Resolving VW's Ethical Challenges with Software Cheating Emissions Testing

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I am a computer science major at Cal State University Monterey Bay writing for CST 373: Ethics in Communication and Technology. As a soon-to-be computer science graduate, I'll be responsible for implementing the software that runs our modern world. Make no mistake, the cost of computer chip fabrication continues to drop and as a result programmable chips are appearing in greater quantities in more and more products. Soon even clothing may be programmable, but today many common products already rely heavily on software to function.

Perhaps no other common consumer item relies on software as much as today's automobiles. Charette reported in 2009 that, "Even low-end cars now have 30 to 50 [microprocessor-based electronic control units] embedded in the body, doors, dash, roof, trunk, seats…". Now software may even replace the driver, as autonomous, self-driving vehicles are being rolled out into service in major cities like London (Titcomb, 2017).

There can be no doubt, then, that ethics in software engineering is now a social and policy issue that impacts almost everyone living in a developed nation. It's imperative, therefore, that we understand not only the consequences of unethical software development, but the why and the how, as well. To that end I present herein a comprehensive look at a recent scandal in the automotive industry centered around unethical software design.

In 2014 it came to light that German auto manufacturer Volkswagen had been selling diesel engine cars that emitted air pollutants in excess of the limits established in United States law. Upon further investigation it was discovered in September of 2015 that Volkswagen had not only done this knowingly, but was in fact using a piece of software referred to as a "defeat device" to cheat emissions tests. Hotten (2015) reports for the BBC that actual emissions were 40 times the legal limit.

In the following pages I detail the history of this scandal and the laws and regulations that were violated in greater detail. I investigate the ethical implications of Volkswagen's deception from a global perspective using the opinions of the media as a window into the modern *zeitgeist,* from a community perspective where I examine the individual communities of country, customer and corporation, and finally from an individual perspective as I hypothesize employee reactions to the software at the heart of the scandal from the viewpoint of three distinct ethical frameworks. I conclude with a brief survey of the current state of clean energy vehicles and offer my thoughts on the future of the industry.

The specific law broken by Volkswagen is titled the Clean Air Act, or CAA. The CAA originated in U.S. Congress in 1970, with refinements made in 1977 and 1990, with the goal of reducing air pollution throughout the U.S. by requiring the, "EPA [Environmental Protection Agency] to establish national ambient air quality standards for certain common and widespread pollutants based on the latest science." ("Clean Air Act Requirements and History", Control of common pollutants section, para. 1, n.d.). The EPA has authored national regulations for six "criteria pollutants": common air pollutants with particularly hazardous health and environmental consequences ("Criteria Air Pollutants", n.d.), including the Nitrogen Oxide (NO) and Nitrogen Dioxide (NO2) – collectively referred to as NOx – emitted by motor vehicles.

Although the EPA sets the regulations for air quality, the CAA requires individual states to, "adopt enforceable plans to achieve and maintain air quality" ("Clean Air Act Requirements and History", Control of common pollutants section, para. 2, n.d.). To this end, the state of California enlisted the efforts of the California Air Resources Board, or CARB – an organization founded in 1967 by then-Governor Ronal Reagan ("CARB History", n.d.) – to develop and enforce, "…a list of emission-related regulations, test procedures, Manufacturers Advisory

Correspondences (MACs), and related documents applicable to on-road vehicles, including passenger cars, light-duty trucks, and medium-duty vehicles…" ("On-Road Light-Duty Emissions Certification Requirements", para. 1, n.d.). It was precisely one of these test procedures that generated the passing results that would later raise serious concerns when compared to the findings of a small research team from West Virginia.

Bigelow (2015) reporting for Auto Blog describes how in 2014 research led by professors Thompson and Carder of West Virginia revealed discrepancies between Volkswagen's test results and the real-world performance of their vehicles. Thompson et al. drove a Volkswagen Passat from Los Angeles to Seattle and back, only to discover that, "the car, which had been certified at a California Air Resources Board facility prior to the start of the road trip, had elevated levels of NOx that were 20 times the baseline levels established beforehand." (Bigelow, para. 3, 2015). When this data was brought to the attention of CARB a deeper investigation into Volkswagen's diesel vehicles was opened.

