Mettle Fatigue:
VW’s Single-Point-of-Failure Ethics

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After a year of denials, Volkswagen admitted in September 2015 that multiple makes and models of its diesel vehicles contained defeat device software. The decisions leading to “Dieselgate” involved a corruption of engineering ethics that the profession ought to address.

Eleven million diesel-powered vehicles Volkswagen sold as high-performing, fuel-sipping, planet-coddling cars have turned out to be gross polluters masked by corporate fraud.—Wired

In September 2015, after issuing denials for more than a year, Volkswagen (VW) officials admitted that multiple makes and models of its diesel vehicles contained defeat device software. Defeat device is a US Environmental Protection Agency (EPA) term of art for any technology that causes a vehicle to behave differently in the lab than on the road.

On 18 September 2015, the EPA and the California Air Resources Board (CARB) issued notices of violation (NoVs) to VW. The NoVs reveal a succession of dishonest actions. For seven years, from 2009 through 2015, VW personnel installed defeat devices, despite apparently knowing that doing so violated the federal Clean Air Act. And it appears that supervisors knew about and condoned these actions.

VW’s installation of the defeat device software and VW’s failure to disclose it when applying for the Certificates of Conformity (CoCs) required to import vehicles appear to violate federal and state laws. At least some VW employees knew that these CoC applications falsely represented that VW’s diesel vehicles had passed emissions control tests and did not contain defeat devices. Dishonesty on this scale by engineers, supervisors, and possibly higher officials at a major engineering enterprise has struck many as incomprehensible, a senseless waste of VW’s hard-earned reputation and credibility.

In December 2015, VW released an interim report of findings from a two-track investigation—by internal auditors and an outside law firm—into the use, on VW’s behalf, of defeat device software. In his extended statement, Pötsch observed, “The key finding is that we are not talking of a one-off error, but a whole chain of errors that was not interrupted at any point along the timeline.”

This characterization seems designed to protect the company. Yet it might have unintended and undesired
consequences because it blurs or obliterates some bright lines on the moral spectrum: first, between right and not right—that is, between accurate and inadvertently inaccurate—and second, between not right and wrong—that is, between inadvertently inaccurate and deliberately false. Participants in any enterprise know that moral spectrum. Mistakes happen, which is lamentable. But falsehoods don’t “just happen.” They require intent. One decides to do wrong.

We usually think of engineering errors as inadvertently, well-intended acts performed incorrectly or as oversights leaving undone what one knew how to do and had planned to do—for example, incorrect computations or not performing a planned computation.

What happened inside VW appears to have involved deliberate misdeeds, not mistakes: supervisors, and possibly higher officials, apparently condoned their commission. For seven consecutive years, they let the company release vehicles embodying the product of their misdeeds. When challenged by federal and state regulators, they made untrue representations on VW’s behalf.

We’re disappointed that VW Group’s highest officials would use a word from one end of the moral spectrum—errors—to characterize conduct that trespassed far into the spectrum’s opposite end. The company admits that its employees used corrupt software to cheat on emissions control tests, sold the vehicles as “clean” machines, and made disingenuous denials when challenged by regulators. Because the participants, regardless of their rank in the VW organization, were with few exceptions trained engineers, their decisions involved a corruption of engineering ethics that the profession ought to address.

We understand that VW asks for patience so that it can complete its investigations, but VW adds that completion might be months away. And it could be years before the courts decide whom to hold responsible. Yet the engineering profession shouldn’t wait years before examining what has come to light. The stakes are too high, the consequences too fraught, and the need to avert repetitions of what went awry too important for delay.

Our intent here is to comprehend how engineers could abandon their mettle and to help other engineers see the perils of doing so, even when company pressure makes dishonest practices seem like part of the job—which appears to have been the case at VW.

In this article, we develop a plausible explanation for how trained VW engineers could have decided to devise corrupt software to cheat emissions control tests rather than design an engine that could pass them. We construct two chronologies: one details the decisions that brought the defeat device software into production, and the other traces VW’s denials to regulators. We draw on facts the chronologies illuminate to explain the dysfunctional practices that appear to account for what happened inside VW. We then discuss serious challenges posed by the use of defeat device software. The first is that VW’s development of defeat devices constitutes a new form of insider cyberthreat: the use of corrupt software for dishonest purposes. The second is the ethical breakdown that occurred and how to prevent its recurrence.

At its apex, VW’s organizational structure is complex. It is our understanding that Volkswagen Aktiengesellschaft (AG) is the parent company of the VW Group. A Board of Management manages both VW AG and the VW Group, and is headed by a chairman who functions as CEO and is thus also often referred to as VW’s CEO. A Supervisory Board “appoints, monitors and advises the Board of Management,” is “consulted directly on decisions … of fundamental significance,” and is headed by a chairman (http://annualreport2014.volkswagenag.com/group-management-report/structure-and-business-activities.html). For clarity, we refer in this article to the head of VW’s Board of Management as the “CEO” and the head of VW’s Supervisory Board as the “chairman.” For convenience, we refer to VW AG and VW Group as “VW.”

**Dysfunctional Practices**

We focus on four dysfunctional practices that took root at VW and provide the most plausible explanation for how VW engineers and officers could decide to engage in widespread, repeated dishonesty. We use the term “dysfunctional practices” to denote a significant departure from good engineering, whether by engineers, their superiors up the chain of command, or their bosses at the company’s apex who started out as engineers. The common ingredient in each case is dishonesty. We derive four dysfunctional practices from an analysis of facts published in open sources. When set forth in a chronology, the causal relationships become discernible. The dysfunctional practices were:
• senior officers’ insistence on the pursuit of infeasible objectives with no tolerance for failure;
• suppression of open communication, enforced by an intolerance for bad news and dissenting views;
• creation of software to cheat, rather than solve, engineering problems and protection of that software from disclosure as if it were a trade secret; and
• departure from honesty in the chain of command and reckless disregard for the consequences.

The authors are not VW customers. Neither owns a car, though each used to. One of us is a software engineer; the other is legal counsel to several engineering firms. We share an admiration for German engineering. Practiced well, it’s exemplary in skill, thoroughness, and reliability. German-designed machines perform to specifications. German engineers know with precision their products’ capabilities and limits. Ask German naval engineers how many deep dives their design of the boat can withstand, and you’ll get an answer supported by analysis and accurate test results. Their drive for boat performance is tempered by an overriding concern for crew safety, because when designing a submarine and its software, every feature is a safety feature. We thought VW had long exemplified engineering excellence and demanded the best from its engineers. Instead, it appears VW let pursuit of growth corrupt its actions. Dysfunctional practices altered the mettle of VW’s chain of command. By adopting these practices, VW officers and engineers made a Faustian bargain. As each practice became further embedded, it threatened greater harm to the company. And as each practice spread through the engineering teams and product lines, those responsible took graver risks with VW’s reputation to keep the deception hidden. The scale of what happened and the denials designed to cover it up make each version of the company’s postadmission account a tough sell—one that pits the company’s credibility against its efforts to regain public trust.

