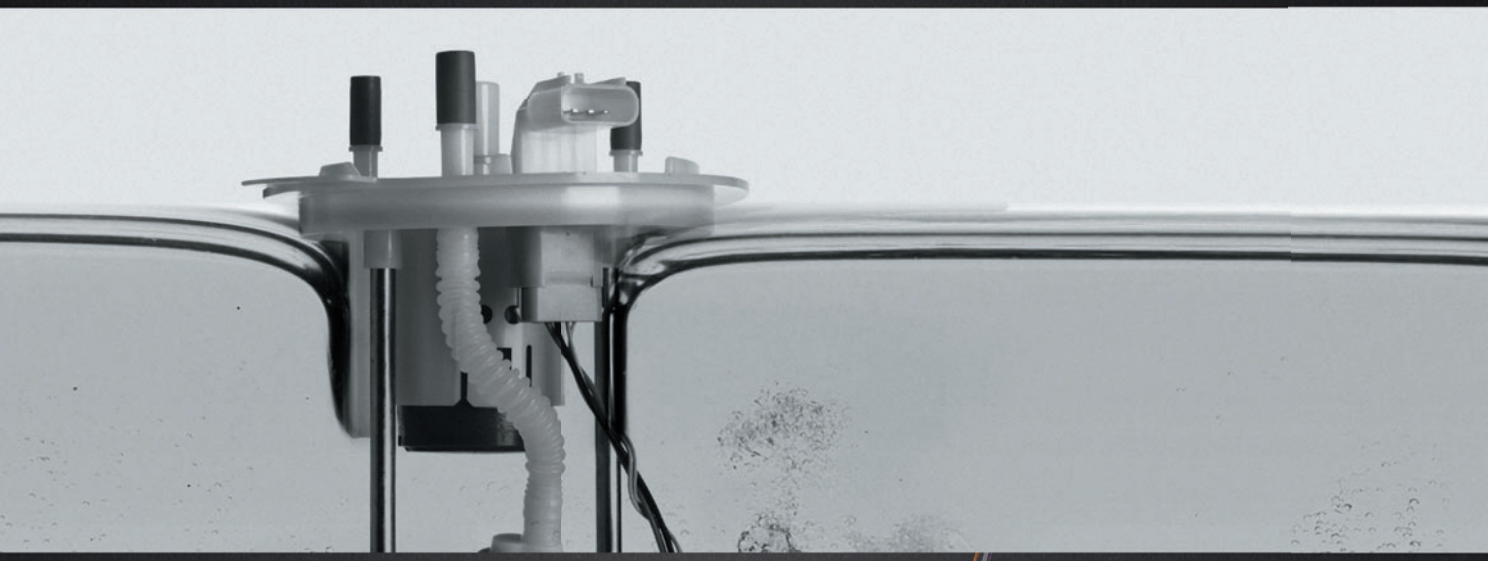

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...BUT WHAT MAKES IT TICK?

TO BE SUCCESSFUL TODAY, YOU MUST UNDERSTAND A VEHICLE'S SYSTEMS AND COMPONENTS

BRANDON STECKLER // Technical Editor

We've all heard the saying "knowledge is power," but it can be quite profitable, too! A rock-solid technician is one who has honed his/her craft as being a problem-solver. We often think of that person as one who can "fix" anything. Although that may be true, there is certainly more to it than being good with your hands. Having an understanding of the systems and the components that they are comprised of, along with the goal of that system, is what it takes to be successful in today's world of automotive service, repair and especially diagnosis. Learning to leverage service information (SI) in your diagnostic approach will surely bring you success and efficiency. I'll show you how it works for me!

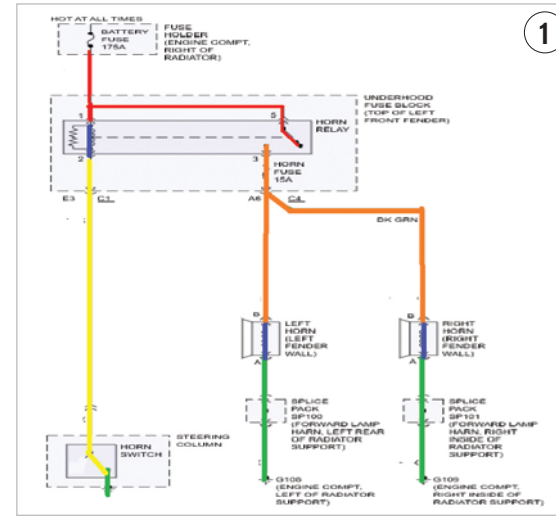
Developing the diagnostic game plan

You've likely heard me speak of this many times in the past, but it's worth repeating because I live by this approach: Having a plan (rather than just attacking the vehicle) is a great way to approach a diagnostic dilemma.

I know it seems counter-intuitive to step back and tread slowly (especially from a flat-rate perspective), but by first separating one's self from the vehicle then creating a game plan and seeing it through, it will keep you focused on the facts. This, in turn, will create efficiency without missing any steps. When I approach a vehicle, I never do so without having a game plan. For me, this means gathering some pertinent data about the components that make up the system I'm to address:

- How are they configured to carry out a goal?
- What is that goal?
- How do we know the goal was achieved or not achieved (how is the system monitored)?
- What are some PIDs that can give me easy-to-grab insight into the system's functionality?

Examples like the ones above can yield plenty of preliminary information about any problem on any system, in any vehicle, you may be facing. Think for a moment how powerful of a statement that is. Regardless of what is in your bay, it's this information that will allow you to efficiently solve the riddle. Think of the game plan as nothing more than a series of questions. I invest my time (away from the vehicle) developing the questions I wish to ask the vehicle. The tools I use and the tests I perform will carry out the questioning process. The results of those tests are the answers I need to make the necessary diagnostic decisions.



Calling the huddle

Just like players in a sport, it's the individual components that make up the team. The team is the system being addressed. It is our job as diagnosticians to know what players on the team are responsible for winning the tournament, the goal that the system is trying to carry out. And how do we know what the goal is? Through research.

This is why I separate myself from the vehicle. It takes time to familiarize oneself with the players on the team and how the sport is played. Thus, I spend my preliminary/initial diagnostic time understanding the information I mentioned earlier. This key information can be found in the service information (or SI). Many of us rely on aftermarket sources like ALLDATA, Mitchell, IDentifix, MotoLogic, etc. Some of us purchase access to OE service informa-

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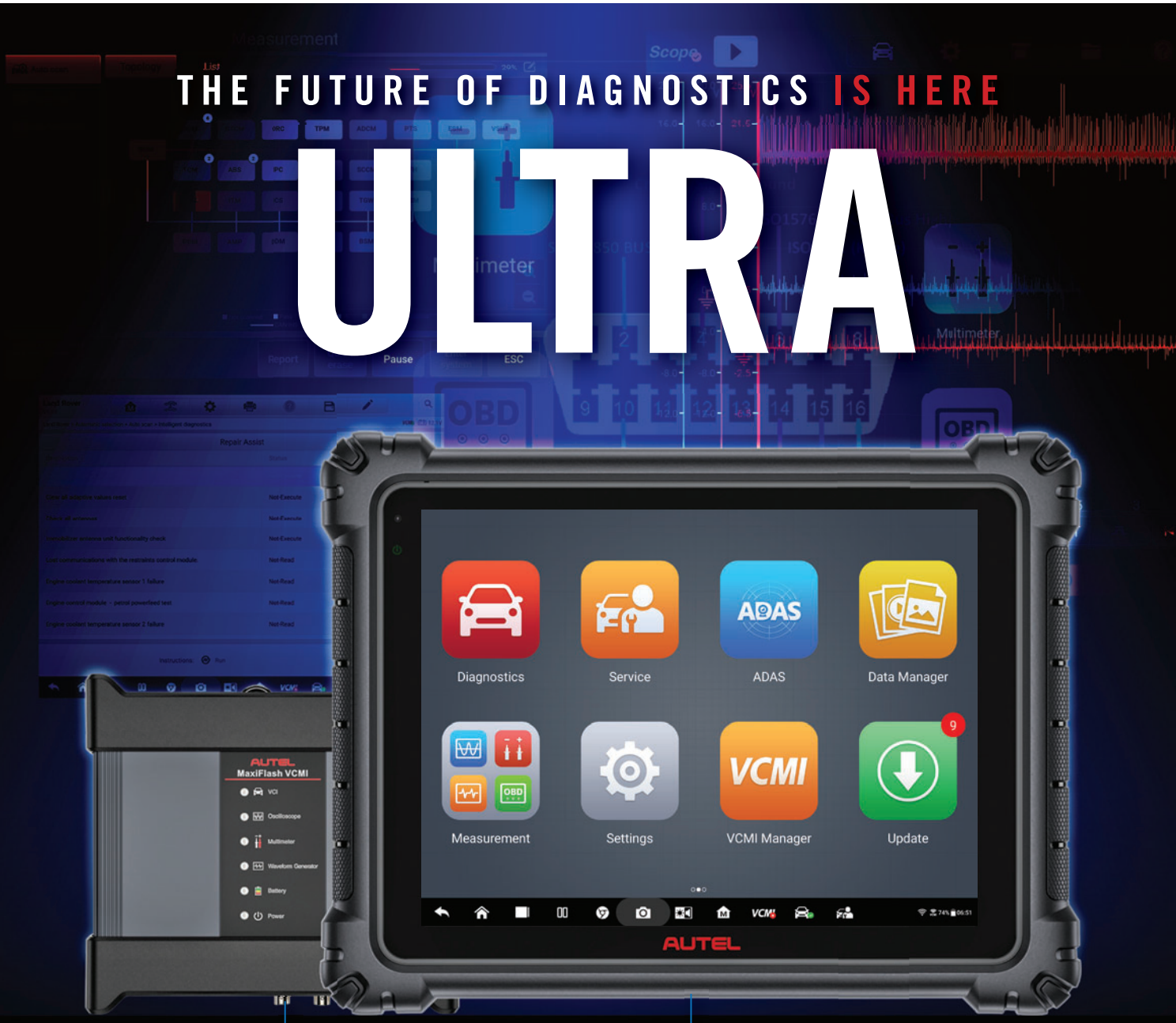