The result of the investigation is best summarized by the EPA, which itself ultimately came to be involved in the investigation, when it reports that in 2016, "…the United States filed a complaint against the Volkswagen entities alleging violations of the CAA with regard to approximately 590,000 diesel vehicles sold in the U.S." ("Volkswagen Clean Air Act Civil Settlement", Clean Air Act Certification Requirements and Violations section, para. 2, n.d.). Although this formal complaint was filed in 2016, it would later be revealed that Volkswagen had been shirking EPA regulations by cheating CARB and similar emissions tests since 2007.

In 2017, as reported for the BBC by Leggett (2017), Volkswagen pleaded guilty to criminal charged and hired law firm Jones Day to investigate the corporation. The results of the investigation were used in the creation of a "Statement of Facts" submitted as part of

Volkswagen's plea bargain. Leggett (2017) summarizes part of this document when he describes how, in 2006:

> Supervisors in the engine department [of Volkswagen] realised they had a problem. They could not design an engine that would meet tough emissions standards due to enter into force in 2007, and at the same time give customers the performance that they wanted.

The solution Volkswagen's supervisors devised was to order the creation of a "defeat device" that would cheat the new emissions tests.

The defeat device created by Volkswagen was a piece of software embedded into their diesel vehicles. The software was written to surreptitiously improve the performance of the vehicle's nitrogen oxide trap when it detected a test was being performed on the vehicle. Once the vehicle was returned to the road, however, the nitrogen oxide trap was recalibrated, "increasing emissions far above legal limits, most likely to save fuel or to improve the car's torque and acceleration." (Gates, Ewing, Russel and Watkins 2017).

This defeat device technology was used in Volkswagen's diesel vehicles until 2014, when the data produced by Thompson et al. prompted CARB to begin questioning Volkswagen about their diesel vehicles. Rather than cooperate with authorities and reveal the existence of the defeat device, however, the Statement of Facts submitted by Volkswagen in 2017 shows, as Leggett (2017) further reports, that:

> Engineers were told to "check their documents", which several of those present "understood to mean that they should delete their documents".
>
> The message was repeated at a number of subsequent meetings, one of them attended by 30-40 people and ultimately thousands of documents were deleted.

It would ultimately take a whistleblower from within Volkswagen to reveal the existence of the defeat device to authorities.

The ultimate consequences of Volkswagen's behavior would prove severe. In 2016 Volkswagen was required to spend $10 billion to buy back the illegal vehicles from customers and another $4.7 billion to invest in zero-emission technology (EPA, 2016). In 2017 the Department of Justice charged Volkswagen a $2.8 billion criminal fine and a $1.5 billion, "settlement of civil, environmental, customs and financial violations" (DOJ, 2017). Volkswagen continues to suffer damage to their brand and corporation as the result of continued global media reporting on the scandal, legal action taken against them by communities outside the U.S., and class action suits comprised of U.S. citizens.

Even before it came to light that Volkswagen was actively cheating emissions tests media coverage of the story was profuse. Once the depth of Volkswagen's unethical and illegal behavior was revealed the stories only became more ubiquitous and the opinion pieces more bold. These reactions of the press to the unfolding Volkswagen scandal became a microcosm of the modern, global world's ethical and political convictions on the issue. To understand why, it is necessary to first understand two influential modern philosophies – Kantianism and Marxism-Leninism – and the relationship between the ideas contained in each and the press. It is to these philosophies, the press and the global reaction to Volkswagen revealed by their union that I now turn.

