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COEN288: Software Ethics
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3/9/16
Word Count: 2031 words, 2143 overall

Automotive engineering encompasses a multitude of engineering disciplines such as electrical, mechanical & structural, embedded software, and systems design engineering. As consumers, our orthodox concerns when choosing a car resides with the overall safety, budget, space requirements, customer-service reputation, and decent gas mileage. For car manufacturers and companies, their concerns relies specifically making a profit from the sales of vehicles with the acceptable balance of development time invested, production budget, and overall reasonable build quality. The environmental factor had been an overlooked, downplayed characteristic for both consumer and companies' decisions until the beginnings of the 21st century. With the oil crisis, the progressive climate change movement, and global warming attribution to gas emissions, sustainable energy and energy efficient vehicles resurfaced through the promotion of hybrids (Toyota Prius) and electric vehicles (Tesla Motors). Despite such growth, gas guzzling vehicles still remain indispensible to modern society. In the saturated competition for motor vehicles, Volkswagen attempted a major thrust to sell diesel cars in the U.S. In relevance to computer/software ethics, this paper investigates and evaluates the ethical considerations surrounding the Volkswagen gas emissions' scandal, coined as "DieselGate."[3]

The engineering problem with the Volkswagen incident resides in the company's engineering team's inability to properly synchronize diesel engine performance to meet gas emission standards. To put it simply, Volkswagen diesel engines are notably reputed for its fuel economy (higher mileage for less fuel consumption); however, Volkswagen's diesel engines have an important computer controlled parameter, which is the amount of unburned fuel going into the NOx mechanism.[3] The NOx mechanism is a device that absorbs and traps nitrogen oxides (pollutants) from escaping into the atmosphere. The NOx mechanism functions properly when more fuel is consumed, which contradicts with the existing diesel engine design of maximizing fuel efficiency. In order for the vehicles to pass U.S. emissions test, Volkswagen fitted a "defeat device", a special software program that causes the vehicle to behave differently in the lab than on road conditions, on 11 million cars worldwide, 482,000 cars in US, and eight million cars in Europe, during the years 2009-2015. [1][2] When the cars were tested under controlled laboratory conditions usually using a stationary rig, the device set the vehicle to a safety mode in which the engines ran at lower power and performance with higher fuel consumption to make the NOx device "work". [1] The software was extremely sophisticated to sense test inspections by monitoring the speed, engine operation, air pressure, and the position of the steering wheels.[3] As soon as the vehicles were on the road for real-world driving, the engines switched out of the test mode resulting in 10- 40 times the amount of nitrogen oxide pollutants above the standard value permitted in the US. [1][2]

The ethical problems concerning the Volkswagen scandal are profoundly major and globally impacting. Analogizing with chemical companies with illegal dumping in reservoirs/rivers, Volkswagen deliberately condoned an advanced "cheating" method resulting higher than estimated nitrogen pollutants emissions into the atmosphere. In addition, engineers/programmers, senior officers and higher management knowingly participated this disingenuous endeavor, violating the IEEE/ACM code of conduct and betraying people's trust in investing in Volkswagen's product. The aftermath of the "DieselGate" resulted in the loss of credibility, money, jobs, and probable massive recalls for customers owning Volkswagen models

between the years 2009-2015.[2] In summary, Volkswagen's ethical problem was the lack of overall ethics in the first place.

The three ethical tools best chosen to evaluate the problem of the ethics of the Volkswagen scandal would be the six parts of ethics (intentions, rules, consequences, virtues and vices, institutions and culture), managing ethics, and the "Am I Responsible" toolkit. Despite being a recent 2015 case, all investigation details have been revealed to the public regarding each category of the six parts of ethics. Moreover, all the different news sources, government organizations' reactions/responses, and judicial court proceedings had their share of condemning Volkswagen's actions and uncovering the conspiracy of its ulterior motives. The next two tools of "Managing Ethics" and "Am I Responsible?" serve as appropriate tools to apply towards company ethics in understanding from an employee's insider perspective of addressing the issue. Unlike the ACM code of ethics, the tools of "Managing Ethics" and "Am I Responsible" allow the individual to reflect proactively on his/her ethical situation, encompassing the details of the workplace to evaluate its effect on the greater society. The general public cannot promote justice if they are not directly involved or knowledgeable with a company's practices or day-to-day operations handling such issues.

