



2017 NSPE MILTON F. LUNCH ETHICS CONTEST

FACT SITUATION #3: PUBLIC HEALTH, SAFETY, AND WELFARE—
DRIVERLESS/AUTONOMOUS VEHICLE

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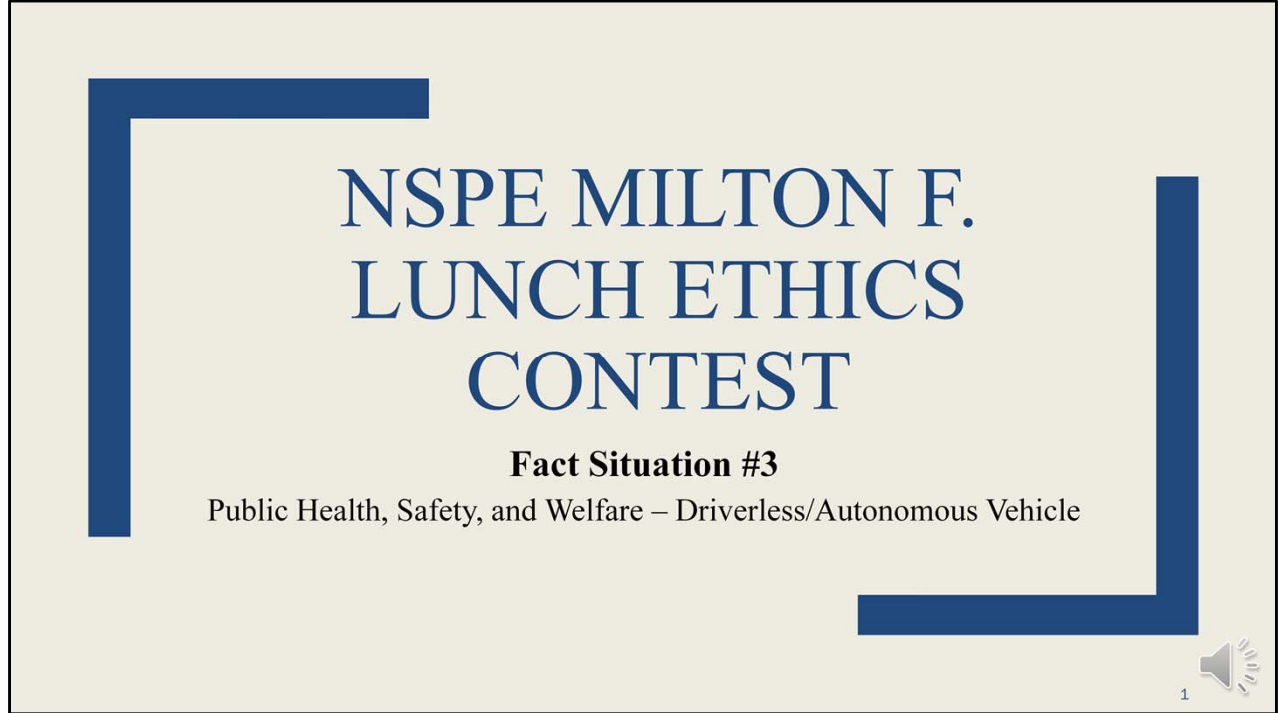
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NSPE MILTON F. LUNCH ETHICS CONTEST

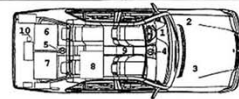
Fact Situation #3
Public Health, Safety, and Welfare – Driverless/Autonomous Vehicle

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The situation involves a professional engineer working as a consultant to an automobile manufacturer that is considering the development of a driverless/autonomous vehicles operating system. The engineer is assigned to an engineering risk assessment team whose members are being asked to make a recommendation relating to potential situations that could arise in connection with the operation of driverless/autonomous vehicles.

History of Driverless Vehicles

- Middle Ages: Leonardo Da Vinci designs self-propelled cart
- 1925: Houdina Radio Control
- 1939: World's Fair
- 1960's: More attempts at smart highways
- 1977: First stand-alone driverless vehicle



- | | |
|--------------------------------------|--|
| 1 Torque motor for steering | 6, 8 Transputer system, image processing |
| 2 brake system | 7 processors for gaze & locomotion control |
| 3 electric throttle control | 9 user interface |
| 4 front platform } for 2 CCD cameras | 10 linear accelerometers |
| 5 rear platform } | |



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Self-driving cars are cutting edge technology, the wave of the future, but the idea is not as new as you may think.