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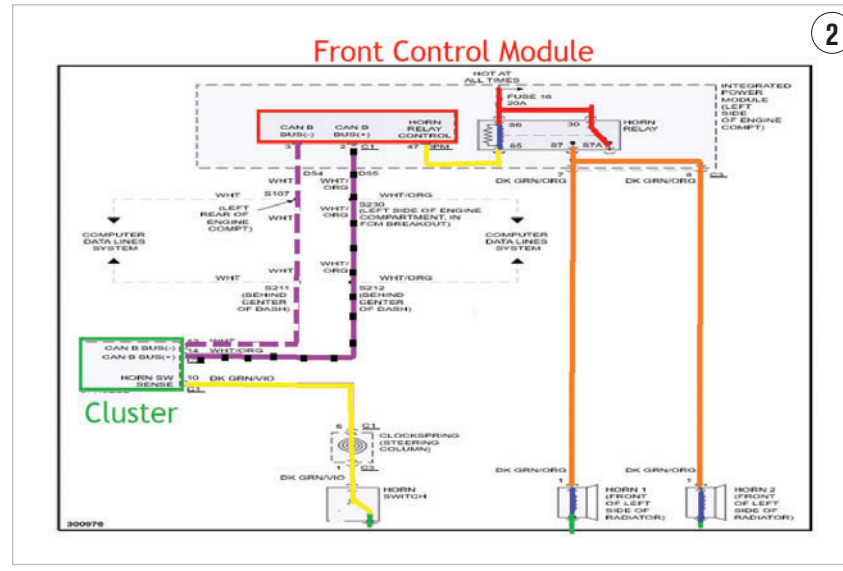
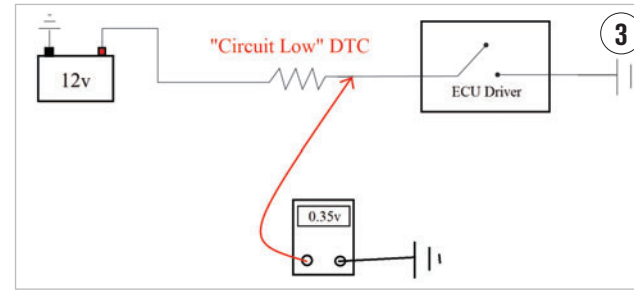
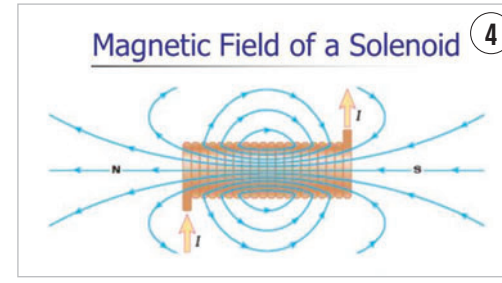
tion provided by the manufacturers. It's a common assumption that OE service information is the most complete. This is true in many instances, but I will warn you — even the information that comes from the manufacturer can be wrong at times. So when it comes to answering the age-old question: Which source of information is the best? The answer is simply "All information is the best."

In many instances, I have found missing information from the factory side (or OE) that required my referencing an aftermarket source to find what I was looking for.

To demonstrate the importance of referencing SI, I want you to recall another recent *Motor Age* contribution of mine, "Diagnosing the causes of a 'no communications' concern," March 2020, demonstrating two different vehicles carrying out the same goal (sounding the horn), but in two totally different ways (**Figures 1, 2**). The point is the horn sounds milliseconds after the horn pad is depressed… in both cases. If you weren't aware, you may assume both vehicles function the same. You'd be sorely mistaken and assumptions tend to be costly. When developing a diagnostic game plan, I always seek out at least two key pieces of information — the theory and operation (sometimes called description and operation) of a system as well as the wiring diagrams. Together, those two pieces of information allow me to create the diagnostic game plan for whatever vehicle or system I'm addressing.







Troubleshooting flow charts — are they of value?

I recall at one point in my career being let down by the troubleshooting flow charts. I was then confident that any issue could be solved, so long as the flow charts were followed stringently. It was only to my dismay that many a time I was left with only the option to substitute a known-good component (like a PCM — I'm sure we've all been down those winding roads a few times).

I recall being discouraged by the fact that not only was the vehicle's ailment still present, but I had invested a lot of time/money and was no further along than I was hours ago. How could this have happened? What was the missing element that prevented me from being successful? After all, the flow charts were written to help me fix the car by the same people who designed the vehicle, right?

WRONG! The flow charts are there to help the average factory-trained technician repair a vehicle (that is under warranty), in the most financially efficient way, the majority of the time. The flow charts were written concerning the most likely failures the system(s) might encounter. They were not written concerning our wallet. This is why we may spend so much time with disassembly/reassembly, rather than a pursuit with logic. Of course, we realize that the engineers who design the flow charts aren't necessarily the same engineers that design the systems, either. There tends to be a disconnect between the two at times. My point is my frustration grew to the point that I viewed the flow charts as nothing more than toilet paper.

My point of view has changed over the years, though. I've learned that there is great information/key information within those flow charts that I use every day to streamline my diag-

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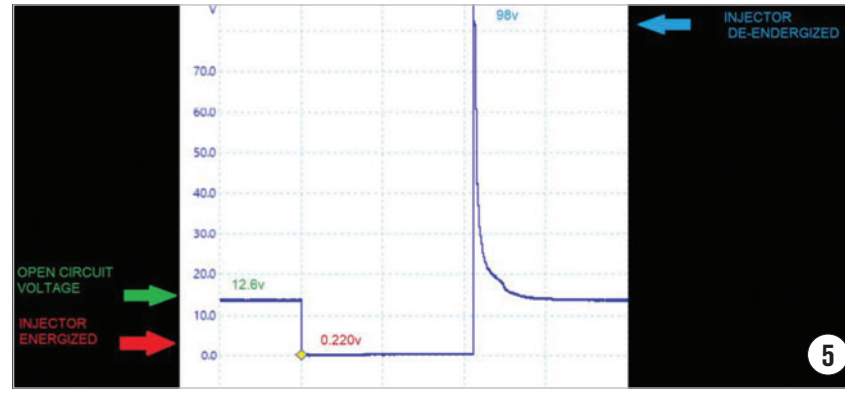
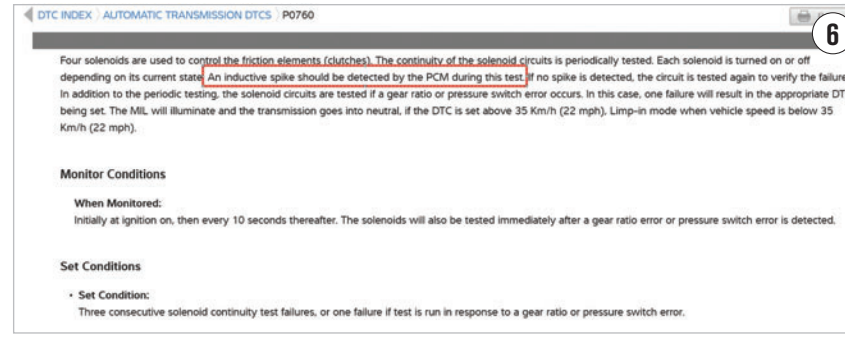
nostic approach. Reading the steps and following them blindly is never recommended. Understanding what it is each of the steps is asking for will give you a good idea of what the ECU (monitoring the system) is looking for and anticipating, as well as a logical approach.

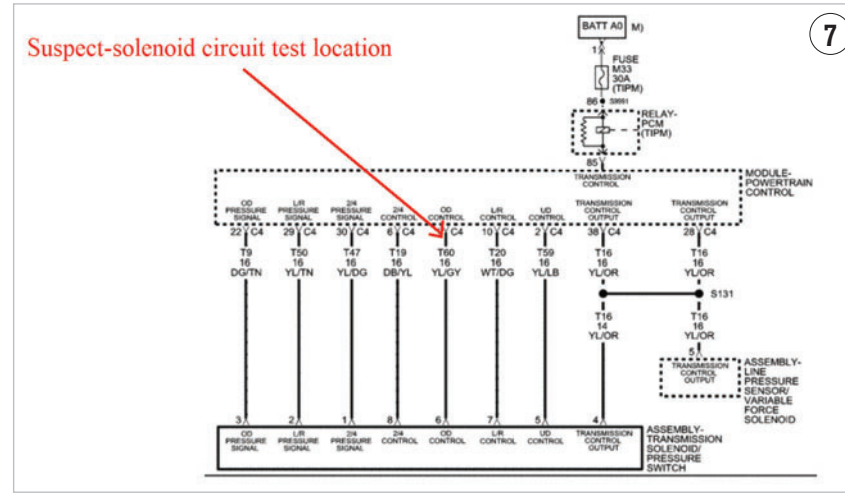
For instance, let's look at resistance specifications. Keep in mind that voltage drop, resistance and current flow all relate to one another. Knowing what the resistance specification is calling for will allow us to anticipate how much current flow the circuit being monitored should draw. This is how circuits are being evaluated for performance and the reason why related DTCs are set when components' ohmic values fall too far outside of specification. I'd much rather monitor a circuit's current flow dynamically than to open the circuit and measure for resistance statically. A comparator circuit is used to carry out this task for the ECU's self-diagnostic strategy (**Figure 3**). It serves as a DVOM (but within the ECU) to measure voltage in the circuit under various states of operation. In the example drawn here, a few things can be seen:

- This circuit is of a pull-down design (ECU provides the ground-path, to energize the circuit)
- The circuit is open and no current should be flowing
- The DVOM should be measuring/indicating source-voltage (12volts) in the circuit's current state of operation

(This is what is typically is occurring when an ECU sets a DTC about "circuit low" faults).







The basic building blocks of diagnostics

By viewing not only the wiring diagram, but also the theory and operation of the circuit, this provides for a solid understanding of the circuit functionality and anticipation of what the ECU expects to see on that circuit during its current state of operation (energized or de-energized circuit). The DVOM represents not only where the ECU is monitoring the circuit, but also where we would place our DVOM to monitor the circuit ourselves. In the example in **Figure 3**, it should be obvious that the intended state of the circuit would have us anticipate source voltage at that point under the circuit's current state of operation. A lot can be derived from just these few pieces of data.

Another statement you've heard me stand by many a time is that having fundamental knowledge of the individual component's functionality (at the most basic level) can be applied to any vehicle or system out there.

The point is that nearly 85 percent of what occurs in any automotive cir-

cuit can apply to any vehicle or system out there. This is due to the physics involved. The other 15 percent is how each manufacturer chose to make that circuit function (like what was described earlier in **Figures 1 and 2**).

Here, we see a diagram representing the magnetic field that builds within a device (like a solenoid or ignition coil) when it is energized (**Figure 4**). Assume, if you will, the circuit is configured similar to the circuit shown in **Figure 3**. As the solenoid is energized, the current begins to flow within its coil windings. Some of you will recall from science class that if a coil of wire is wrapped around a conductor and an electrical current, then passes through the wire, a magnetic field is created. This magnetic field allows the pintle (in the solenoid) to move.

This is because electricity and magnetism are very similar to one another. The time for the magnetic field to build is referred to as dwell. If the circuit is opened and the current flow is interrupted, the magnetic field will collapse almost instantly. The energy that was created (over the dwell time) will have to dissipate instantaneously. The magnetic field will transform back into electrical energy and will be many times higher in voltage then the initial source voltage. A basic waveform representing the voltage signature of a healthy solenoid (magnetic/inductive device), when viewed on a lab scope is seen in **Figure 5**. Some of the characteristics exhibited display:

- Available source voltage (on the switched-side of the solenoid) with the circuit de-energized
- Very little voltage available with the circuit energized (indicating a good path to ground)
- A healthy inductive-kick nearing 100 volts (counter-voltage produced as the magnetic field collapses). This couldn't have occurred if the ECU driver wasn't functioning correctly or there was a lack of current flow/magnetic field, due to a voltage-drop or high resistance issue

Combining these basic fundamental concepts (from years of practice) along with the tools/testing techniques you've learned to employ (again…with prior practice) can help yield a diagnosis quite efficiently.