We’ve watched VW’s unmasking with mixed emotions: sadness at how far company personnel sank before admitting engineering malpractice, frustration as VW scrambled to conduct damage control that further undermined its reputation, and ire at the hubris that seems to have characterized the company’s culture as far back as 2004. Even VW’s renewed focus on regaining customer trust seems off target because it emphasizes what VW wants from its customers rather than what it owes them, which is honest engineering or, as it proclaimed in the motto adopted in 2007 for its US business, “Truth in Engineering.”

Chronology 1: Decisions Leading to the Defeat Device
The “Origins of the Defeat Device Software” sidebar chronicles the events and decisions that brought the defeat device to market.

This chronicle has moments of certitude—decisive actions that clearly happened—separated by interludes of shadowy human interaction, where it’s unclear which of several possible actions occurred. Yet the range of possible actions, along with who performed them, is often severely limited by certitudes in the aftermath, in which public revelation shined a light on failed nitrogen oxide (NOx) emissions tests, deceived regulators, falsified CoCs, blatantly untrue ads, customers sold substandard vehicles, and other undeniable acts. Thus, the sidebar’s timeline is our best estimate. Although it’s only an approximation, it’s close enough to let an observer discern the four dysfunctional practices that appear to have become the standard for certain engineers and supervisors at VW. Let’s consider in detail what the chronology reveals about each of those practices.

Insistence on Infeasible Objectives
This practice involved insistence on objectives in the face of evidence that they were unrealistic, leaving dishonest means as the only way forward.

Ordering the pursuit of infeasible objectives is evident in the 2007 release of CEO Martin Winterkorn’s ambitious “Strategy 2018” and subsequent events, which set the goal for VW to become “not only as large, but as profitable as its Japanese competitor Toyota Motor Corporation.” As The Economist observed, “The company has been obsessed with surpassing Toyota and becoming the world’s biggest car company.” Under Strategy 2018, VW would, by that year, “increase unit sales to more than 10 million vehicles a year” and become “the world’s most profitable … automobile manufacturer,” in part by tripling its 2008 US sales to reach Winterkorn’s US “target of one million cars a year.” Thus, the VW leaders set the objective in an autocratic manner, for which the CEO was known. VW’s interim report takes a similar view, although it traces the practice back to an earlier date: “The starting point [for the ‘NOx issue’] was a strategic decision to launch a large-scale promotion of diesel vehicles in the United States in 2005.”

At roughly the same time as Strategy 2018’s announcement, top executive decisions removed from consideration a reliable way to achieve a clean diesel engine; VW canceled its license of Daimler’s AdBlue technology. AdBlue is a urea-based treatment for engine exhaust that removes NOx pollutants. If VW hadn’t scrapped the license, its engineers would have had a solution to meet the new, reduced limits on NOx imposed by California. Instead, its engineers were left with no feasible alternatives, or at least no honest ones.
(After VW admitted its use of defeat device software, it announced it would once again use AdBlue.9)

There’s convincing evidence that engineers understood the emissions control design tradeoffs very well. Yet officers at the highest levels of VW, experienced engineers themselves—placed price, performance, time-frame, and technological bounds on acceptable solutions that were infeasible.9 They appear to have required their subordinates to achieve success without fail. Thus, managers and engineers apparently had to choose between loyalty to the company—including continued employment—and fidelity to their origins of the Defeat Device Software

Here we present a chronicle of events and decisions—some documented facts and others inferred as probable—that brought the Volkswagen (VW) defeat device to market.

2005
VW makes "a strategic decision to launch a large-scale promotion of diesel vehicles in the United States."1

February 2005 Wolfgang Bernhard is appointed CEO of VW core brand (owned by VW). VW Brand begins planning a new 2-liter EA189 diesel engine chiefly for the US market.2 CEO Bernhard "entrusts the new project to Rudolf Krebs, a developer at VW’s Audi brand."3

May 2005 VW engineers report to senior VW officers that "it will be impossible [for the EA189 engine] to comply with US [NOx] emissions standards using [VW’s] current technology."3 They recommend using competitor Daimler’s BlueTECH with AdBlue technology.3

Bernhard faces a choice: license BlueTECH from Daimler, his former employer, or risk that VW’s technology cannot be improved to meet NOx emissions limits. A group of top decision makers at Audi—CEO Martin Winterkorn, chief engineer Ulrich Hackenberg, and another senior engineer Wolfgang Hatz—favor the latter course.3

An unidentified executive reports that "many VW engineers felt that the company’s native technology was not good enough to return sufficiently low emissions." Over opposition by Winterkorn, Bernhard licenses BlueTECH with AdBlue from Daimler.4

2006
5 June Automotive News reports, "Next year, Volkswagen AG will change its diesel systems from an old-style mechanical fuel injection system to a new high-pressure electronic version. ... Most other automakers switched years ago to computer-controlled ... systems. ... The switchover will take almost a year because VW says it needs the time to ensure that its new system will meet stringent US emission regulations."5

Fall First prototypes of EA189 are tested in South Africa.3

7 November VW’s CEO Bernd Pischetsrieder resigns effective 31 December 2006;6 Winterkorn emerges as a possible successor.

15 November Reports circulate that Bernhard might resign as threatened in May 2006 if Winterkorn is appointed CEO of VW.7

17 November VW states it will market diesel vehicles in the US using BlueTECH,6 but VW will call it "Clean TDI."9 TDI is the basic VW engine technology used in EA189. VW’s Supervisory Board appoints Winterkorn as VW Group CEO.

29 November VW announces that its Clean TDI engine with BlueTECH will be used in the future Tiguan model.9

1 December VW posts to its website that "[n]ew powertrains, including the engine concept developed by Volkswagen under the working title ‘Clean TDI’ for use in the USA, are already in the prototype stage. These engines will satisfy the strictest emissions laws in the world—even the so-called Tier2Bin5 in California. The ‘Clean TDI’ engines are an important component of the BlueTECH."9 The inference is that VW was on track to market emissions-compliant engines using BlueTECH.