Kant, an 18th-century German philosopher, proposed the concept of the categorical imperative, a sort of moral axiom that can be applied universally. Kant reasoned that there was ultimately only one categorical imperative, and he stated it perhaps most famously as, "Act only

according to that maxim by which you can at the same time will that it should become a universal law" (Categorical Imperative, 1998).

Marx was a German economist, historian and philosopher who lived and wrote during the 19th-century. Marx is perhaps most famous for his prediction that unchecked capitalism and industrialization would lead to a global revolution amongst the working class. When this revolution failed to materialize, the Russian communist leader Vladimir Lenin proposed "a 'vanguard party' of the proletariat, comprised primarily of intellectuals rather than the workers, needed to foster the necessary revolutionary consciousness" (Marxism-Leninsim, 2014).

Journalists, knowingly or not, interpret the categorical imperative for their age in the context of current events through their reporting. In this way a journalist acts, in some proportion, as a voice in the conscience of the global community. By choosing what to report on, and how to report it, a journalist both reflects the ethical convictions – the set of maxims which society has deemed satisfy Kant's categorical imperative – of the times and directs the discussion of those maxims, often towards their own areas of conviction.

Lenin despised a free press, believing it to be a bourgeois institution. Yet, his idea of an intellectual vanguard that seeks to stir a desire for political change in the common man would become a key stratagem of the Soviet Union during its cold war with the west. Inevitably, propaganda, information control and appeals to intellectual authority were being used by governments and the press on both sides of the cold war. Understanding this legacy is key to understanding today's journalism.

We see many examples of Kantianism's influence on journalism in the opinion pieces written about the Volkswagen scandal. Some are fairly benign, such as Spicer's "How could

VW be so stupid?" (2015) which explores the titular question in the context of modern corporate structures and the ethical dilemmas faced by middle managers tasked with achieving impossible goals. Others are more scathing and direct in their critique, like the evocatively titled "Make an example out of Volkswagen" wherein authors Becker and Gerstenzang (2016) prescribe, like Medieval priests, a set of legal punishments Volkswagen must endure to pay penance for their crimes against humanity and the environment. Despite their difference in tone, both articles are preoccupied with the moral consequences of Volkswagen's behavior rather than the legal facts or economic fallout of the situation.

We see shades of Lenin's vanguardism in two more opinion pieces on opposite ends of the political spectrum. Ewing's 2017 article "Inside VW's Campaign of Trickery" posits that Volkswagen's greater crime is not cheating the emissions tests, but attempting to hide that fact when first caught. The history of the Volkswagen scandal is retold in narrative form, with Volkswagen's executives cast as slippery villains trying to pull the wool over the eyes of the proletariat. The right-leaning Heath (2015) argues in "The Volkswagen scandal reveals the corruption of the Left's regulation dreamworld" that Volkswagen's behavior is not a result of capitalist free markets, but of the overbearing European Union's naïve push for clean diesel coupled with unreasonable and burdensome government emission regulations.

Whether circling the wagons to defend an ideology as members of an unspoken political vanguard, or calling attention to the moral failings of our time as modern-day prophets, the press reflects the global conscience towards Volkswagen. But how have national and regional communities reacted to the corporation's unethical practices? Turning away from the global, let us consider now these three key communities: countries, customers and the corporation itself.

Although Volkswagen's troubles began when they violated a U.S. law – the previously discussed Clean Air Act – the revelation of their defeat device aroused the legal bodies of many other countries against them. Predictably, the primary concern at the level of the national community is the enforcement of laws. Some countries, however, are also ruling against Volkswagen on ethical grounds, such as in Brazil where Autos Esporte (2017) reports that the court of Rio de Janeiro has fined Volkswagen one-billion Brazillian real in part for "indemnification to Brazilian society". Hong Kong ("VW Caddy model banned", 2015) and Switzerland (Ruddick, 2015) have gone so far as to outright ban Volkswagen diesel vehicles. Many other countries where Volkswagen does business have ongoing investigations into the company for both legal and ethical reasons.