A shift in strategy

To demonstrate how I carry-out the process, I will use an example: 2008 Dodge Grand Caravan experiencing a stored DTC P0760 "Overdrive-solenoid circuit fault," along with a transmission functioning in a defaulted state (no upshift from 2nd gear). The point isn't necessarily that the vehicle was fixed, but more so how the circuit is being monitored and what techniques I recruited (from my experience and fundamental knowledge) to prove the fault and repair the vehicle.

As can been seen in **Figure 6**, I built my game plan away from the vehicle by referencing the service information for DTC P0760. The description/operation of the system and the wiring diagram proved to be all I needed in my arsenal to approach the vehicle and ask of it the questions I would like answered.

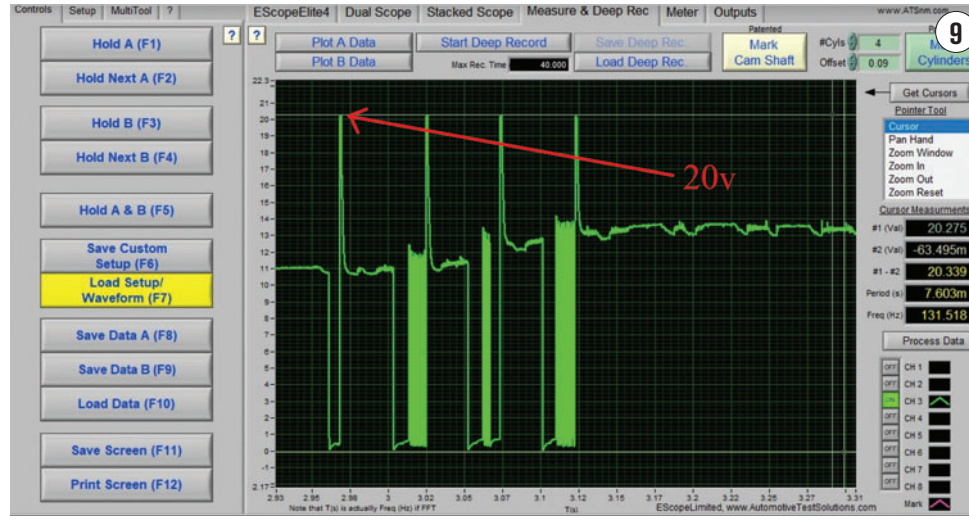
- Why won't this vehicle upshift?
- Why is the DTC set?
- Is the solenoid functional?
- Does the solenoid have everything it needs, to function?

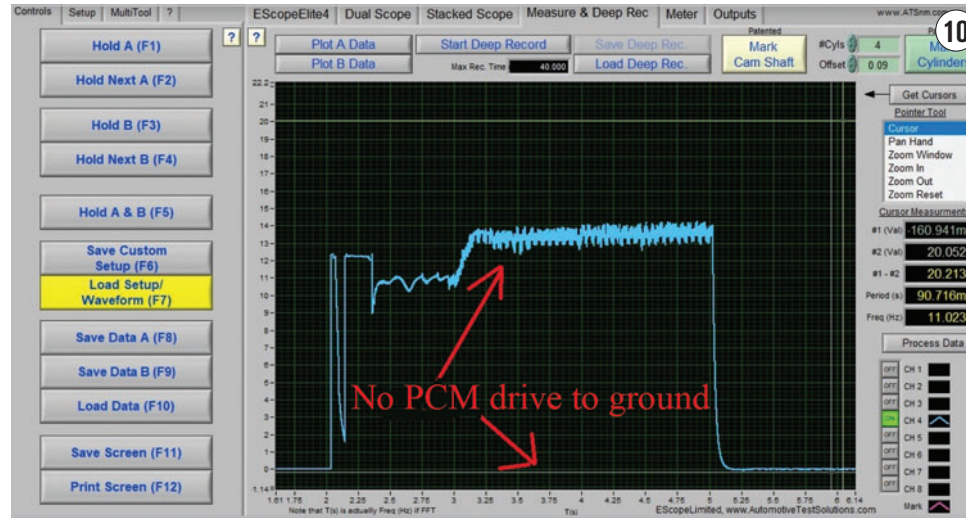
We can see that the ECU is anticipating seeing an inductive kick (sound familiar?). If you've made it this far through the article, you should realize that to have a healthy functioning solenoid, the resulting inductive kick (from its magnetic field collapsing) should be present. Said another way: If a weak inductive kick is present, the solenoid cannot do its job properly.

The service information and wiring diagram together tell us where to test, how the circuit functions, what we should anticipate seeing during a test and (most importantly) what the ECU is looking for to either verify or condemn the circuit, for functionality (**Figure 7**). By placing a lab scope at the point indicated on the wiring diagram

and referencing it to ground, we could then, compare the signature to that derived from testing one of the known-good solenoids controlled by the PCM.

The PCM was located within the left-front fender well of the vehicle (**Figure 8**). The appropriate connector/circuits were identified and then probed to be monitored while using the scan tool to carry out a bi-directional control of the individual solenoids. The test results proved that the suspect solenoid circuit DID NOT produce a healthy inductive kick, like that of a healthy solenoid circuit (**Figures 9, 10**). It also displayed that the ground-side of the circuit was compromised and the PCM was likely at fault. This conclusion was made because when energized, the ground path still had significant voltage available on it. That, coupled with the fact that we tested directly at the PCM terminal, concluded that wiring was not an issue. If the PCM's ground was compromised, the other solenoids' circuits would've suffered as well.





The only logical explanation was a poorly functioning solenoid driver within the PCM itself. To further prove the fault, I continued to monitor the suspect circuit, but this time I supplied an external ground, which allowed me to bypass the PCM. This enabled the solenoid to function properly. This resulted in a voltage signature that pulled very close to the ground and an inductive kick, similar to the known-good solenoid (when the circuit was de-energized). What isn't displayed is a subsequent test I conducted. I followed the above test with a measure for current flow from each of the solenoids using the lab scope and a low-amp probe. Seeing that they all drew about the same amperage reassured me that the failed PCM driver hadn't anything to do with a shorted solenoid winding.

Being an efficient and accurate diagnostician isn't about having the fastest hands in the shop. It's more about using logic. Having fundamental knowledge, built from mastering the basics (the 85 percent) and learning to utilize the tools you have properly means practicing on known-good vehicles and investing your free time to better yourself. Taking the time to develop a diagnostic game plan is derived from the goodies provided by service information. A combination of the wiring diagram and description/operation will yield you the arsenal you need to combat the vehicle and win the battle. It all starts with a little bit of discipline and patience; but, it ends with the rewarding feeling of a job well done and in a timely fashion.

BRANDON STECKLER is Techical Editor of *Motor Age*. He is a working tech at Lykon Automotive in Bristol, Pa. He has worked in the field for over 18 years and holds mulitple ASE certifications.
bhsteckler@gmail.com

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PREPARING FOR ADAS

IN PART II OF THIS SERIES, WE EXAMINE USING THE PROPER TOOLING TO CALIBRATE THESE MISSION-CRITICAL SAFETY SYSTEMS

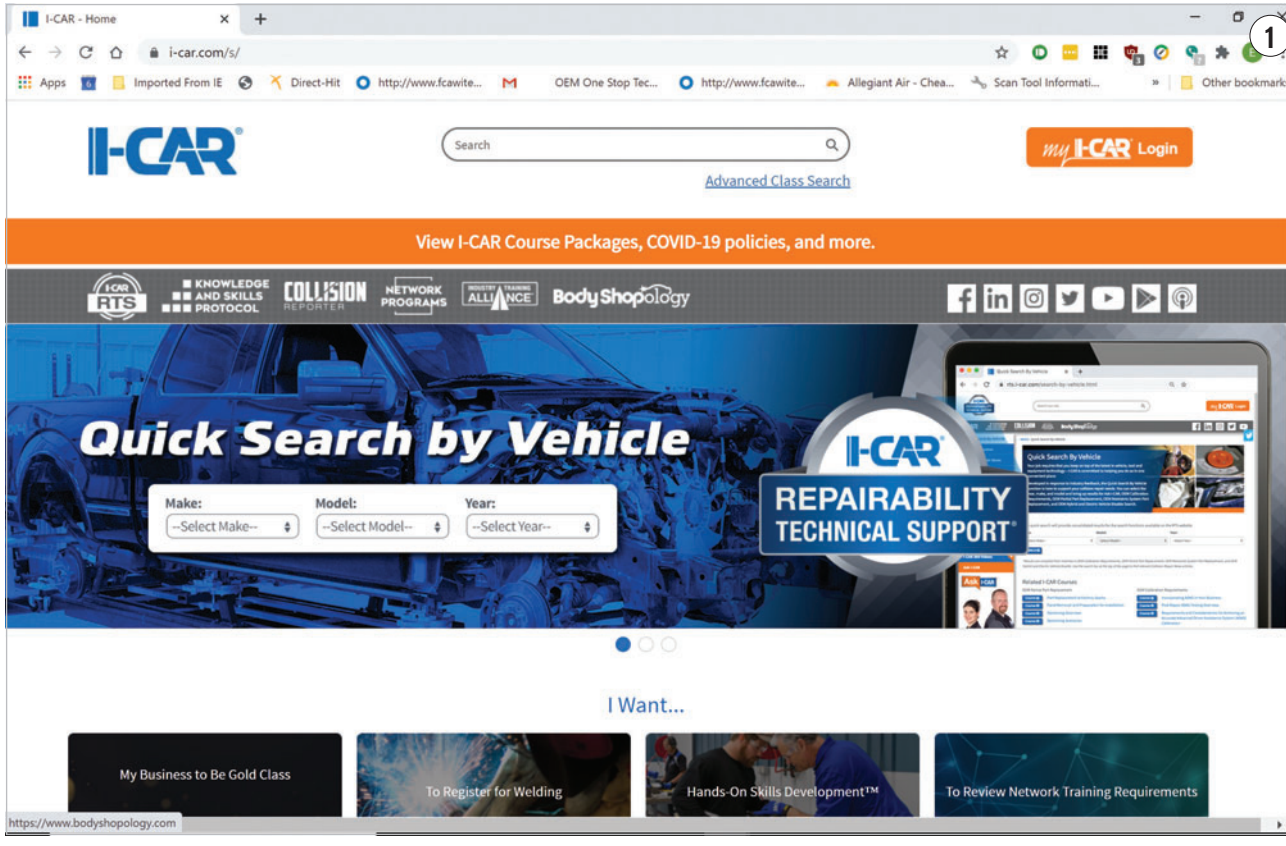
ERIC ZIEGLER // Contributing Editor

In "Getting ready to service ADAS-equipped vehicles" July 2020, we discussed how Advanced Driver-Assistance Systems (ADAS) seemed to be everywhere we turned. TV commercials, print ads, tool sales pitches for scan tools and calibration equipment are all a buzz about this latest topic. The first part of this two-part series introduced the different levels of autonomy defined by SAE. We discussed some of the fundamental systems and how they are integrated through sensor fusion. Moreover, I shared how it was of the utmost importance to have the proper information as to the when, where and how to calibrate these critical safety systems. There is a continuum in the modern automotive industry between OE tooling and aftermarket systems.