26 December VW, with Winterkorn in charge, decides not to sell TDI-equipped Jetta’s until 2008.11

2007
January Bernhard leaves VW Brand before EA189 goes into production.12

23 January VW unveils Clean TDI Jetta at the Washington, DC, Auto Show, declaring that it will soon be approved in all 50 states, "satisfying the stringent ‘Tier 2/Bin 5’ emission requirements."13,14

January–February VW approves the appointment of Winterkorn’s key engineers from Audi—Hackenberg15 and Hatz—to senior VW positions, probably responsible for EA189 development, certainly with strong influence over it. Hackenberg becomes a member of VW’s Brand Board for Technical Development.16 Hatz moves from Audi head of engine and transmission development to the same job at VW.17

VW 2006 Annual Report (issued February 2007) states, "An innovative and advanced system that keeps CO2 emissions particularly low while at the same time avoiding 90% of NOx emissions will soon be introduced to the market: the ‘Clean TDI’. ... ‘Clean TDI’ is an especially clean, low-consumption diesel engine by Volkswagen that meets the toughest emissions standards—even in the US."18 The inference is that VW’s marketing group has identified features that VW cars need in the US to achieve Winterkorn’s strategic sales objective: low emissions, power, and good fuel economy. Winterkorn approves.

4 April Jetta SportWagen debuts at the New York Auto Show, Continued on page 16
including a 2-liter diesel model to be available in early 2008, probably the “new BlueTECH diesels.”

May Winterkorn completes the February board-approved installation of Hatz as VW’s engines chief and Hackenberg as leader “in charge of development.” The team of three that opposed use of BlueTECH while at Audi is now in charge at VW. Presumably, VW’s engineering group attempts to design EA189-powered vehicles that achieve all objectives, but eventually concludes that the desired power and economy can’t be obtained along with acceptable emissions using TDI alone. (For convenience, we call this “the problem” in this chronology.)

As VW later admits, “Initially, it proved impossible to have the EA189 engine meet by legal means the stricter nitrogen oxide requirements in the United States within the required timeframe and budget.” Seeking relief from infeasible specifications is standard engineering practice—as is alerting superiors when specs cannot be met. The inference is that VW’s engineering group faced decisions, including

■ whether to report up the VW chain of command that the problem is intractable;
■ whether to propose alternatives such as new performance objectives, reduced sufficiently to allow legal emissions; and
■ what to do if no alternative is accepted.

Reporting up the chain is the most plausible course of action. It’s what any responsible engineer would do.

As later reported by Handelsblatt, “VW uses software in its EA189 engine that allows vehicles to be switched into test mode. This is intended to make work easier for technicians. ... The software was developed by automotive supplier Bosch.” In a letter, “Bosch warned” VW that “it would be illegal to use engine management software ... in production cars.” The inference is that someone at Bosch determined that the company’s software was intended for use in a defeat device.

Industry norms and CEO Winterkorn’s leadership style aren’t tolerant of bad news. When Ferdinand Piech, Chairman of VW’s Supervisory Board until 2015, was asked what would happen if an engineering team reported they couldn’t deliver, he replied: “Then I will tell them they are all fired and I will bring in a new team. ... And if they tell me they can’t do it, I will fire them, too.” Winterkorn’s reputation is such that “[b]efore anyone reports to him, they make sure they have good news.” The inference is that with line engineer reports in hand, VW’s officers Hackenberg and Hatz face difficult decisions:

■ whether and how to report to their CEO that the problem is, indeed, intractable;
■ whether to request additional time and funds to attempt a redesign; and
■ whether to propose alternatives—perhaps involving the Bosch software.

For Hackenberg and Hatz, the stakes were enormous: US legal compliance of several VW models. Corporate officers understand legal obligation and liability. Remaining silent would risk termination without severance pay and criminal liability. An informal report of the problem would’ve maximized the opportunity for the team of three to debate and devise the best possible way forward, but also would’ve exposed engineers to termination and liability. A formal written report directly to the CEO probably offered the best risk balance. The inference is that, despite the adverse climate for bad news, Hackenberg and Hatz might have decided to report the problem informally to their CEO along with some alternative ways forward. But it’s more plausible that they put their report in a written memorandum. VW pulls “its small diesel cars from many US markets after the 2007 model year because the old engines didn’t meet new emissions standards” and plans to replace them with the EA189 engine models like the Jetta SportWagen.

6 July In an email, VW informs its US dealer network of a delay in the Jetta SportWagen’s launch from August 2007 to March 2008 (but later delays it again to August 2008).

August “The diesel EA189 engine is used for the first time in the new Tiguan model. It contains the software that will later be used to cheat in emissions tests, although it is not yet being used [for that purpose].”

6 August Winterkorn terminates VW participation in the BlueTECH Alliance along with its license, sealing its reliance on VW-designed emissions controls for the EA189.

24 September VW announces that it plans “on toppling Toyota as world’s largest car manufacturer by 2015” and “will begin by launching 12 new vehicles in the next three years.”

19 October Winterkorn announces VW “will be dropping prices in the US to be more in line with Toyota.” The inference is that VW has a new competitive advantage in production costs.

12 November Automotive News reports, “A problem with the professional ethics. If they couldn’t engineer a product that would meet objectives by honest means, it seems they understood implicitly that illicit means might be tolerated, even expected. They knew they had to report upward what they’d accomplished and how. Let’s examine why.

Given VW’s autocratic control, we can reasonably infer that its engineers were accountable to report both serious design problems and the solutions found to overcome them. Indeed, engineers are usually keen to report “we found a way!” Similarly, colleagues and bosses can’t resist asking “how did you do it?” When
The stakes riding on the solution are high, the probability of this question is commensurately so, and for a simple reason: the report will draw the same question at each step in the chain of command. No one wants to be caught out, especially on news everyone wants to hear. Honest and dishonest engineering solutions are the same in this regard—good news travels fast, and with all the details intact.

How far up would the good news have reached? Because any corporate strategy would include a monitoring and progress evaluation plan, Strategy 2018 almost certainly did as well. After all, Winterkorn had “worked
continued from page 17

Air Resources Board requirements, under which is [sic] qualifies as a SULEV, or Super Low Emission Vehicle."37 Jetta is the first diesel to win the award. A key factor: its price is less than hybrid cars.38 No VW engineer or officer steps forward to say that the award is undeserved.