- The first self-propelled vehicle was designed by Leonardo Da Vinci in the Middle Ages.
- In 1925, Francis P. Houdina developed a radio-operated automobile by equipping a 1926 Chandler with a transmitting antenna which was operated using a transmitter in a second car.
- The 1939 World's Fair brought another system for driverless vehicles. An exhibit called "Futurama" by renowned industrialist Norman Bel Geddes was remarkable not only for its innovative ideas, but also for the realistic depiction of a city of the future. For example, it introduced expressways as a way to link cities and surrounding communities. It proposed an automated highway system, which sent electronic signals to cars. The cars moved without drivers, allowing occupants to arrive at their destinations safely and in an expedient manner.

Many groups followed on the idea of smart highway systems, such as RCA in partnership

with GM, and United Kingdom's Transport and Road Research Laboratory. They all ended up at the same conclusion: it was too expensive.

In 1977 Japan's Tsukuba Mechanical Engineering Laboratory developed the first stand-alone driverless vehicle. It used machine vision from built-in cameras. The prototype was capable of speeds close to 20 miles per hour and was programmed to follow white street markers.

Present Day

- Numerous Companies worldwide developing technology:

- *Google: mapping*
- *Tesla*



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Today, companies worldwide are working to enter the driverless vehicle market.

Most people are aware of Google's mapping technology. In 2012, using Google's technology, a Toyota Prius took Steve Mahan, a blind man, to Taco Bell and to a dry cleaners.

In the US, Tesla expects that by the end of 2017, one of its cars will be able to drive from New York City to Los Angeles without the driver having to do anything.

Sweden plans a pilot program in 2017 and Great Britain has a program rolling out in 2018.

Challenges

- Tesla: first fatal crash
- First car race crash
- Great Britain's unmarked Volvos



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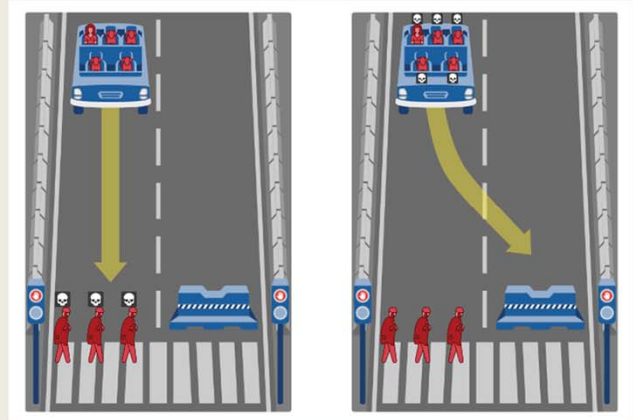
The rise of this technology has not come without problems.

- An early Tesla vehicle was recently found at fault for a crash that occurred on May 7, 2016. The car failed to apply the brakes when a tractor-trailer made a left turn in front of it.
- The first ever driverless car race was held in Buenos Aires in February 2017, and ended in a crash. It was held by RoboRace, a nascent self-driving racing series, on a professional course. The race was between two vehicles and only one completed the race (the other crashed). Both vehicles operated at far lower speeds than human-controlled Formula E racers typically reach.
- The first self-driving cars in Great Britain, expected in 2018, will be unmarked so that other drivers don't try to bully them. The fear is that other road users might slam on their brakes or drive erratically in order to force the driverless cars into submission.

Ethical Dilemmas

In the case of an unavoidable collision, who should the car protect?

- Occupants
- Pedestrians



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There are a variety of scenarios that must be addressed in the driverless vehicle software design. The risk assessment must define the action the driverless vehicle will take in a variety of scenarios.

In the scenario addressed here, the engineers must determine whether the vehicle system should choose the outcome that protects the safety of its occupants but may cause a fatal injury to a pedestrian, cyclist or other driver, OR the option that causes the least amount of potential harm to any and all of those involved in the accident with the probability of causing some passengers serious but non-life threatening injuries. Professional Engineers charged with designing the vehicles and operating systems are at the forefront of this ethical dilemma.