Hopefully, the takeaway from part 1 is that this technology is not a red herring (like the 42-volt systems of the past) but is here to stay and provides us another revenue stream at a time when so many other previous revenue streams afforded us are fading away! We merely need to tool up, train up and educate ourselves on these high-tech systems that have become standard equipment on both higher-end and base model newer vehicles.

Let's get after it!

In addition to being an automotive training instructor, I own and operate a mobile automotive diagnostics and programming company, EZ Diagnostic Solutions, which specializes in serving repair shops, fleets and especially collision repair centers. Each year, our workload becomes more and more focused on collision repair centers. This is largely driven by the greatly increased number of vehicles that are equipped with ADAS that oftentimes need to be



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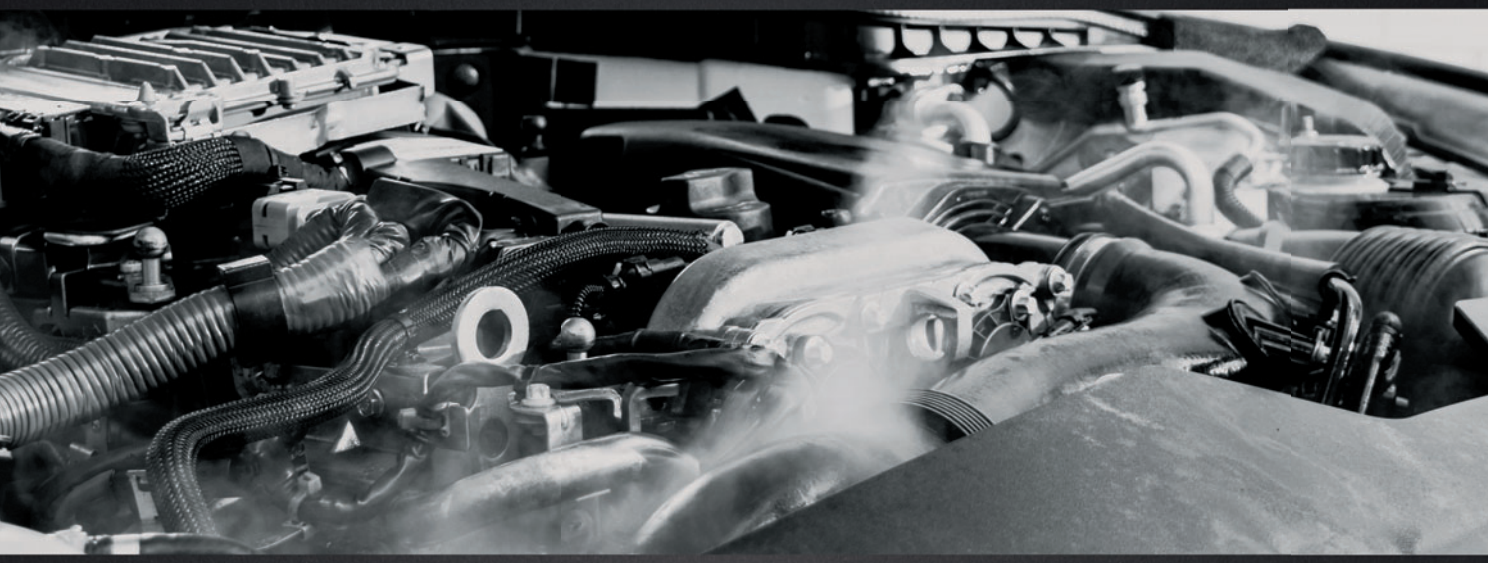

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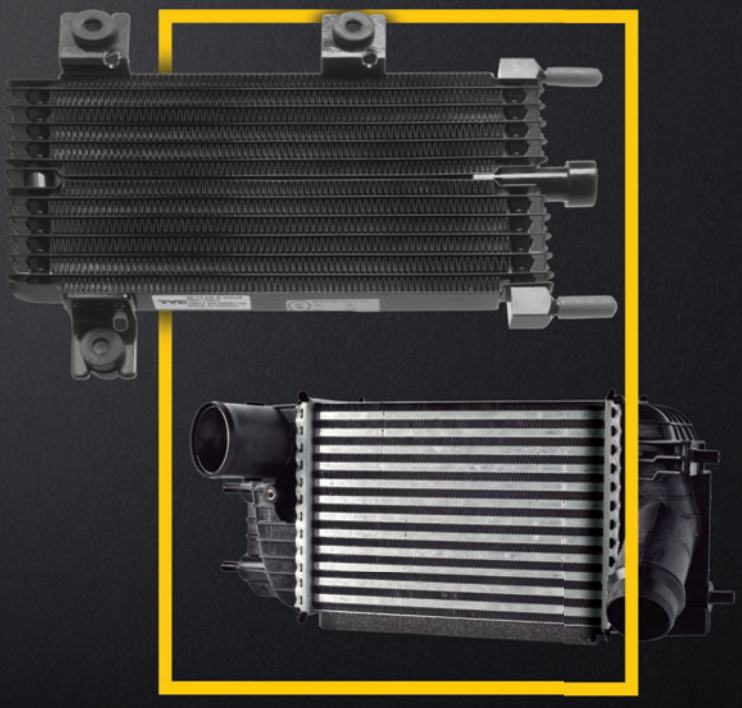

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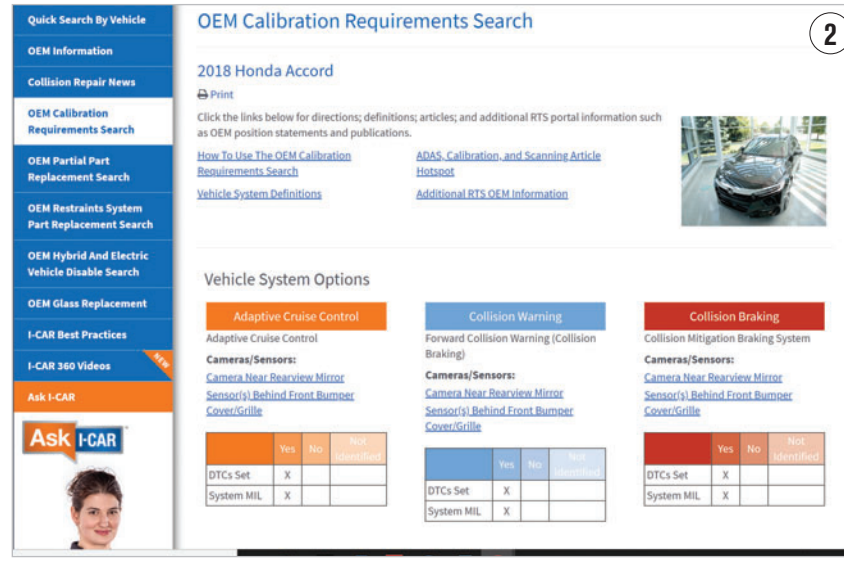
calibrated post-collision repair to ensure they have been restored to safe, pre-loss condition. Our phone rings regularly with questions about lights being on in the dash (MILs), prompts on the driver's information center (DIC), loss of ADAS functionality or more commonly, questions regarding potentially required calibration for any particular system. So the question of when is indeed one of the most important ones when working on ADAS-equipped vehicles!

This is where I believe that information/knowledge is power. I prefer and subscribe to many OEM service information systems. For me, it is part of the modern cost of doing business (CODB). I believe no one knows the ADAS systems better than the original equipment manufacturer, or OEM. Many OEMs have service information (SI) available at a very affordable short-term subscription rate. There are also service information providers that purchase, copy and paste the actual OEM SI procedures. I ALWAYS check the OEM SI procedure before performing any calibrations. I would recommend this especially if you are using an aftermarket tool that incorporates the procedure in the scan tool, as functions can be erroneous, omitted or lost in translation.

The "when" to perform calibrations is kind of obvious when components like the millimeter-wave radar unit is physically replaced. But what about when a bumper cover is simply removed to repair a cracked headlight, or suspension work and/or wheel alignment work has been performed, or how about just a simple battery disconnect? This is about knowing how and where to find the appropriate and accurate information, and it is key. I am also a firm believer in performing pre- and post-repair scans on vehicles we service, preferably with an OE scan tool. This is two-fold. First, it gives the technician valuable information and documentation of a baseline at the beginning of the repair. Secondly, it often will help to guide the technician to what ADAS systems (and subsystems) were affected and might require more research and attention. The post-repair scan gives us documentation that the vehicle left with a clean bill of health. So where would you start that information search?



Information is key

They are some awesome non-OEM sites that can help point us in the right direction. I like the site www.oem1stop.com. It is a great centralized portal to point the technician to the OEMs' website with the click of a mouse! Also, there are valuable OEM position statements regarding SRS wiring repair, when OE glass is required or even if the forward-looking radar must be recalibrated for something as simple as a front bumper cover removal. Another great source of information especially for (but not limited to) collision repair centers, is

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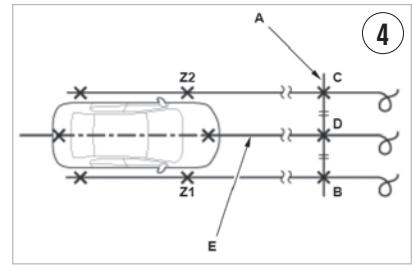
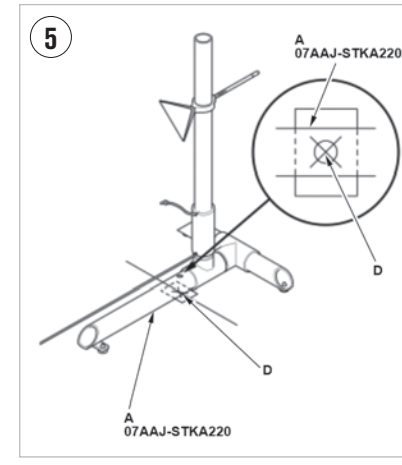
www.i-car.com (**Figure 1**). This a great source of the where and when to perform the necessary ADAS calibrations. Moreover, it is a great place to educate oneself on the operation and repair of vehicles equipped with these mission-critical systems. On the I-CAR site, the technician or service writer can do a quick OEM ADAS Calibration Requirements Search to get a vehicle-specific idea of the systems the vehicle could be equipped with, as well as the componentry, the locations and the calibration requirements for the ADAS equipment (**Figure 2**). This system is easy to navigate and gives valuable information about where and when to calibrate a particular ADAS system.

Let's use an example of a 2018 Honda Accord Adaptive Cruise Control, or ACC (**Figure 3**). The search matrix quickly identifies that this system works off the millimeter-wave radar sensor (or MMWR, which is the component that determines the distance from the vehicle in front of it). With a couple of clicks of the mouse, one can determine what components are involved and the systems that are affected. Furthermore, it explains in clear terms as to when calibration of the MMWR unit is required — for example, if the unit has been removed or replaced, if there was impact within 300mm of the unit, if an airbag deployed or if something as simple as a wheel alignment was performed. Another handy feature is that the search matrix will indicate whether the vehicle will set DTCs or turn on a MIL, whether a scan tool will be required to calibrate, and whether special tools are required. I am a big fan of sites where one can glean a lot of information in one centralized location; the I-CAR website does this, thoroughly and simply.