2009–2010

VW engineering groups install "defeat devices" in multiple models of VW vehicles for the US market.39

VW submits annual applications for CoCs, each with "a list of all auxiliary emission control devices (AECs)" installed on the vehicles," a "justification for each AEC ... and a rationale for why it is not a defeat device,"40 as required by EPA regulation. (An AEC is "any element of design which senses temperature, vehicle speed, engine RPM, transmission gear, manifold vacuum, or any other parameter for the purpose of activating, modulating, delaying, or deactivating the operation of any part of the emission control system."40) Nothing resembling the defeat device is listed. Had it been listed, the corresponding vehicles wouldn’t have been certified for US sale.40

26 February 2010

VW issues the 2009 Annual Report that details Strategy 2018, including "Volkswagen intends to become a world leader by using intelligent innovations and technologies, while at the same time delivering customer satisfaction and quality."41

2010

VW introduces its code of conduct. "In the first step, the Chairman of the Board of Management [CEO] informed all the Company’s managers of the importance of the Code of Conduct and called on them to lead by good example. ... Each employee received a copy. ... [T]he message was driven home in on-site seminars."42

References


in ... quality and production roles at VW and Audi, earning a reputation as a boss who obsesses about the tiniest product details. ...”7 He was known for being hands-on, “insisting on having his way even over tiny details,”10 and he was “always the one who wanted to know everything.”11 In his own words, he emphasized achieving, without fail, his objectives: “I have always been driven by the ambition to solve every problem I face, whether as a scientist, engineer or entrepreneur.”11 He also made clear that he expected to be told when a
solution wasn’t possible. As VW’s 2010 Annual Report quotes him, “If developers say that a solution is not possible from a technical, timing, or financial point of view, I am able to challenge them. And everyone knows possible from a technical, timing, or financial point of view.”

“VW’s interim report supports this analysis, acknowledging that ‘it proved impossible to have the EA189 emissions design impasse would have been reported in the normal course of Strategy 2018’s progress, the NOx emissions design impasse would have been reported high in the VW chain of command, if not to the top.”
engine meet by legal means” the US NOx emission requirements. How else was this learned other than from an internal report? The interim report continues, “This led to the incorporation of software that adjusted nitrogen oxide emission levels according to whether vehicles were on the road or being tested.” Is this the “we found a way” report from internal files? It seems likely. VW installed the EA189 engine, equipped with defeat device software, for seven years in 11 million vehicles worldwide.

Thus, it’s surprising that VW America’s CEO Michael Horn gave the following account in his October 2015 testimony to Congress: “This was a couple of software engineers who put this in for whatever reason.”

For the same reasons, we think that VW’s account of its R&D risk (which appeared in its 2011 Annual Report and has reappeared in substance as late as its 2014 Annual Report) is obsolete and that VW’s announced commitment to revise its internal processes confirms it. An interesting window into VW’s evolving culture will be to compare its descriptions of R&D risk in future annual reports to this one from 2011.

There is also a risk that it may not be possible to develop products or modules within the specified time-frame, to the required quality standards, or in line with cost specifications. To avoid this risk, we continuously and systematically monitor the progress of all projects and regularly compare this progress with the original targets. In the event of deviations, appropriate control measures are initiated in good time.

Suppression of Open Communication
This practice involved the creation of a work environment in which engineers couldn’t communicate freely when attempting to solve tough design problems. Engineering is an increasingly collaborative activity because the task of designing a cutting-edge technology is too complex for one person. Collaborative engineering thrives on open communication. The tougher the problem, the greater the need. Conversely, any factor that causes friction or discomfort in free expression impedes engineering accomplishment. Indeed, credible descriptions of VW’s work environment by former personnel suggest that open communication was lacking and that what the German newspaper Handelsblatt aptly terms “culture of fear and hubris” more commonly characterized the workplace.

Current and former Volkswagen executives say that Mr. Piëch [supervisory board chairman from 2002 until April 2015] and his protégé Martin Winterkorn, CEO from 2007 until his resignation [in September 2015] ... created an autocratic, corrosive culture in which dissent and criticism weren’t tolerated. [According to a former VW executive] “Workers and managers are afraid to speak the truth. ... Dissenting opinions are at best ignored and at worst suppressed.”

German auto executives are reportedly “used to getting what they want.” Winterkorn’s management style was reportedly one of intolerance for bad news: “He doesn’t like bad news. Before anyone reports to him, they make sure they have good news.” He reported to a chairman who boasted publicly that he would fire any engineering team that failed to achieve an objective. The 10 December 2015 interim report confirms this by acknowledging that change was necessary. According to VW’s new CEO Matthias Müller, “the future will be about more open discussions ... and a willingness to allow mistakes if they are understood as an opportunity to learn.”

The final caveat is a chilling hint that low tolerance for failure might remain at VW, notwithstanding the trouble it’s already caused.

Use of Corrupt Software
This practice involved VW’s systematic use of software for corrupt purposes. VW wrote code that gives vehicles two operating modes, but keeps their existence secret. The software implements a “switch” that detects whether the machine is operating in test or highway conditions. If the machine is undergoing tests, the switch engages features to produce good test results. If testing isn’t detected, the switch disengages these features and boosts other elements of the machine’s performance to levels the company can tout to market the product.

The 18 September 2015 EPA NoV regarding the VW 2-liter EA189 engine describes the switch algorithm. It’s clever and sophisticated, co-opting several sensors with legitimate vehicle operation purposes.

VW manufactured and installed software in the electronic control module (ECM) of these vehicles that sensed when the vehicle was being tested for compliance with EPA emissions standards. ... [T]he EPA is calling this the “switch.” The “switch” senses whether the vehicle is being tested or not based on various inputs including the position of the steering wheel, vehicle speed, the duration of the engine’s operation, and barometric pressure. These inputs precisely track the parameters of the federal test procedure used for emission testing for EPA certification purposes. ... At all other times during normal vehicle operation, the “switch” was activated and the vehicle ECM software ran a separate “road calibration” which reduced the effectiveness of the emission control system. ... As a
result, emissions of NOx increased by a factor of 10 to 40 times above the EPA compliant levels.

How did such an algorithm come to be? Engineers would have to conceive it, verify that it would work, implement it in computer code, and then test it in simulated and real operating conditions. After all, the stakes for algorithm failure were high. An erroneous “normal driving” output when a vehicle was being tested would’ve caused failure and a certification problem. A “test” output under normal use would’ve robbed vehicle performance and economy. Engineers must have repeated design, verification, and testing for every VW model in which the defeat device needed to work: some 30 models and 11 million cars over seven years. As described by a mechanical engineer:

Computer sensors monitored the steering column. Under normal driving conditions, the column oscillates as the driver negotiates turns. But during emissions testing, the wheels of the car move, but the steering wheel doesn’t. That seems to have been the signal for the “defeat device” to turn the catalytic scrubber up to full power, allowing the car to pass the test.