In ruling out ethical tools, the Volkswagen scandal involved secret, intentional software installed in Volkswagen's automobile engine computers (technological machine-related)—thus tools such as Diamond's lessons, people's rights, three kinds of justice, and informed consent could not be applied properly due to the company's planned hidden course of action. The software had no intention of harming humans (RISK = HARM x PROBABILITY = 0 x 0) and the case was the first particular instance of its kind (casuistry involved cases of gross negligence/inattentiveness, and previous "defeat devices" did not have such levels of sophistication) regarding automobiles and embedded software. Additionally, the three intellectual values meaning can be interpreted as promoting good in regards of "ethically serving" prioritizing the company's interests, such as future prospects/profitability, instead of environmental ethics. The ACM/IEEE code of ethics can be applied as simple complimentary guidelines, though they provide insufficient, deeper rationales or reasoning on why one should follow them, especially if one is not part of the organization. The tool lacks follow-through, and is difficult to interpret when engineers are faced with an adverse culture of what's "right" and "wrong". [2]

Using the six parts of ethics toolkit, one can generally examine the corrupted ethics of the Volkswagen scandal. The Volkswagen Corporation "intended" for the production of "defeat device" be installed in its automobile models, motivated by competition to meet profitability margins and vehicle sales in the U.S. The fast-paced, high intensity company culture may have contributed to the rules defined by company policy and reckless disregard for consequences in favor of efficient, completed objectives. Volkswagen decided to ignore the virtues of good business practices of finding a solution to their diesel engine problems and settled for the vice of creating software for the purpose of "cheating" the U.S. emissions test system and involving many layers of personnel to comply with their methods. In the article, "VW's Single-Point-of-Failure Ethics," the authors mention the possibility that Bosch, an automotive supplier, could have discovered that VW was using their software to design the defeat device, but ended up taking no action (no institutional intervention).

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In the second ethical toolkit, "Managing Ethics", we can analyze the Volkswagen scandal much more precisely.

- Relying on Employee Values: Depending on the team one was involved, everyone generally accepted to remain consistent with the company's culture norm of following unethical practices to ensure job stability and the company's success. The engineers and programmers directly involved with the "defeat device" is a silent acknowledgement that most everyone was not sophisticated enough to solve the true problem with Volkswagen's diesel engines. While everyone may have had different values, they cannot act on them from the non-disclosure agreement when they joined the company.

- Compliance: Volkswagen did not truly meet the compliance for U.S. emissions for real-world testing of its vehicles. One of the dysfunctional practices included senior officers' insistence on implausible objectives with no tolerance for failure. [2] Raising such high bar for success may have pressured engineers to find a hasty workaround no matter the ethical ramifications.

- Ethics Exhortation: The priorities of company ethics outweighing any other type of ethics. One personal ethics of self-preservation are concurrent with company ethics as well, as employees may not desire to face immediate risks being an expendable asset when job employment rates are low in the economy. (maintain one's job for financial security/health benefits)

- Managing values: The employee keeps his/her job continuing everyday job responsibilities without questioning ethical or non-ethical practices of the company (reward). The employee observes morally ethical values by resigning from the company and attempts to explain his reason for leaving by criticizing his/her former company (risk) to get another job (alone and appearing believingly wrong). The employee works to complete realistic and ambitious job objectives that help bring prosperity to the company, and is awarded with bonuses or career advancement. (reward). In order for a company to survive, upper management, directors, bosses pressure employees to work until the job gets done no matter the methods used to meet important deadlines.

In applying the "Am I Responsible" ethical toolkit, one can plainly observe the grossly unethical practices Volkswagen allowed:

- Severity of the harm: The extraordinary, global environmental impact of 11 million cars outputting more than 10-40x the accepted emissions standard. As a result, the higher density of nitrogen oxides contributes in the atmosphere to the accelerated development of premature health problems (respiratory problems including asthma, bronchitis and emphysema), and premature deaths for people

occupying cities/towns that possess these cars, especially in Europe.[4][2] The employees face no short-term harm and keep their jobs for meeting their work deadline.