Let us look at the OEM SI to figure out the how, where and when to calibrate the ACC system. This is for the same 2018 Honda Accord. Honda publishes a great document that is known as a Job Aid for Aiming Driver Support Systems. The most recent publication is April 2020, which supersedes the April 2019 document. This also illustrates the need to make sure your information is up to date and how in the ADAS world, change is constant. I was able to find this information while logged into one of the two Honda OEM SI options. They are called Service Express or the Service Information System (SIS). Both are located at techinfo.honda.com. SIS is available for $25 a day. A quick Google search revealed a downloadable PDF version as well. I would strongly suggest downloading and saving this valuable service document. The OEM SI 29-page document details where the ADAS components are located and gives precise details as to when calibration is required. But, most importantly, lists the OE tool part numbers and pictures of the tools required for the job. If a shop was interested in doing ADAS calibrations, this would give you an idea of the tools required to service Honda vehicles.





So, in the case of the 2018 Honda Accord ACC, if the MMWR component was removed or replaced, an airbag deployed, was involved in a collision (where the structural repair was done), wheel alignment was performed, or if any DTCs set (such as P2583-xx), a recalibration or aiming of the MMWR is required. The Job Aid lists the tools as follows:

- 07AAJ-TK8A100 stand
- 07AAJ-STKA200 reflector
- 07AAJ-STKA210 alignment set

The tools are required to perform the ACC recalibration. The Job Aid does not offer how to perform the calibration and is not a substitute for the appropriate SI regarding how to perform the calibration. In addition to the above-listed tools, you will need a tape measure (metric scale preferred), some painter's tape, a felt tip marker (or ballpoint pen), some string and a capable scan tool (my business model is to use the OE scan tool, the i-HDS).

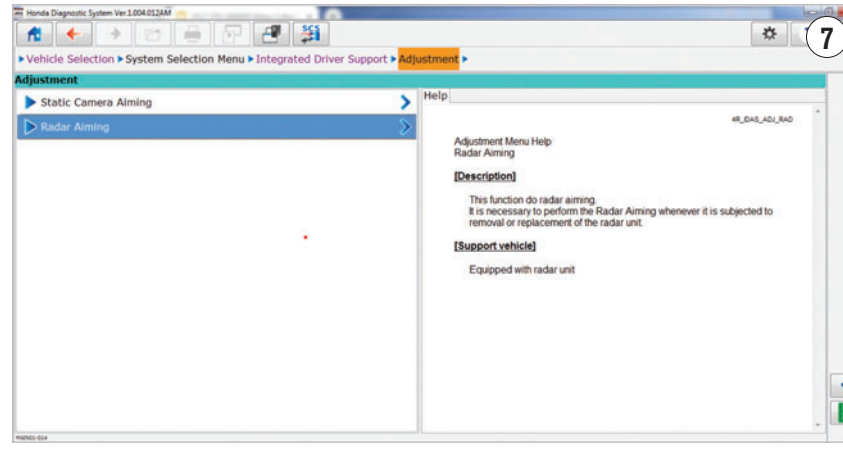
I always suggest consulting OE SI or a service information system that copies/pastes OE SI on the calibration of ADAS systems. Often, crucial details change from year to year and model to model. Here is a suggested pathway. Go to www.oem1stop.com and select the Honda icon. This leads to the Honda SIS website. Select your subscription and pay for it. Then, simply log in. Build the vehicle by entering the year/model

and a searchable term. In this case, we will use "radar." Perhaps I had a DTC (such as P2583). I would enter that in the search box and the diagnostic troubleshooting measures would appear. All the instances of the term "radar" that pertain to it will be displayed. "Millimeter-wave radar aiming" is selected and the document is displayed. It starts with the special tools required to perform the calibration. Next, there is information regarding when to perform the MMWR aiming/calibration, followed by a specific amount of space required to execute the procedure. In this case, the amount of space required in front of the vehicle is 10 m (33 ft), measured from the front bumper, 4 m (13 ft) in width, 1.5 m (4.9 ft) in height, measured from the floor.

Next, there is a section on the setup of the lines or grids (**Figure 4**). The first step is written in blue (representing a hyperlink) to a prerequisite section. This is needed for the setup of the lines and determining the centerline for aiming. I like to think of it as building a box, squaring the box with the vehicle and determining the true centerline of the vehicle, projecting it forward. This centerline is critical for the calibration! This is also why is it imperative that the thrust angle of the vehicle is correct and wheel alignment is often required before the MMWR calibration (or aiming), especially if the vehicle was involved in a collision. This is where technicians tend to over-complicate things.

It's geometry class all over again

To be successful and proficient in ADAS calibrations, one must have good reading skills and the ability to thoroughly follow directions. Paying attention to detail is critical as well. At the end of the day, this is just that same special oriented math you learned in high school geometry!



So, now that you have set up your lines/grids square to the vehicle and determined your centerline (built your box), you now must place the target in front of the vehicle. The target is a triangular-shaped device with a pointer on the back of it that slides on to the stand, which is made of PVC (**Figure 5**). Before placing the target in front of the vehicle, the target height needs to be configured. The pointer that is on the opposite side of the triangle is placed up against the bottom edge of the MMWR unit. This will be done after the radar cover bezel is removed from the lower bumper cover, allowing access to the MMWR unit. You'll then draw a reference line with a pencil (or use a piece of tape) at the top of the target collar indicated at reference Y. Now, raise the triangle 22mm to establish reference point Y1. The triangle target is now at the proper height to calibrate the MMWR unit (**Figure 6**). Before the target placement at point D (outlined in the setup), prepare to aim/calibrate the MMWR unit. As, per Honda SI, the steps are as follows (**Figure 7**):

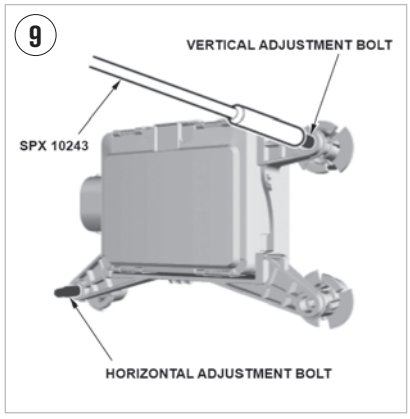
1. Connect the HDS.

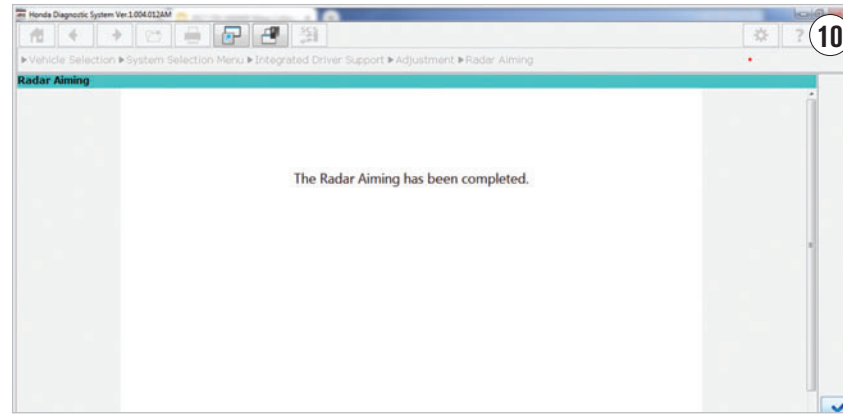
NOTE: Keep the aiming target away from the vehicle until you are instructed in a later step. Make sure that the front license plate frame is removed if equipped.

2. Check for DTCs with the HDS.

NOTE: Troubleshoot any DTCs first before proceeding. If DTC P2583-54 is indicated, proceed with the aiming procedure.

3. In the DRIVING SUPPORT MENU, select INTEGRATED DRIVER SUPPORT SYSTEM, ADJUSTMENT,





then Radar Aiming and follow the screen prompts.

4. Press ENTER on the HDS to enter the aiming mode.

NOTE: The ACC and LKAS indicators (amber) blink when aiming mode is activated.

5. The MID will indicate the number 4 for a few seconds, then displays NO TARGET.

6. Make sure the MID indicates NO TARGET on the display (**Figure 8**).

NOTE: If NO TARGET is not indicated, the stand set is placed in front of the vehicle or there is an unwanted radar reflection in front of the vehicle, in the range of the radar. Make sure the stand set is set aside away from the range of the radar until you are instructed to place it in front of the vehicle. If you are still getting an unwanted radar reflection, stack tires about 1.5 m (4.9 ft) in height in front of either the immovable object, such as a pole or in front of any object causing the unwanted reflections. The tires will block the radar reflections. Make sure NO TARGET appears on the MID. If it still does not appear, move the vehicle to a different location until NO TARGET appears on the MID.

Now place the triangle target and stand at point D measured out earlier. This is 4000mm from the centerline of the front wheels as well as the line that bisects those lines and the centerline of the vehicle projected forward. There is a hole in the stand that corresponds with the face of the triangle. It must line up with point D. Now select enter on the scan tool to calculate the alignment angles used to aim the MMWR. The tolerances are 0 +/- 0.1 degrees for both the horizontal and vertical angles.

If either angle is out of specification, the technician must adjust by rotating the adjustment bolts with a 3.5 mm driver. You can usually watch (in real-time) the adjustment by viewing the data on the scan tool, provided the radar zone to the target is not obstructed (**Figure 9**). If the zone is obstructed, 12.8 degrees will be displayed. If 12.8 degrees is displayed for longer than 15 seconds, the aiming process will stop. After the horizontal and vertical alignment angles are within a specified range, select enter on the scan tool. This will record the angles to the MMWR unit. The scan tool should now display, "the radar aiming has been completed" (**Figure 10**). Select enter one more time and the ignition is switched to the locked position. The radar cover can be reinstalled and the vehicle should be test driven.

Cover your tail!

I also like to document the process for liability's sake. I would suggest keeping screenshots of the scan tool's horizontal and vertical angles, both before and after adjustment. Capture the screen indicating the "radar aiming completed" as well. Programs like Google Slides, Paint or the Window Snipping tool work well for this. I would also suggest taking pictures of the target setup. Include the vehicle and its license plate. Ensure a time date/stamp is exhibited and keep a copy for your records. A verification test drive should be performed on any ADAS calibrations before returning the vehicle to the customer.

ADAS systems are here to stay and are becoming more and more prevalent on the vehicles that are coming into your bays. While the actions involving a vehicle's functionality vary from car to car, they all seem like they are from a sci-fi movie. Many of their calibrations may require some specialized tooling, but ultimately it is just good old-fashioned geometry. Following detailed instructions from quality service information and attention to detail is absolutely critical. It's not rocket science; it just requires us to do what we have always done — research, train and adapt to the changes in our industry!!