Engineers would also have needed to ensure that with the switch (and emissions controls) off, the engine would achieve a desired tradeoff. For VW, the gain appears to have been “better fuel economy.”

With the switch in place, engineers determined how to make it affect emission controls. They obtained software capable of putting the system in a low emissions mode, ostensibly for developmental testing. In 2007, when Bosch—the fuel injection and emissions controls vendor who also provided the software—discovered VW’s intent to use it in production cars, it sent a letter to VW warning of its illegality. It would appear that VW engaged Bosch to provide the software, sharing enough information for Bosch to infer VW’s intentions. If so, a significant group of managers and engineers probably read the letter and ignored it.

Finally, VW’s engine controls include—as most modern automobiles do—sophisticated onboard diagnostics that continuously assess emission controls. These diagnostics are responsible for the “check emissions” warning light you might have seen in your own car. VW engineers arranged for the onboard diagnostics to allow noncompliant operation and somehow verified by testing that no warning occurred. By keeping the warning light off when the switch engaged, VW concealed the switch from customers and regulators.

Compounding the scope of VW’s misconduct is the revelation in EPA’s 2 November 2015 NoV on 3-liter engines. This NoV details a substantially different technical mechanism to achieve the same result—dialing down emissions in conditions exactly corresponding to static tests, but releasing NOx emissions up to nine times the allowed amount in normal mode operation:

When this software determines the vehicle has begun the emission test procedure, it directs the vehicle to employ a low NOx temperature conditioning mode. In this mode, the vehicle operates in such a way that the parameters yield low engine-out NOx emissions below the applicable emissions standard.

However, the software employs a “timer” that coincides with the low NOx temperature conditioning mode. At exactly one second after the completion of the initial phases of the FTP 75 Federal emissions test procedures (1,370 seconds, which is when the vehicle would normally be turned off), this software directs the vehicle to cease low NOx temperature conditioning mode. The emission control system is immediately less effective and yields higher levels of NOx from the engine. In sum, as soon as the vehicle senses it is not being tested, it uses “normal mode.”

[And] tailpipe emissions of NOx are up to 9 times the applicable NOx standard levels.

Writing software code to create a cheat disguised as a solution represents the advent of a new insider cyberthreat. Such software isn’t typical malware.

When writing software code to create a cheat disguised as a solution represents the advent of a new insider cyberthreat. Such software isn’t typical malware; it’s not causing the machine to do anything that its designers didn’t intend. What makes it unique—and a serious threat—is that it’s written to satisfy an engineering objective. Yet it subverts tests. It helps bring substandard products to market. It confers a tremendous competitive advantage as long as the company can keep it hidden. Such software is effectively a trade secret—important for its value and for the peril it poses to the company if its existence ever comes to light. We call this corrupt code. Unlike some other cyberthreats, technical means to mitigate the effects of corrupt code are unlikely to appear. The only real counter to corrupt code is engineers with the mettle to challenge its use.
The Bosch company’s role in authorship of the defeat device remains murky. We know the company furnished the control software that puts the EA189 engine in a low NOx emissions mode.8 We don’t know whether VW ordered the software specifically for the cheat or for some legitimate purpose and then diverted it to the illegitimate aim. In either case, at some point Bosch engineers perceived VW’s intent, realized its illegality, and issued an official caveat—a letter. Whether this absolves Bosch of further responsibility is an interesting question that’s being investigated. Nonetheless, with Bosch’s software, the rest of the defeat device constituted a few tens or at most hundreds of lines of specialized code to co-opt sensor inputs meant for other purposes and to cleverly combine them to produce the fateful binary bit signifying whether the car was being tested or driven by an end user. In the “haystack” of 1002 lines of code of typical vehicle control systems, 102 is indeed the proverbial needle. Corrupt code is a tough problem to solve.

Departure from Honesty

The fourth practice was the VW chain of command’s departure from honesty and reckless disregard for the consequences.

Honesty as a checkpoint for quality control of engineering and corporate decisions must operate consistently. In VW’s design process, it appears to have ceased performing that role, or performed it only selectively. There’ve been no reports of anyone in VW’s senior chain of command recognizing or protesting such practices, or considering the risks that engineers and officers were taking with the company’s hard-earned, intangible assets: its reputation and the trust customers and investors placed in it. There also seems to have been little or no recognition that the participants were committing a blunder. Instead, those involved were impelled to draw more participants into dishonest practices due to the expanding number of affected models over the seven years. They didn’t prepare one year’s application for a CoC to the EPA, but rather seven years of annual applications for each of the defeat device makes and models.

Trial lawyers often caution their witnesses that lying is a blunder, because you can never tell just one. And, the more you tell, the greater the risk you will be impeached. VW personnel seemingly discovered that each lie told required telling more to cover up what they’d done. This might help explain VW’s decision to deny for more than a year that its vehicles contained defeat devices, despite EPA and CARB claims.

Chronology 2: Aftermath and Cover Up

Our second chronology details the extent to which the fourth dysfunctional practice—the departure from honesty—went from helping engender the decision to use a defeat device to covering up the software’s existence when regulators confronted VW with test results of excessive NOx emissions in highway driving.

Disingenuous Denials

When regulators asked VW whether its vehicles contained an undisclosed defeat device, VW launched a campaign of denials. The “Disingenuous Denials to Regulators” sidebar documents this campaign.

No report to date has shown that VW considered admitting the defeat device deception until it faced unbearable commercial consequences. Only when the EPA threatened to prevent imports for model year 2016 by withholding necessary certification did VW revelations begin.

At some early point, the deception appeared to turn inward, with engineers, supervisors, and bosses deceiving themselves that—having succeeded in 2009—they could cheat again with more models in succeeding years. Perhaps hubris helped, along with another self-deception: that if the truth ever did come to light, the enterprise was too big to fail and that the top echelons of VW could manage the consequences with adroit damage control.

In fact, VW’s postdisclosure communications have continued to disappoint. The dribble of admissions, often corrected and reversed, seems disingenuous, with both content and tone reflecting the secretive, authoritarian culture that apparently made them necessary. Euphemistic word craft abounds: “irregularities” rather than failures, “chain of errors” rather than deception, and agentless passive voice as in, “This led to the incorporation of software,” so that amorphous causality seems to have controlled events rather than people. It’s hard to place credence in such conspicuous efforts at managing appearances.