A significant consideration is whether the driverless vehicle will choose to allow non-fatal injuries to occupants, or fatal injuries to a pedestrian, cyclist, or motorcycle rider.

Mercedes has made it clear that if a situation arises where one of its driverless cars has to choose between saving the lives of its occupants or those of bystanders, it will save the occupants.

However, most people want to live in a world in which driverless cars minimize casualties.

Many agree that from a moral standpoint, cars should save the maximum number of people even if they must kill their occupants to do so. BUT they want their own car to protect them at all costs.

Conflict in the NSPE Code of Ethics for Engineers?

The Fundamental Canons state that Engineers shall:

1. "Hold paramount the safety, health, and welfare of the public"
4. "Act for each employer or client as faithful agents or trustees"



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In considering these dilemmas, two parts of the National Society of Professional Engineers Code of Ethics stand out. Both are found in section one, the fundamental canons:

- Number 1, Hold paramount the safety, health, and welfare of the public.
- And Number 4, Act for each employer or client as faithful agents or trustees.

Is the engineer's need to hold paramount public safety in conflict with the engineer's responsibilities to their employers and clients? Is there a point at which creating an automated vehicle which is safe for its occupants becomes detrimental to society?

In the following slides we present a rationale for working through the general ethics surrounding this issue. Once the framework for these thoughts is developed, we will apply the reasoning to address the specific problem posed in this situation.

Discussion & Rationale

Faithful Agent & Trustee

- Humans respond to danger with “fight-or-flight” response for self-preservation
- Vehicle occupants try to preserve their own lives in the event of an emergency
- Programing driverless cars to protect the occupant’s life improves the chances of saving their life



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The first consideration is - what do people want from driverless technology in the event of a potentially fatal crash?

In general, people want to live.

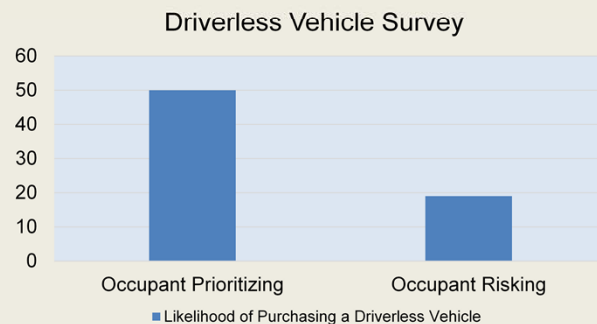
This can be seen in how we all tend to automatically react in life threatening situations. People instinctually process immediate danger with a “fight-or-flight” response that normally results in an attempt to take self-protective measures. Our automatic responses to danger reveal a desire to avoid death and serious harm.

Without having better information about how any given individual would prefer to behave in an emergency event such as an imminent car accident, it can reasonably be assumed that the normal response of any given driver to impending danger is that of self-preservation and the protection of occupants. In other words, drivers typically exercise their autonomy by making choices that prioritize their own life and their passenger’s lives.

The driverless technology engineer has an opportunity to help people do this even better : to avoid and survive life threatening collision emergencies.

Faithful Agent & Trustee

- Driverless vehicle designers are responsible to the customer
- Public surveys show people want driverless cars to prioritize occupant lives



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Research supports that this is exactly what people want when occupying a driverless vehicle. In "The Social Dilemma of Autonomous Vehicles," the authors report on a set of studies regarding participant's attitudes toward the ethical dilemmas presented by driverless vehicle programming.

The study respondents generally expressed that a simple utilitarian approach would be the most moral—that is, a situation in which driverless vehicles would be programmed to reduce the number of potential casualties in an accident overall.

However, respondents reported a serious aversion to riding in a driverless vehicle that was programmed to risk its occupants' lives for the greater good. The study indicates that people are much less likely to buy driverless vehicles if they are programmed in this manner.

To quote a conclusion from the authors, "utilitarian algorithms may paradoxically increase casualties by postponing the adoption of a safer technology." If the design must protect the occupants at all costs, then the safety of others could be compromised. This conflicts with the Code of Ethics Fundamental Canon number 1, which requires engineers to "hold paramount the safety, health, and welfare of the public".