ERIC ZIEGLER is an ASE Certified Master Tech who specializes in module programming, drivability, electrical and network systems diagnostics. He owns and operates EZ Diagnostic Solutions Inc. and is a trainer for Automotive Seminars and The Driveability Guys.
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OUR EV FUTURE

HYBRID AND EV VEHICLES MAKE UP LESS THAN 2 PERCENT OF THE CURRENT U.S. FLEET, BUT CALIFORNIA MAY JUST HAVE GIVEN EVS A BOOST!

PETE MEIER // Director of Training

If you're an old-timer like me, you know that what happens to the automotive industry in California eventually finds its way to the rest of the country, especially when it comes to emissions. In late June, California announced that state regulators had approved new rules that would see a massive shift from conventional gas and diesel trucks and vans to ones powered by batteries and hydrogen fuel cells in an effort to address air pollution issues in the state.

In an article written by Cassandra Profita and published on NPR.org, Anthony Victoria, with the Center for Community Action and Environmental Justice, says the communities that large commercial trucks are driving through in Southern California are living in a cloud of air pollution that he calls a "diesel death zone." Victoria's group has counted more than 1,000 diesel trucks an hour passing through largely Latino neighborhoods.

"We're considered, in a lot of ways, America's shopping cart," Victoria says. "In our communities you have high asthma rates, high cancer rates, high diabetes rates and that could all be attributed to the industry that exists here, the logistics industry."

Victoria says California's electric truck mandate could help save lives in these communities. The state estimates it could prevent 900 premature deaths, deliver $9 million in public health benefits and remove 17 million metric tons of climate-warming carbon dioxide from the atmosphere.

The new regulations take effect in 2024 and govern a wide range of the commercial truck market, from medium

PHOTO: DAMILER

THE DAMILER TRUCK/FREIGHTLINER ECASCADIA has up to 730 peak horsepower and a range of 250 miles per charge.

duty up to Class 8 rigs. Guidelines already in place have addressed the state's desire to move the light-duty segments (possibly, in part, explaining the move by GM and Ford to shift their focus from hybrid to EV with both scheduled to release all-electric light trucks in the next few model years).

Under the new guidelines, at least 40 percent of the tractor-trailers sold in California would have to be powered by some form of zero emissions technology by 2024. On the medium-duty side, 55 percent of all trucks sold would need to meet the zero emissions requirement by 2035, as will 75 percent of all delivery trucks and vans sold in the state.

PHOTO: TESLA

THE TESLA SEMI HAS THE ADVANTAGE of a company-built nationwide charging network. Will that give Tesla an edge in this market?

California's push to reduce truck emissions could lead to some major changes in the automotive industry. Among other things, it could encourage the emergence of new competitors such as Nikola Motors, which is producing an array of hydrogen-powered heavy-duty trucks, and Detroit-based start-up Rivian, which has a contract to produce around 100,000 all-electric delivery vans for Amazon. That doesn't mean the domestic OEMs are taking a back seat, though.

General Motors recently announced plans to build electric delivery vans, in addition to the all-electric Hummer pickup to debut in 2021. The various subsidiaries of Daimler AG, such as Freightliner, have already launched an assortment of electric vans and heavy trucks, with more in the works. And Toyota is partnering with truck giant Kenworth to develop hydrogen-powered Class 8 semi prototypes that could lead to production models later this decade.

What does this mean to you as shop owners and technicians? The future, my friends, is getting closer to becoming the present. Are you prepared and trained to deal with the technologies?

PHOTO: NIKOLA

NIKOLA IS BUILDING A CLASS 8 that uses hydrogen fuel cell technology and is also developing vehicles in the light-duty segment.

New challenges for thermal management

The move to EV also creates challenges in keeping the occupants comfortable without impacting the range of the vehicle. In addition to cabin comfort, the battery assembly and related HV components also have to be kept cool.

In the March issue of SAE's publication, "Automotive Engineering," Paul Weissler shares insights gained from the SAE

PHOTO: GM

GM HAS GONE "ALL IN" IN ITS EV DEVELOPMENT. We should see this EV GMC Hummer later this year.

Thermal Management Systems Symposium. He writes that there are two major challenges engineers are working to overcome: heating the occupants in the winter and keeping the battery (and occupants) cool in the summer.

One solution is the use of a heat pump system, similar to what I've shared with you in the past and currently in use on the Nissan Leaf and Toyota Prius Plus. To put it simply, a heat pump is a conventional air conditioning system that is run in reverse to heat the cabin — turning the evaporator into a condenser and the condenser into an evaporator. The new system concepts, though, use liquid cooling for the battery pack rather than rely on the air cooling these two systems have. Other solutions being developed include a secondary loop system where the A/C system is used to chill a liquid coolant that is then used to cool down the battery pack and/or passenger area.

Another idea the OEMs are experimenting with is an improved, high-tech version of the heated/cooled seat. By providing heat or cooling directly to the occupant, the demand on the cabin system can be reduced and that reduces battery loss and maintains range.

Want to know more? Join me at the Mobile Air Conditioning Society training event in February or visit www.sae.org/publications/magazines/content/20autp03/ to read Paul's article in its entirety.

Six months and counting

As I write this, it's been nearly six months since we all came to know about COVID-19. For many of us, life changed and brought us challenges unlike any we've ever seen. But as "essential workers," the majority of you still got up every morning and went to work to do what you do best — keeping America moving.

And you've shared with us how hard it's been. Business is still there, but for many of you it's substantially less than what it was pre-coronavirus. Customer fears keep many away, but you adapted to do all you could to reassure them they, and their families, would not be at risk when doing business with your shop.

I just want to applaud you all for that. And to thank you for the sacrifices you've made to keep your doors open. I hope and pray that, by the time you read this issue, those days will have passed and we will be back on the path to normal. But if not, know that we at *Motor Age*, and all those in the *Motor Age* family (*PTEN, ABRN*), will be here to do what we can to provide you with the tools and resources you need to stay afloat.

Stay well.

PETE MEIER is an ASE certified Master Technician with over 35 years of practical experience as a technician and educator, covering a wide variety of makes and models. He began writing for *Motor Age* as a contributor in 2006 and joined the magazine fulltime as Technical Editor in 2010. Pete believes in the mission of the magazine to "advance the automotive professional" and provides resources to working techs around the country through print, social media and YouTube.
pmeier@endeavor.com

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IN THE END, IT'S ALL JUST VOLTAGE

THE MOST COMPLICATED ELECTRICAL ISSUES THAT ENTER OUR BAYS ARE OFTEN FAULTS CAUSED BY INADEQUATE VOLTAGE SUPPLY, BUT THEY CAN TAKE SOME CRITICAL THINKING TO CHASE DOWN

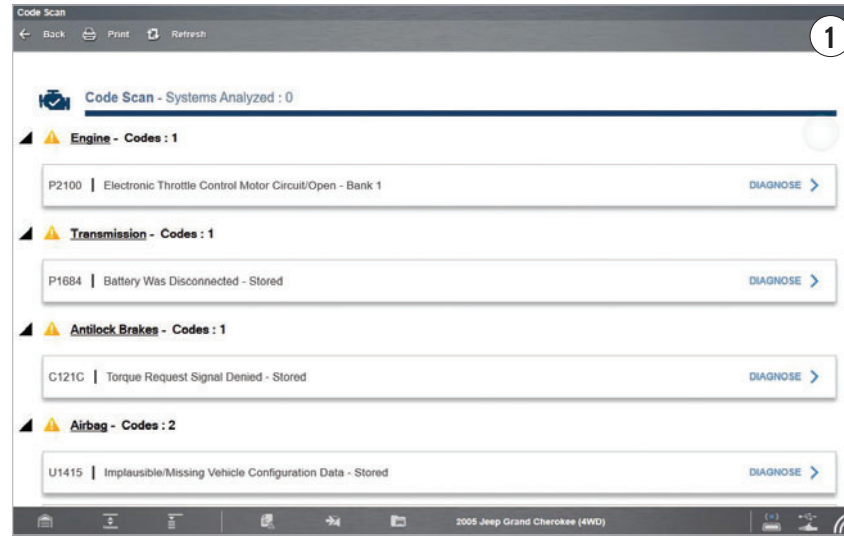
MIKE REYNOLDS // Contributing Editor

The subject is a 2005 Jeep Grand Cherokee with a 5.7L engine. I know what you're thinking... "Who still works on 2005 Jeeps?" But I chose this Jeep because the operation of the ETC (Electronic Throttle Control) system on this truck has stayed relatively the same. Not just on Jeeps, but on most makes and models going forward, and it doesn't look like that will change any time soon. At least until we no longer need a throttle plate.

I often get calls from shops struggling with ETC faults, and I was called to look at this truck after it had been setting throttle body codes and running rough. When I arrived, I found the shop had already installed a brand new throttle body, but the same symptom was present, so they reinstalled the original unit. A code P2100 set almost immediately (when the ignition was turned on), indicating a fault with the ETC motor (**Figure 1**). The engine would start but run rough.

Before I dive too deep into this diagnosis, I thought about what the most likely causes of this concern may be, using my knowledge of how most electronic throttle body systems operate. Most of these "fly-by-wire" or TAC (Throttle Actuator Control) assemblies operate similarly in that the ETC motor is wired directly to the PCM. And the PCM controls the position of the throttle plate by changing the polarity of applied PWM (Pulse Width Modulated) voltage to a DC motor connected to the throttle plate. If a voltage is applied to one terminal of the DC motor and ground to the other, the motor will turn in one direction. When polarity is reversed, the motor will turn in another direction. As a safety feature to prevent a runaway-engine, the throttle plate is held to a closed (or almost closed) position by a throttle return spring. This means that the PCM is typically only opening the throttle plate. But the PCM doesn't need the throttle plate to be slammed open or closed; it needs to control the position of the throttle plate. This is accomplished by pulsing the voltage of the ETC motor (PWM). By changing the PWM duty cycle, the PCM can have precise control over the position of the throttle plate.

In addition to the motor, most throttle bodies have two TPS (Throttle Position Sensors) that read the throttle position (if the PCM doesn't know where the plate is, how can it control it?). There are two sensors because of the need for redundancy. If there was only one sensor, and it became skewed, it may show the throttle closed when in reality it was open. The PCM (thinking the throttle was closed) would operate the ETC motors, opening the throttle even more! This type of situation could



PHOTOS: MIKE REYNOLDS

cause an engine to rev to WOT (Wide-open throttle) while a customer is attempting light throttle. Of course, this could potentially cause an accident.

By adding a second TPS sensor, the PCM can compare the values from both sensors and determine if they are both operating correctly and accurately. It is important to note that both TPS sensors will read different values at different throttle body positions. So, if somehow both TPS signal circuits were shorted together, the PCM would be able to determine that the signals were not correct (they should never share the same voltage at any given throttle angle).

This same principle that applies to redundant TPS sensors also applies to APP (Accelerator Pedal Position) sensors. Depending on the manufacturer, the PCM will have some type of strategy that will put the vehicle in "limp home mode" so the engine can't rev past a predetermined level. This is in case the throttle plate were to stick open or if a sensor failed. "Limp-home" is often achieved by disabling cylinders. I have seen plenty of technicians chase a misfiring engine, but the misfire was intentionally caused by the PCM to regulate engine speed due to a malfunction in the ETC system.