- Certainty of the harm: Over an extended period of time, the environmental impact of the Volkswagen's automobiles will degrade/pollute the atmosphere invisibly causing widespread complications in all aspects of life. On the other hand, one can say that they are other sources of pollutions on our planet. This particular problem is just one of the many unneeded, undesired variables that could be prevented.

- Degree of involvement: The Volkswagen scandal resulted from the collaboration of managers, development leads, engineers, and programmers—multiple layers of corruption. Even if one employee decides to quit/resign, the status quo will still be followed. The degree of involvement of one employee would be similar to the roles of former, lower-tier Nazi soldiers/technicians involved with the Holocaust ("I was just doing my job/following orders." excuse).

- Cost of acting: For employees directly involved with the engineering and programming of the vehicle, employees risk their future job prospects and reputation for violating company policy (similar to the BART train case). In an ethical decision of self-sacrificing one's career advancements or employability over the social welfare/environment, individuals accept the former decision.

- Certainty of the solution: Trying to solve the actual problem would sacrifice the company's profitability from the amount of development time spent and neglect one's job responsibilities (the employee not doing his/her job).

A possible solution to the DieselGate scandal may lie primarily on the intuitions part of the six paths of ethics. Volkswagen did not count on an independent investigation done by West Virginia university researchers (educational institution) that reported on their study of Volkswagen automobiles' irregularity of emissions testing. This event prompted the Environmental Protection Agency (governmental institution) and the California Air Resource Board to look into the subject, perform their own testing, and issue notices of violation of the federal Clean Air Act to Volkswagen about their dishonest actions.[2] In the ethical case concerning industrial giants/famed brand-name companies, proper regulation by higher authority, third-party organizations as well as relevant ethics education are the tools at our disposal. Governmental organizations then manage the third-party organizations to be responsible for reporting unethical practices. Alternatively, the software code developed with automobile manufacturers could be released open-source in order to safeguard against unethical practices by exposing possible avenues of exploitation and vulnerabilities. The government and society then can make policy decisions concerning the software's attributes.[5]

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Software exponentially affects our personal lives, the overall economy, society, and our planet. We, as individuals, often underestimate the significance of software engineers' participation in tough decisions straddling ethics and more narrowly defined corporate interests. Unlike the physical mechanical/electrical design, software engineering design involves the most trust and ethical treatment because of its property of being flexible, complex, and the least transparent of engineering artifacts.[2] The Volkswagen diesel incident acts as a cautionary anecdote of the unprecedented, insider cyber threat that could preclude our full trust in machines. One positive outcome of the incident called to attention more awareness towards other automobile companies who may be engaged in similar practices. In conclusion, proper, persistent vigilance and continuous education would provide the most insight for us to discern and prevent such events from happening once again.

[1] Hotten, Russell. "Volkswagen: The Scandal Explained - BBC News." *BBC News*. BBC, 10 Dec. 2015. Web. 09 Mar. 2016. <http://www.bbc.com/news/business-34324772>.

[2] R. L. Trope and E. K. Ressler, "Mettle Fatigue: VW's Single-Point-of-Failure Ethics," in *IEEE Security & Privacy*, vol. 14, no. 1, pp. 12-30, Jan.-Feb. 2016. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7397718&isnumber=7397706

[3] The Verge. "Volkswagen's diesel scandal, explained." Online video clip. YouTube. YouTube. 24 Sept 2015. Web. 9 March 2016 http://www.bbc.com/news/business-34324772

[4] *Seth Borenstein (3 October 2015). "AP analysis: Dozens of deaths likely from VW pollution dodge". Associated Press. (used Wikipedia for Volkswagen Scandal, with cited reference)*

[5] D. Spinellis, "Developer, Debug Thyself," in *IEEE Software*, vol. 33, no. 1, pp. 3-5, Jan.-Feb. 2016. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7368033&isnumber=7367974