Moreover, the company inexplicably took postdisclosure positions that it later had to abandon. On 2 November 2015, VW’s supervisory board stated, “Volkswagen AG wishes to emphasize that no software has been installed in the 3-liter V6 diesel power units to alter emissions characteristics in a forbidden manner.”23 Three weeks later, Audi’s CEO met with EPA officials to admit that all 3-liter diesel engines “sold from 2009 to this year—including Audi, VW and Porsche sports utility vehicles” contained auxiliary emissions control device software in violation of the US Clean Air Act (though Audi continues to deny the software is a defeat device under the EPA definition).24,25

VW’s Interim Report and Code of Conduct

VW’s dysfunctional practices pose disquieting
challenges to the engineering profession. Perhaps the greatest is still developing. In its interim report, VW appears intent on putting what the German media designated as “Dieselgate” behind it by assigning responsibility below C-level officers:9

Group Audit’s examination of the relevant processes indicates that the software-influenced NOx emissions behavior was due to interaction of three factors:

- The misconduct and shortcomings of individual employees,
- Weaknesses in some processes,
- A mindset in some areas of the Company that tolerated breaches of the rules.

The focus on “individual employees” is worrisome. There’s no assumption by top-level officers of responsibility for creating the work environment in which enormous failures occurred. Also worrisome is the chairman’s drawing a distinction between being honest and more honest: “[W]hen it comes to thresholds we need the courage to be more honest. The growing industry-wide discrepancies between official emissions data and real-life levels are no longer acceptable. We need to break new ground here.”2

VW’s interim report also suggests that VW had rules that would have been sufficient if only “some areas of the Company” hadn’t developed a “mindset that tolerated breaches of the rules.” It’s not clear which rules are being referred to, but it’s reasonable to infer that some appeared in VW’s code of conduct, available on its website since the code’s adoption in 2010.26

The aggressive company business objective is in the code’s foreword: “Our common goal is to be number one among the world’s automobile manufacturers ... based on superior quality.”26

The code reads as a book of rules in the same autocratic tone of recent announcements: “Each of our employees shall make sure that his or her demeanor in public does not damage the reputation of the Volkswagen Group. The fulfillment of his or her duties must always be directed hereto in all respects.”26

By contrast, we have seen other companies’ codes that speak in the first person, addressing all in the enterprise as “we,” evoking equal applicability to officers and employees, and putting standards of behavior in the context of some greater good.

It’s easy to conclude from the VW code that “demeanor,” “actions,” “behavior,” “reputation,” “performance,” and other outward displays are paramount, while principled judgment and honesty are secondary. The greatest sin from the code’s viewpoint is damaging the company; the second is deviating from rule-based norms. There’s little encouragement of independent, honest, and forthright thought. The code is incompatible with the new mindset that the current CEO Müller announced in his interim report:9

We don’t need yes-men, but managers and engineers who make good arguments in support of their convictions and projects, who think and act like entrepreneurs. I am calling for people ... who follow their instincts and are not merely guided by the possible consequences of impending failure. In short: the future at Volkswagen belongs to the bold. We need a little more Silicon Valley.

Noteworthy are the emphasis on entrepreneurs with no mention of engineers and the tone-deaf invocation of “a little more Silicon Valley” with no word about honest use of technology. The summons to “the bold” to repair the failures of Dieselgate is tenuous at best, especially considering that bold dishonesty was its cornerstone. A corporate culture consistent with
Disingenuous Denials to Regulators

When confronted by US Environmental Protection Agency (EPA) and California Air Resources Board (CARB) regulators about undisclosed defeat devices, Volkswagen (VW) launched a campaign of disingenuous denials that lasted more than a year. Here we present a chronicle of the company’s cover-up and eventual disclosure.

2014

Early 2014 West Virginia University’s (WVU’s) Center for Alternative Fuels, Engines, and Emissions (CAFE) completes a study on the 2012 Jetta and 2013 Passat. In lab tests, the two VW vehicles produced NOx emissions “50 and 64 percent below EPA regulations for Vehicle A (the Jetta) and Vehicle B (the Passat), respectively.” By contrast, in real-world driving, NOx emissions of Vehicle A (the Jetta) exceed EPA emissions limits “by a factor of 15 to 35” and those of Vehicle B (the Passat) exceed EPA emissions limits “by a factor of 5 to 20 times the Tier2-Bin5 standard.” In other words, emissions on the road vastly exceeded EPA limits that were inexplicably met under static test conditions.

31 March Marc Besch of the WVU test team presents the test results at the 24th Coordinating Research Council Real World Emissions Workshop in San Diego and the data is “questioned by Volkswagen.”


Mid-2014 CAFE’s findings prompt EPA and CARB to “start an investigation and discussions with Volkswagen Group of America on the reasons behind these high NOx emissions observed on their 2.0 liter diesel vehicles over real world driving conditions.”

May–December VW asserts to CARB and the EPA that “the increased emissions from these vehicles could be attributed to various technical issues and unexpected in-use conditions.” As recollected by CARB communications director Stanley Young at meetings between CARB officials and VW engineers from VW “tried to ‘discredit the findings’ [by WVU] by challenging the data and methodology of the study. . . . [VW’s engineers] were recalcitrant. . . . It was a range of issues, every time it was something different.” VW said that “our calibration was off” and that the discrepancies had to do with “the conditions under which the test was done.”

18 September EPA and CARB inform VW that they believe its vehicles far exceed emissions limits and have used a defeat device to circumvent the emissions tests.

VW’s code would probably not prevent dysfunctional practices. The code doesn’t demand that engineers and officers honor a guiding set of ethical principles. Rather, it declares that their duty is to perform as directed by their superiors, who are, in turn, responsible for subordinates’ performance: “Every superior has responsibility for his or her employees. Every superior sets an example and must act in strict accordance with the Code of Conduct.”