Governments aren't the only groups pursuing legal action against Volkswagen. Despite some of them being offered trade-ins and cash bonuses for their diesel vehicles (Bartlett, 2017) many customers – and ex-customers – of the corporation are banding together in lawsuits. Class action suits against Volkswagen have been filed in the United States (Martin, 2015), Canada (CBC, 2015), the United Kingdom (Massey, 2017) and the Netherlands (Dutch News, 2016). In addition to the money lost in these suits – in legal fees at minimum, if not in court-awarded payments – Volkswagen will have to contend with the monumental loss of consumer trust in their brand (Abuelsamid, 2015).

No doubt the most directly impacted community is the Volkswagen corporation itself. In the wake of the scandal's outbreak in 2015 then CEO Martin Winterkorn resigned with the statement, as reported by Markortoff (2015), "Above all, I am stunned that misconduct on such a scale was possible in the Volkswagen Group". Alongside the $4.3 billion fine levied against the company in 2017, "prosecutors […] charged six current and former senior VW executives for

their roles in the scheme" (Reuters, 2017). Tragically, an additional 30,000 Volkswagen employees were laid off to, "cut costs as it tries to recover from its diesel emissions scandal" (McHugh, 2016). Amid these personnel losses, Volkswagen has been trying to restructure its organization to be more transparent and ethically accountable, but this is proving a difficult task. Cremer (2017) writes that new Volkswagen CEO Mattias Mueller laments, "There are definitely people who are longing for the old centralistic leadership." No doubt the corporate community of Volkswagen will struggle for many more years as it tries to reinvent itself internally.

Bill Chappell of National Public Radio reported in 2015 that Michael Horn, U.S. CEO of Volkswagen, stated under oath that the defeat device was the work of, "a couple of software engineers". It was, of course, revealed two years later in the aforementioned Statement of Fact submitted alongside Volkswagen's plea bargain that creation of the device had been ordered by supervisors within the company's engine development group and that knowledge of the device existed high within the company's management.

Yet, it would be disingenuous to suggest that the entirety of the blame for "dieselgate", as its come to be called, rests with Volkswagen's management. Even if the request to create the defeat device came from high within the company, individual software engineers were responsible for implementing it. The Statement of Fact suggests that these engineers were aware of what they were implementing, and that many even protested its development (Leggett, Defeat device section, para. 5, 2017), yet developed it was.

While the precise reactions of these particular Volkswagen employees may never be fully known, it is an interesting thought experiment to consider how oneself, or some hypothetical employee, would react in such a situation. It is in this spirt that I wish to consider the ethic of the

individual in this scandal through the lens of three distinct philosophies: Divine Command, Marxist and Objectivist.

Divine Command theory holds that, "moral obligation consists in obedience to God's commands" (Divine Command Theory, n.d.). Although the exact commands will vary with the religious beliefs of the divine command theorist there is implied a moral absolutism that does not change with situation or personal motivation (not unlike Kant's categorical imperative). As pertains to Volkswagen's defeat device, consider that most major religions of the world advocate against lying, such as the decree "you shall not bear false witness against your neighbor" in the Judeo-Christian tradition (Exodus 20:16, ESV). For a software engineer convicted as such, the order to develop a program that effectively lies during emissions testing would be in stark contrast to their ethical obligations.

How does this developer react? The specific answer lies with the religious beliefs his or her theory of Divine Command is predicated upon, but assuming their ethical convictions not to lie outweigh their ethical convictions to remain employed, he or she objects. If this objection is met with resistance, he or she appeals to a higher authority – perhaps their manager's manager or even a government agency. The belief in morally absolute divine commands leaves little wiggle room to justify unethical behavior.