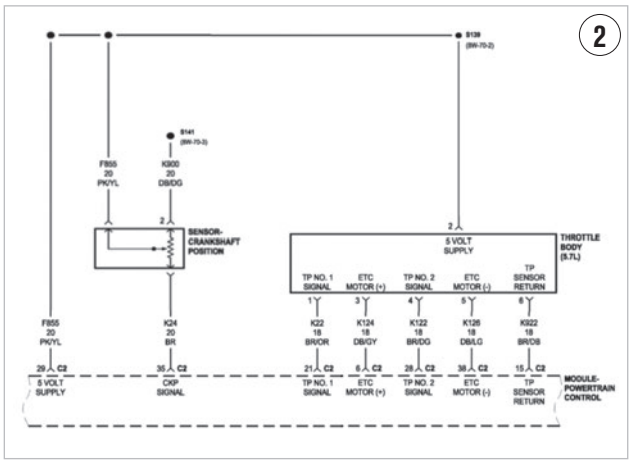
The ETC system and its components

We can break almost all electronic throttle control systems into four main components:

- The throttle body assembly (which includes the ETC motor and TPS sensors)
- The APP sensor
- The wiring
- The PCM

Because the PCM must maintain control of the throttle plate at all times, the circuits are typically not shared with any other components (i.e. the 5v reference for the TPS sensor is not likely shared with the MAP sensor). In the case of this Jeep, however, the 5v reference circuit for the TPS is shared with other sensors (**Figure 2**). What this means for us is that although ETC diagnostics is usually isolated to the four above-mentioned (potentially failing) components, we need to consider an issue with the other sensors that share the 5v reference with the TPS sensors.

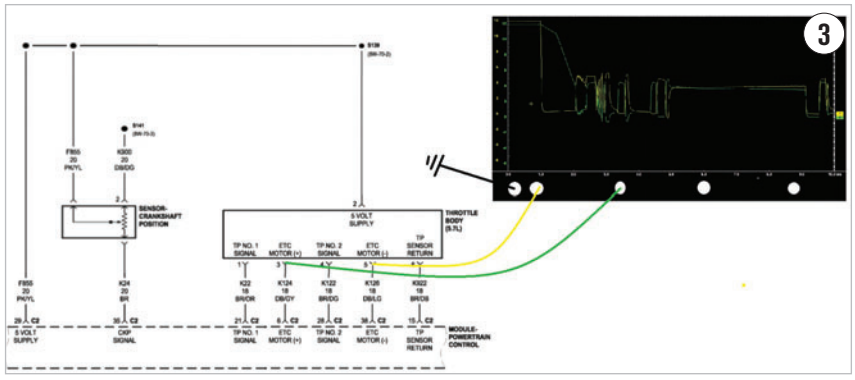
With that knowledge in mind, I began to think about what tests I need to perform first. I decide not to focus on the APP sensor (because there are no APP codes). Since the TPS sensor/ETC motor are all part of the throttle body (and we had one nearby), I tossed it on and verified that the code did reset right away with the new unit. Although possible, it wasn't likely that both the new and original throttle bodies were causing identical issues. I also decided not to focus on the TPS signal or 5v reference circuits (because I would

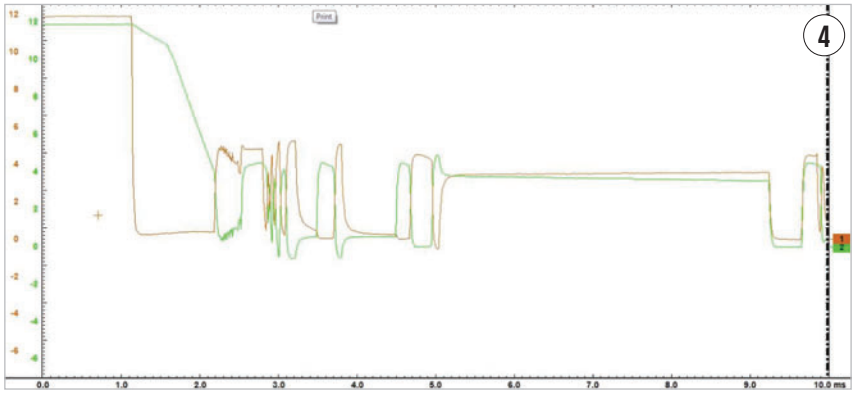


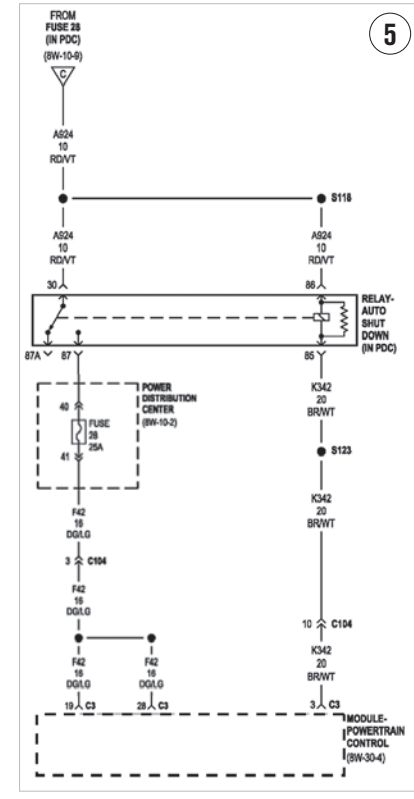
expect the PCM to set TPS related fault codes if there was a TPS related concern).

Narrowing the area of focus

At that point, I was focused on the PCM and the wiring between the PCM/ETC motor as potential causes of this symptom. I researched the P2100 code and found the diagnostic procedure directing me to check the resistance of the circuits







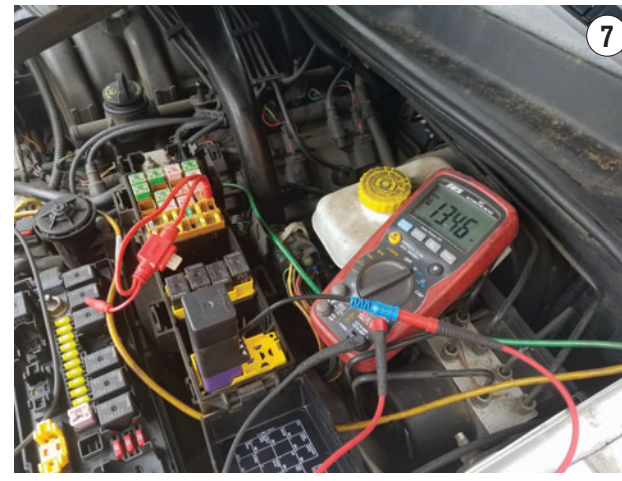
with an ohmmeter. As I expected, two circuits connect from both poles of the ETC motor directly to the PCM. I typically don't like to use an ohmmeter to test circuits. In the case of this ETC motor, an ohmmeter can only check continuity of the circuit. It is not able to test the circuit's ability to carry the amount of current required to operate the motor. But, because the code would set immediately with the key turned on, I was expecting to see an open circuit (or very excessive resistance if the wiring were faulty). I quickly checked both circuits with my ohmmeter, while wiggling the harness, but found no excessive resistance whatsoever.

At that point, I was ready to condemn the PCM as faulty, but I first wanted to look at the voltage on the ETC circuits and see what (if anything) the PCM was doing. Using two channels of my scope, I connected to circuit K124 and K126 (the ETC motor circuits) at the throttle body and referenced my ground lead directly to battery-negative (**Figure 3**). I then cleared the code and cycled the key a few times while recording. I want to point out that I cleared the codes (which may or may not have been a critical part of this test). Service information does not tell us exactly what happens when this code sets. It might be safe to assume that the PCM may remove power from the circuit. If it detects a fault (meaning if the code is set), we will not see anything on those circuits with our scope. On the other hand, P2100 is a continuously-monitored code, and because the key must be on to clear the code, we may find ourselves in a catch 22 of trying to record the exact instant when the failure is present. In our case, we were able to catch at least some sort of activity and recorded this screenshot **(Figure 4)** just as we keyed the ignition on.

Looking at this screenshot, we were confident that it wasn't correct. Since there wasn't anything else on the ETC circuit, it was easy to condemn the PCM. As a rule of thumb, we never condemn a PCM without testing the power and grounds. And by testing, I mean load-testing — we're about to find out why load-testing is so important.

Flushing the fault to the surface

Many years ago, I was taught to use a sealed-beam headlight (to test power and ground circuits) rather than a voltmeter or a test light. The reason for this is that just because a circuit can carry enough current to light up the tiny filament in a test-light bulb, it does not mean it can carry enough current to operate the component on a vehicle. Consider the multiple strands of copper wire in the heavy gauge B+ wire, like the wire supplying the starter motor. Let's say that the wires at the battery terminal (connected to that starter wire) are severely corroded so that only one strand of wire is making contact



and connecting the circuit. If we were to use our voltmeter (with one lead connected to the negative battery post and the other at the at battery positive wire of the starter) at KOEO we should see battery voltage present, because there is one strand connecting the circuit. But that one strand is not capable of flowing enough amperage to crank the starter. The same principle applies to a test light. Just because that circuit shows 12v available (or illuminates a test light) does not mean it can do the same under load.

And there are many different ways to load test a circuit. One common and easy way to load test a circuit is by using a voltmeter (while the circuit is loaded). In the case of our corroded starter wire, that would mean checking the voltage while cranking the engine. We may see 12 volts with the starter at rest and 4 volts while cranking the engine. This is because the single strand of wire (resistance in the circuit) is using 8 volts, of the available voltage and all we have left at the starter is 4 volts. You may also notice that the portion of the wire connected by the single strand gets hot or maybe even "glows!" That's where the voltage is being used, in the same way a light bulb or heater element converts energy into light or heat.

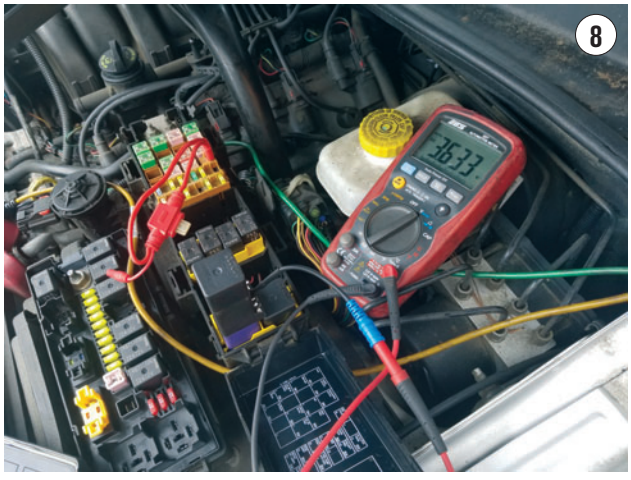
I, on the other hand, am lazy and for me, using a sealed-beam headlamp (to load test most circuits) is typically quicker. This is because a sealed-beam headlamp will draw enough current to load most circuits on a vehicle. It certainly won't work for a starter circuit, but for most modules and low current devices, if the circuit can light up a sealed beam headlamp, it can certainly carry enough current to power a module. If a circuit is not healthy, it is easy to tell. The bulb may visibly illuminate but is dim. This comes in handy, especially when you have to cycle a key inside the vehicle while performing a load test outside.