A requirement to “act in strict accordance” with a code that provides no restriction on means is an invitation to make poor decisions, which is amplified by
19 August According to reports based on Lower Saxony State Chancellery records, in discussions with the CARB, VW makes “partial confessions” of irregularities in the programming of engine controls in VW vehicles.14  
August–September CARB and EPA make clear to VW they won’t approve the Certificates of Conformity (CoCs) for VW’s 2016 models (and thus will bar their importation to the US) until VW adequately explains the “anomalous emissions and assures the agencies that the 2016 model year vehicles would not have similar issues.”15  
21 August At a conference on transportation and energy in Pacific Grove, California, VW representatives disclose to Chris Grundler, director of the EPA Office of Transportation and Air Quality, that VW “hacked its own cars to deceive US regulators about how much their diesel engines pollute.”7 At the same meeting, VW also told CARB officials of the deception.  
August–2 September VW CEO Martin Winterkorn negotiates an extension of his contract with VW through 2018. The Executive Committee of VW’s Supervisory Board agrees to submit a resolution at its 25 September 2015 meeting for a new contract as “Chairman of the Board of Management” [CEO] of VW through 31 December 2018.15  
3 September During a meeting or conference call, VW America and VW executives in Germany admit to EPA and CARB that its Gen1, Gen2, and Gen3 diesel vehicles were “designed and manufactured with a defeat device.”5,10  
VW executives reportedly "went over written details provided to the participants explaining how software used in its diesel cars was able to manipulate emissions tests in the United States” — thus ending 15 months of denials by VW.7  
August–September Winterkorn receives word that VW America has admitted using defeat device, but decides to postpone disclosing that to VW's Supervisory Board. In ensuing weeks, he concludes negotiation with the Board regarding his new employment contract.  
18 September EPA issues a notice of violation (NoV) of the Clean Air Act (CAA) to Volkswagen AG, Audi AG, and VW Group of America, alleging that vehicles from model years 2009 to 2015 contain “defeat devices” that “bypass, defeat, or render inoperable elements of the vehicles’ emission control system that exist to comply with CAA emission standards,” that VW failed as required to disclose these devices on its CoC applications, and imported and sold vehicles whose “emissions of NOx increased by a factor of 10 to 40 times above the EPA compliant levels.”16  
18 September CARB determines that VW’s earlier recall “did not address the high on-road NOx emissions and also resulted in the vehicle failing certification standards.” In its notice to VW, CARB deems the recall “ineffective” and “unapproved.”16  
20 September Winterkorn makes a statement regarding “manipulations that violate American environmental standards” and adds “we do not and will not tolerate violations of any kind of our internal rules or of the law.”17  
22 September VW issues press release stating, “VW is working at full speed to clarify irregularities concerning a particular software used in diesel engines. … The software in question does not affect handling, consumption or emissions. This gives clarity to customers and dealers. … [T]he relevant engine management software is also installed in other Volkswagen Group vehicles with diesel engines. For the majority of these engines the software does not have any effect. Discrepancies relate to vehicles with Type EA189 engines, involving some eleven million vehicles worldwide.”18

Media report VW’s use of “defeat device,” saying Winterkorn intends to stay on and see VW through the crisis.19  
23 September Winterkorn resigns, stating, “Above all, I am stunned that misconduct on such a scale was possible in the Volkswagen Group … I am doing this in the interests of the company even though I am not aware of any wrong doing on my part.”20  
14 October VW reportedly scraps its “existing emissions technology in its diesel engines in favor of more expensive AdBlue … technology to reduce” NOx emissions—thereby reverting to the technology it had originally licensed to use. “The switch to AdBlue … is a major change for Volkswagen and would appear to be an acknowledgment that its existing so-called lean nitrogen trap technology can’t meet strict US restrictions on tailpipe emissions.”21  
16 October KBA (German Federal Motor Transport Authority) orders VW to recall 2.4 million vehicles and contends in a press release that VW used impermissible software and must remove it.22  
VW America CEO Michael Horn testifies before Congress, stating “it wasn’t a corporate decision to cheat. It was a couple of software engineers.” And that “he first learned of the existence of the defeat devices ‘a couple of days before’ the 3 September meeting” as “anomalous emissions and assures the agencies that the 2016 model year vehicles would not have similar issues.”15  
26 October The internal investigation of VW reportedly widens, “focusing not only on who was responsible for installing illegal software … but also on which managers may have learned of the deception and failed to take appropriate action.”24 VW suspends “anyone who could have been involved in the scam—from high-level decision makers to supervisory managers, down to the employees who were actually involved.”26

Continued on page 26

By providing regular information and instruction about the relevant responsibilities and powers for each work area, supervisors promote behavior by their employees that conforms to the Code of Conduct. The superior places trust in his employees, agrees on ambitious and realistic goals. … Superiors particularly honor top achievements.

Urging superiors to “honor top achievements” is appropriate in a performance/reward system, not a
makers to ordinary engineers” ranging from “board-level executives at some Volkswagen units to low-level technicians.”

2 November VW discloses it had “understated emissions” of NOx by its “Cayenne sport utility vehicle.”

EPA issues a second NoV of the Clean Air Act to VW AG, Audi AG, VW Group of America, Porsche AG, and Porsche Cars North America, alleging VW “developed and installed a defeat device in certain VW, Audi and Porsche ... diesel vehicles equipped with 3.0 liter engines for model years ... 2014 through 2016 that increases emissions of ... NOx ... up to nine times EPA’s standard”—the NoV “covers approximately 10,000 ... cars already sold in the United States since May 2014” and an “unknown volume of 2016 vehicles.”

VW’s Supervisory Board issues a press release to “emphasize that no software has been installed in the 3-liter V6 diesel power units to alter emissions characteristics in a forbidden manner.”

3 November VW discloses “irregularities” in CO2 emissions, that is, it understated CO2 emissions on “800,000 VW vehicles” and estimated the initial economic risk at “two billion euros.”

20 November CARB Chair Mary Nichols confirms that VW has “conceded” it deceptively manipulated emissions on its Porsche models (reversing its earlier denial) —the company whose CEO, Matthias Müller, was selected to be the new CEO for VW.

23 November VW’s Audi CEO admits to the EPA that the illegal software was installed in the larger diesel engines.

1 December Germany’s KBA discloses in an email that software VW installed in the EA189 engine “is an illegal defeat device according to the KBA’s legal interpretation.”

10 December VW issues an interim report providing “initial results” of its internal investigations on the “origin and development” of the NOX issue: “It proves not to have been a one-time error, but rather a chain of errors that were allowed to happen. ...Initially, it proved impossible to have the EA189 engine meet by legal means the stricter nitrogen oxide requirements in the United States within the required timeframe and budget. This led to the incorporation of software that adjusted nitrogen oxide emission levels according to whether vehicles were on the road or being tested.”

References

Each of our employees is obligated to maintain secrecy regarding the business or trade secrets within which they are entrusted within the scope of the performance of their duties. ... Silence must be maintained regarding work and matters within the Company that

code. It cements the impression of a strict corporate autocracy.