Marxism was discussed earlier in the context of proletariat revolution. Much of Karl Marx's writing, however, was focused on a theory he derived from the earlier work of Georg Wilhelm Friedrich Hegel known as Historical Materialism. Hegel proposed that throughout history contrasting ideas have clashed with one another and given rise, through a process called synthesis, to a new, unique idea. Marx extended this theory to the material world, believing that throughout history various social classes have clashed and, through a similar synthesis, created

new social structures (Dialectical Materialism, n.d.). For the Marxist, the present social clash is that between the class that provides labor and the class that provides capital. It's crucial to understand that a genuine Marxist (one who provides labor) working for an organization like Volkswagen, as such views their employers (those who provide capital) with no small amount of suspicion and perhaps even contempt.

It is reasonable to assume, then, that when presented with orders to develop a program that deceives the population the genuine Marxist balks. He or she cannot side with the providers of capital *against* the providers of labor, that is consumers. Likely the Marxist would, like the Divine Command theorist, take their objection to an authority. However, while the Divine Command theorist will likely first approach authorities within the local community of the corporation, turning only to the outside if necessary, the Marxist is far more likely to go straight to "the people" – in other words, the vanguard. The Marxist will only trust an authority with the ability to act as the conscience of the global community, preferably one with the ability to prescribe punishment: the press. The Marxist will whistle blow.

Objectivism is the name given to the 20th-century philosophy devised by "Russian-born American writer Ayn Rand and popularized mainly through her commercially successful novels The Fountainhead (1943) and Atlas Shrugged (1957)" (Duignan, n.d.). Rand argued for a form of ethical egoism that states man's greatest moral obligation is to his self-interest, wherein self-interest is defined not as self-gratification but as self-improvement and, by extension, the improvement of life for others. The philosophy is called objectivism because it views things objectively, just as they are. The heroine of Atlas Shrugged, Dagny Taggart, is an objectivist industrialist who isn't satisfied manufacturing steel train tracks that only meet government

regulations – the tracks should surpass the regulations, surpassing her competitor's tracks in the process.

The relative modernity of Rand's ideas, and the modern, industrial setting of Rand's stories, makes it easy to imagine how an objectivist developer might react to a request to write a defeat device. Primarily, the objectivist must be *objective*, and take the diesel engine as it is. If the engine can't pass emissions tests, it can't pass emissions tests. If asked to resolve this problem *not* by building a better engine, but instead by cheating the emissions test, an objectivist developer would refuse on principle, and possibly even leave the company altogether. Just as Dagny sought to improve herself by building the better train track, the objectivist developer seeks to improve him or her self by writing the better software. Unlike the Divine Command theorist or the Marxist, though, the objectivist likely sees no reason to whistle blow – they're responsible for their own actions, not their manager's.

It is interesting to note that all three philosophical frameworks, despite their vast differences from one another, in their purest incarnations require refusing to cooperate in the creation of an unethical defeat device. This should not reflect poorly on those Volkswagen engineers that did choose to cooperate in developing the device, however. There are both many other ethical frameworks that might legitimize such behavior and real-world pressures that might convince an adherent to one of these frameworks to compromise their values in this situation. It would be unduly self-righteous of us to play the role of an "armchair ethicist" and suppose our own behavior in the same scenario would be pure.

I have discussed at length the history of the Volkswagen scandal and explored its immediate aftermath globally, from the perspectives of multiple communities and individually through multiple ethical frameworks. Although Volkswagen's defeat device is the most

infamous emissions test fabrication in recent memory the auto manufacturer is not alone in producing cars that emit fewer pollutants in test conditions than on real world highways. As Carrington (2015) reports, "[n]ew diesel cars from Renault, Nissan, Hyundai, Citroen, Fiat, Volvo and other manufacturers," are polluting up to ten times more on highways than in labs. Volkswagen may be the most serious offender, but it's clear their scandal is not an isolated incident. Given this, I'd like to discuss the future of diesel and other clean energy vehicles.