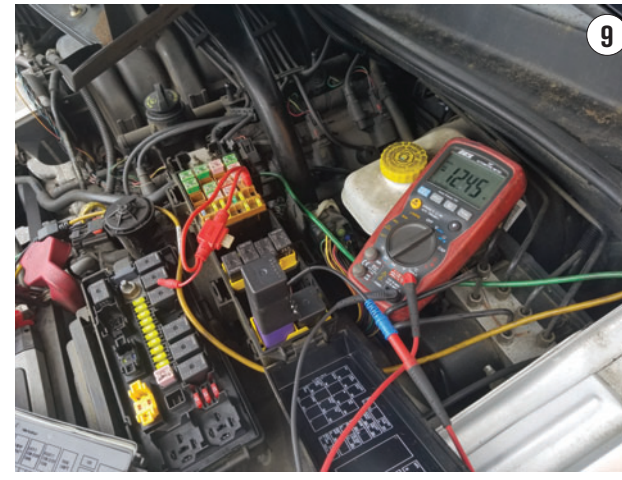
Before I condemn the PCM on this jeep, I want to print out my wiring diagrams, connector views and test all of the powers/grounds with my sealed-beam headlamp. I typically like to spend a few minutes studying the wiring diagram and using multiple colored highlighters to highlight the pins I want to check for either power and ground. In this instance, I needed to check circuits F1, F42, A209 and F942 (for power) and circuits Z130 and Z816 (for ground).

It is important to point out that I am doing this testing with the PCM disconnected. Circuit F42 gets its power from the ASD relay and the ASD relay is energized by the PCM (when PCM supplies the ground path). It grounds circuit K34s, which means we must ground circuit K34s at pin 3 of PCM connector C3 to test for a healthy power on circuits F24 to the PCM (**Figure 5**).

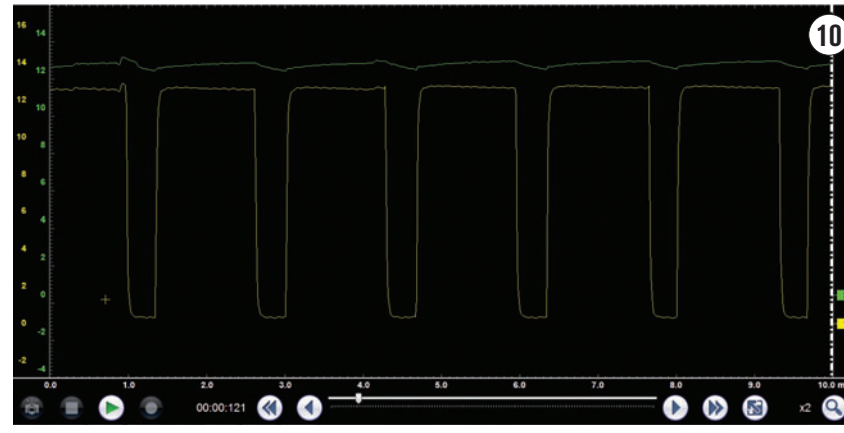
As we are going through the testing I found all of the circuits to have healthy power and ground. They light up our sealed beam brightly, but when I got to circuit F42, we had no illumination (**Figure 6**). I double-checked that I had the correct wire grounded at the PCM, to close the relay and could even hear it clicking when I cycled the ground. I checked and found 12v at that fuse (with the relay closed and the sealed-beam headlamp disconnected), but as soon as I connected the sealed beam the voltage dropped to 3.6 volts on both sides of the fuse. This told me that we did have a voltage drop and that it was upstream (of the fuse) in the circuit towards the relay. Had we only checked for voltage at the PCM connecter (either with the key off or the PCM disconnected), we would have missed this voltage-drop because we needed the circuit to be loaded to see it.

With that information, I decided to take the testing to the relay and installed a relay-testing adapter. I found (with the headlight disconnected) I had B+ voltage on terminal 87A (the output going to fuse #16) (**Figure 7**). When I





reconnected the headlight (loaded the circuit) I measured the same 3.6 volts at terminal 87A (**Figure 8**). Next, I checked and found healthy battery voltage at terminal 30 (the supply power for the switched-side of the relay) (**Figure 9**). This indicated that the relay was using up almost 9 volts of the available 12.5 volts. What I didn't mention is how I already knew that since it burned my fingertips when I removed it!



Retracing my steps

So, going back to the original scope screenshot (that we captured during the failure), we were able to identify exactly what was happening and how the failing relay was able to cause the code to set. We can see that the PCM is supplying 12 volts to each side of the DC-motor, but as soon as it grounds the circuit (our yellow trace) to operate the throttle blade in one direction, the voltage on the power circuit drops to around 5 volts. From there, you can see the PCM trying to flip the polarity. But the waveform does not look clean and the voltage stays around 5v. After replacing the relay, we can see in our known good waveform that the voltage will switch (on and off) with crisp transitions, and the voltage stays steady at B+ voltage (**Figure 10**).

The voltage needed to run the ETC motor for this Jeep was supplied by the ASD relay. And because the ASD relay was not able to allow enough voltage through, the ETC motor failed to control the throttle plate. I was unable to find specific code-setting criteria, but we can assume one of two things caused that specific code to set:

- Either the PCM was expecting to see the TPS readings change (when controlling the ETC motor) and because there were no correlation issues between the two sensors, the PCM flagged the fault in the ETC.
- Or the loss of voltage in the ETC motor circuit under load was detected by the PCM as a circuit fault, which is specifically what the code describes.

Either way, any technician could have easily made the same diagnosis with a procedural diagnostic approach, a little understanding of how these systems operate and an understanding of voltage drop. I didn't use much aside from a scanner, scope, a voltmeter and a headlight bulb to figure this one out. When you consider the fact that you could probably find all of the necessary tools second-hand (to complete just this one diagnostic), for less than the cost of a new PCM/throttle body for this Jeep, it makes you wonder why a large percentage of shops and technicians aren't willing to learn and apply these techniques.

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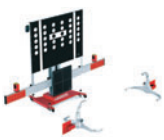

The LAUNCH X-431 ADAS Pro calibration tool is designed to ensure driving safety and comfort by handling the calibration of ADAS camera and radar systems. The automatic calibration frame and the multiple target boards are provided for servicing comprehensive car lines with rapid and accurate calibration. The ADAS Software's easy-to-follow process guides the technician step by step throughout the procedures. The bi-directional X-431 Throttle scanner with OE-level coverage and full diagnostic function ensures a satisfying experience for both diagnostics and calibrations.

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AUTEL EXPANDS ADAS COVERAGE

Autel US released three calibration packages for use with its two ADAS calibration systems. The MA-600CAL3 contains the MA600 Mounting Plate to expand radar/night vision calibrations on vehicles equipped with ACC, BSM, FCW, NV; the MA600LDW3 that contains LDW targets for the MA600 Frame, and the LDWTARGET3 package, which contains additional LDW targets for the Autel Standard Frame. Autel MaxiSYS ADAS calibration software is required for use.

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PASS THRU ASSISTANT

The new Snap-on® Pass Thru Assistant (PTA) expands automotive repair and collision technicians' J2534 programming capabilities, making it easier than ever for them to keep vehicles in the shop, finish the job correctly and increase profits and customer satisfaction. The Pass Thru Assistant reprograms domestic, Asian and European vehicles with the same easy-to-use process.

DIAGNOSTICS.SNAPON.COM

TIRE CHANGER IS SPACE SAVER

Ranger's R980AT tire changer is designed with a swing arm and doesn't tilt back, so it can be installed flush against a wall, which frees up space in small tire shops. It's ideal for full-service repair bays because it can handle most commuter and passenger vehicles, including light duty trucks and race cars. The power assist tower makes it easy to work with stiffer sidewalls, run flats and other low-profile tires.

BENDPAK.COM/WHEEL-SERVICE/TIRE-CHANGERS/R980AT/

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Dana Incorporated has introduced new Spicer ReadyPack™ preassembled kits for the most popular commercial vehicle driveshafts, coupling shafts, and interaxle shafts. These time-saving kits offer convenience, streamlined ordering, and savings on inventory and labor costs. Featuring 100 percent genuine Spicer components, Spicer ReadyPack preassembled kits arrive with u-joints that are professionally installed in the yoke shaft for the slip joint and in the tube yoke for the tight joint.

WWW.SPICERPARTS.COM/READYPACK

TRAINING PROGRAMS

Worldpac Training Institute (WTI) and Carquest Technical Institute (CTI) launched two new training programs, World Professional Automotive Community and Virtual Classroom, respectively, offering no-charge live online training. This joint venture provides automotive industry professionals a training series featuring advanced technical and business management classes. Instructors from WTI and CTI, guest industry leaders and automotive experts from OE and premium aftermarket suppliers and manufacturers deliver course content.

WORLDPAC.COM/TRAINING/CLASSES/ONLINE

LONG HAUL STEER TIRE

Continental has released the Conti EcoPlus HS3+, an ideal steer/all-position product in the long haul or line haul application, where vehicles travel 100,000 miles or more per year primarily on the highway. In field tests, it delivers 27 percent better mileage than its predecessor, Conti EcoPlus HS3. The tire is optimized for maximum mileage performance, lowest overall fuel consumption and durability for retreading – the key aspects for Lowest Overall Driving Cost in this segment.

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AD INDEX

AD INDEX

PRODUCTS

TRAINING

SOLVING ELECTRICAL PROBLEMS IN THE REAL WORLD

LESSONS IN A POWERPOINT CAN HELP US MASTER FUNDAMENTAL PRINCIPLES AND LEARN NEW TESTING TECHNIQUES, BUT NOTHING BEATS EXPERIENCE AND APPLICATION

PETE MEIER // Director of Training

I've said numerous times — if you want to become a decent electrical diagnostician, you need to master three things. The first thing you must master are the electrical fundamentals — the principles that govern how electricity and electrical circuits function. The second you must master is your ability to read and understand a wiring schematic. And the third you must master is electrical testing techniques, with voltage drop at the top of the list.

And it can be easy in the classroom. Where it becomes a challenge is when you are dealing with a customer's concern late on a Friday afternoon, and they are waiting in the front lounge for you to get it done. Tunnel vision clouds your judgement; the myths you worked so hard to unlearn are trying to find their way back into your diagnostic routine, and the problem remains unresolved.

Diagnostics (or troubleshooting, if you prefer) is a process, but it is a fluid process — one that moves with the needs of the technician and the problem at hand. In this month's edition of The Trainer, I'm faced with a Scion tC exhibiting an intermittent electrical fault that needs to be resolved — because the car in question belongs to my wife! I'll share how I use service information to diagnose the most likely causes of the problem before I even open my toolbox and how I select the tests most likely to provide direction with a minimal amount of work.

Will I uncover the culprit? Find out by watching the September "Trainer!"

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