Although a top-down directive structure ensured unquestioning development of the defeat device, only strict secrecy could have sustained it for seven years. Here again, VW’s code is consistent with VW’s behavior. In the section on treatment of information lies a subsection entitled “Secrecy.” It demands that personnel
are significant to the Volkswagen Group or its business partners and have not been made known publicly, such as, for example, product developments, plans, and testing.

The defeat device was certainly a product development. Consequently, the code requires employees to treat it as a trade secret. Because VW adopted the code in 2010, for the five subsequent years, the code had its intended effect. VW employees fulfilled their duty of secrecy, conferring a tremendous competitive advantage on the company. Only when outside discovery rendered secrecy moot did VW face the folly of a code that insisted on secrecy at all costs.

As a window into VW’s culture, it will be worthwhile to watch for changes in the code of conduct. Indeed,
drastic change is needed to effect the new mindset demanded by CEO Müller and to promote to senior positions persons who might have foreseen and avoided the current trouble: persons of mettle. A barometer of VW’s ability to heal itself will be the degree to which a new code adopts a changed tone and priority scheme.

The Aftermath of Disclosure
If the code of conduct is a harbinger of problems in VW’s corporate culture, then VW’s postdisclosure statements have only reinforced this impression. Denials of EPA and CARB findings, reversals only when forced, perfunctory apologies, and a dearth of meaningful explanations have encouraged opinions worldwide that the company has much to hide.

An additional indicator appeared in The Wall Street Journal as we were completing work on this article. Although VW’s interim report dates Dieselgate’s beginnings to 2005, its willingness to skirt emissions law was evident a year earlier. In 2004, a US VW employee informed superiors in Germany that the number of Audis returned for repair of broken emissions sensors had triggered a “legal requirement to include the part in mandatory reports to regulators.” The employee dutifully listed the faulty part—an exhaust-gas temperature sensor (EGT)—in a draft report to California regulators. According to the newspaper: “[A]n Audi official in Germany called for a revision. ‘Delete the EGT.’”

Two days later, the employee’s supervisor obediently reported: “Der EGT ist raus”—“the EGT is out.” Indeed, it didn’t appear in VW’s report to California regulators.

VW’s strategies with regulators have backfired. On 4 January 2016, the US Department of Justice filed a civil complaint covering VW’s use of defeat devices in 580,000 vehicles, its tampering with emissions controls, and its nondisclosure of defeat devices in more than 70 CoC applications. The upshot: VW must negotiate a settlement under threat of tens of billions in fines. The current trouble: persons of mettle. A barometer of VW’s ability to heal itself will be the degree to which a new code adopts a changed tone and priority scheme.

Ethics and Mettle Fatigue
Good engineering design avoids “single points of failure”—any single component whose failure would bring down the entire system. By analogy, VW’s climate of results at any cost and lack of checks on dishonest behavior set the stage for a complete organizational breakdown. The strict secrecy that VW’s personnel maintained for seven years about the defeat device implies a uniform acceptance of dishonest practices, which is further evidenced by the absence of publicly stated questions, reservations, misgivings, and refusals by employees to participate in the defeat device work. Ethics were VW’s single point of failure.

For people who work in situations in which no one questions ethically dubious activities, including outright subterfuge like the defeat device, there can be a corrosion of character. Long exposure can only worsen the effect, preventing those who succumb from recognizing reality, accepting facts, and responding with integrity. We refer to this as “mettle fatigue.”

When decent engineers join their colleagues and senior officers as corrupters of software in company products, there’s something wrong with the company itself. Whether the corrupters work across the enterprise or in a tight-knit engineering group, it’s unlikely that they were inherently evil. Rather, the company’s culture probably forced them to make a no-win choice: leave the company with mettle intact or stay and embrace dishonest work, consistent with the cultural norm.

Those who stayed at VW, conforming with the enterprise’s value system and pursuing its aggressive growth strategy, in fact ensured its fall. Their work producing corrupt software constituted an insider threat, regardless of their intent. The software they wrote put people at risk in a manner so stealthy that it was discovered only after seven years and nearly by accident during an emissions test study by engineering researchers at West Virginia University. That discovery led to losses: billions of euros, probably thousands of jobs, and the pride of a national industry. The probable explanation for their actions? Mettle fatigue.

Trust: Another Casualty
The scope of trust broken by VW’s corrupt software is hard to comprehend. It allowed the company to misrepresent the environmental impact of 11 million cars. It betrayed buyers who believed they were doing something positive with their purchase, but now know the reverse. Those buyers face burdens in VW’s recalls and uncertainty as to what performance or economy their cars will retain in the aftermath, not to mention resale value.

More abstractly, we live in a time when people routinely put trust in machines and the people who create them. Software involves perhaps the greatest trust of all. It’s the most malleable, most complex, and least visible of engineering artifacts. Future developments like the Internet of Things and robotics can only magnify this trend. Consider the trust implicit in riding a self-driving car or in a walking robot carrying a person with a disability. In this context, the VW story is a cautionary tale. The potential for current and future technologies to improve mankind’s lot hinges on a trust the VW affair has broken at a fundamental level. The mechanism of that break—corrupt software written by insiders—is a
true cyberthreat that behooves all engineers, not just VW’s, to address.

Codes of the Profession
If the VW code is a window into its culture, so are the codes of the engineering profession. What does IEEE’s code of ethics say about engineering professionals? More saliently, does it say enough for those who find themselves in an adverse culture, perceiving an expectation—explicit or implicit—to do wrong? IEEE’s code provides some of what’s needed. It commits an engineer to “accept responsibility in making decisions consistent with the safety … of the public” and “to disclose promptly factors that might endanger the public.” VW might quibble—and its spokesmen have—that their vehicles are safe to drive. Of course, this ignores the high risk to respiratory health that NOx emission standards are meant to curb. The crux is that the words of the IEEE code assume that full knowledge of the end use of the engineer’s work is in hand, when gaining that knowledge might be the most difficult task of all. Missing in the IEEE code is follow-through: a call for engineers to understand and consider the broader effect of their work when making decisions and disclosing dangers.

IEEE’s code of ethics also commits engineers “to be honest … in stating claims.” That’s important but, again, lacking follow-through. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who met with the EPA and CARB probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors. The VW engineers who developed, tested, and installed defeat devices were probably not called upon to be dishonest in their statements. They probably reported honestly to their superiors.

Perhaps the best outcome of VW’s plight would be for mettle fatigue to be taken seriously as a danger to both engineers and the organizations that employ them. Continuous vigilance and education to ward off its pernicious effects, avoiding VW-like crises in the future, are cheap insurance in a world in which trust in engineers and their work is becoming ever more fundamental.

References

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