As Sapienza (2017) reports, diesel engines are almost as old as the internal combustion engine itself, originating in the late 19th-century, but only began gaining popularity in consumer vehicles during the 1990s and early 2000s. Diesel fuel is less refined than standard automotive gasoline, making it cheaper but also more pollutant. Mercedes-Benz has introduced "BlueTEC", a suite of technologies that break down diesel emissions into less polluting substances, onto many of its recent vehicles ("BlueTEC Clean Diesel", How BlueTEC works section, n.d.) but it remains to be seen if this distinction is enough to save the diesel brand among consumers wary after Volkswagen's fraudulent use of the technology.

Salvaging consumer trust in diesel engines will be particularly difficult in North America, where diesel never quite gained as much recognition as a clean energy source as electricity. Current consumer demand for clean energy-powered vehicles is centered around hybrid and electric cars. Hybrid cars use a combination of traditional automotive gasoline and electricity to achieve often astounding gas mileage, such as the impressive 50 miles per gallon the U.S. Department of Energy reports for the Toyota Prius ("2013 Toyota Prius C", n.d.). Electric cars, as popularized by auto manufacturer Tesla, do away with an internal combustion engine altogether and rely purely on incredibly dense – and thus incredibly heavy - lithium-ion batteries (Rachel, 2016).

Although the Tesla and similar electric cars produce zero emissions when on the road there are still concerns surrounding their viability as clean energy vehicles. A recent study published in the journal Ingeniøren is summarized as per Autovista Group (2017) as, "[calculating] that a fossil fuel vehicle can currently drive for more than eight years before it reaches the same environmental impact of a Tesla." This impact is a result of the extraction processes of lithium used in the Tesla's battery and the manufacturing processes of the battery itself. Additional environmental impact is incurred by the generation of the electricity stored in these batteries, with less than 15% of electricity in the U.S. generated from renewable sources (U.S. Energy Information Administration, 2017).

A promising alternative to battery-powered electric vehicles like the Tesla is fuel cell technology. Fuel cell vehicles are still powered by electricity, but rather than relying upon a difficult-to-manufacture lithium-ion battery they use a fuel cell stack to convert hydrogen and oxygen into electricity, emitting no pollutants in the process ("Fuel Cell Vehicles", n.d.) which will come as no surprise to those who recall that hydrogen and oxygen bond to form water molecules. Although the fuel cell stack is still expensive to manufacture and hydrogen difficult to deliver to customers the technology is already being applied in consumer vehicles like Honda's Clarity sedan that's rated at a staggering 68 miles per gallon ("Clarity Fuel Cell", Frequently Asked Questions section, n.d.).

Despite the Volkswagen scandal, then, I believe we have good reason to be optimistic when considering the future of clean energy vehicles. No doubt manufacturing processes for lithium-ion batteries and fuel cell stacks will improve in the coming years, making these alternative technologies more environmentally friendly, more efficient and – perhaps most importantly – more affordable.

It is important, however, that governments understand the current limitations of these technologies and resist the urge to regulate them too severely or too quickly. The promise of cleaner cars led to the strict regulations in the U.S. that Volkswagen was unable to meet, spurring their initial conception of a defeat device. To be sure, strict – even overly strict – regulations are no excuse for Volkswagen's deception, but as we've seen most other auto manufacturers aren't meeting the regulations either. To wit, the regulations in the European Union are *less* stringent than their U.S. counterparts. Perhaps U.S. lawmakers have become overzealous in their regulation of air quality, demanding the impossible and then acting surprised to discover auto manufacturers have no choice but to fudge test results, if not cheat outright.

I can think of no worse fate for future technologies like lithium-ion batteries and fuel cell stacks than to be overregulated to the point where auto manufacturers no longer see the benefit in pursuing them honestly and ethically. If, however, the public as well as lawmakers can maintain realistic expectations I believe these technologies, particularly the fuel cell stack, have the potential to revolutionize not only the auto industry but the way we generate and consume energy everywhere. Just as the combustion engine itself wasn't birthed from the human mind in its current form, though, electric and fuel cell technology will need time to develop from their nascent state into maturity. If we can be patient and optimistic then I believe a bright future awaits us.

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