Public Safety, Health, & Welfare

- Public safety and welfare will benefit from adoption of automated vehicle technology
 - *Studies indicate up to 90% reduction in traffic accidents*
- More lives remain at risk due to public distrust of driverless vehicles
 - *40% of accidents are due to speeding, drinking, or distracted driving*
 - *These accidents are preventable with driverless vehicles*



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In the aforementioned studies, respondents considered the "utilitarian" option, which means "the greatest good," in the context of a single tragedy. However, we can also apply a utilitarian approach in considering how the programming of driverless vehicles might affect public safety as a whole. If programming driverless vehicles to be utilitarian in a specific instance means more harm to society as a whole, it is reasonable to consider the solution that most lowers risk to human lives to be the actual greatest good.


Most automobile accidents are preventable. The National Highway Traffic Safety Administration says that 94 percent of accidents are caused at least in part by human error. Of the 6 percent of accidents that are not due to human error, it is conceivable that only a small fraction would relate to an occupant versus non-occupant fatality dilemma. In other words, very few real life scenarios will match the situations considered in studies like "The Social Dilemma of Autonomous Vehicles".

This does not mean that the question is not important. Rather, the point is that there is much more to risk in lives harmed and lost if people feel unsafe in driverless vehicles than there is if driverless vehicles do not always make the utilitarian choice in a highway emergency. If fears over occupant safety delay the adoption of driverless vehicles, then preventable accidents will continue to kill at a rate of tens of thousands of lives lost per year in the United States.

In terms of the greater good for society and public safety, much stands to be gained by the widespread adoption of driverless technology. In order for that to happen, people must feel safe when they are occupying driverless vehicles.

Public Safety, Health, & Welfare

- Consider current laws and customs and their impacts
- Pedestrians have some control over risk exposure and behavior
- Occupants in utilitarian driverless vehicles could be vulnerable to negligent & malicious pedestrians



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As a second consideration, think about the unintended consequences that might result from roadways full of driverless vehicles designed to risk Occupants for the greater good, and how these accidental consequences might affect public welfare.

The real-world impact of well-meaning technology is often accompanied by harmful drawbacks. For example, the widespread use of social media in our society has shown evidence of increased anxiety and depression due to the emerging mental health condition termed the “Fear of Missing Out.”

Driverless vehicles are already going to make highways much safer than they currently are, but what new risks and incentives might be introduced by programming driverless vehicles to be occupant risking vs. occupant sparing?

Highway use involves an inherent risk that is proportional to the type of transportation used. Vehicle users have incentives to be mindful and cautious, but pedestrians and cyclists carry the greater risk in terms of safety. There is still the occasion when pedestrians are inattentive or negligent on roadways, such as people crossing the street while texting or entering the road while inebriated.

Driverless vehicles will do a better job than human drivers ever have at minimizing injury in

these situations, but in a world full of vehicles programmed to endanger its occupants for the sake of pedestrians, the risks and incentives for roadway caution will be flipped.

As roads become safer than they have ever been for pedestrians, the incentive for pedestrians to be mindful of traffic is greatly diminished. If pedestrians know that driverless vehicles will do everything possible to avoid hitting them, most of the risk is placed on the occupants of driverless vehicles. Driverless vehicle occupants will have no ability to protect themselves from the poor actions of those outside their vehicle.

This vulnerability might even create new avenues of risk for the occupants of these vehicles, such as malicious acts intending to trick the vehicle's programming into thinking a pedestrian is at risk in order to possibly harm the occupants.

And while we might want every precaution taken to avoid serious injury to a child that darts into the road, it might be readily considered a moral hazard to create a scenario in which driverless vehicle occupants are helpless to avoid an occupant-risking collision forced by an inebriated or suicidal pedestrian.

Much will change as driverless vehicle technology increases on the roadways, but it would be a mistake to decrease the incentive for pedestrians and cyclists to act with appropriate caution. Programming driverless vehicles to prioritize the lives of its occupants would allow those incentives to remain while making everyone much safer on the roads.

Public Safety, Health, & Welfare

- Allocation of resources in an emergency to save the most lives is an accepted ethical standard
 - *Medical triage protocol*
 - *Similar concept with driverless vehicles*



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So for the sake of occupant safety and the public welfare as a whole, driverless vehicles should be programmed in accordance with the occupant's need to preserve their own life and feel secure. But to what extent? It is doubtful anyone would desire that a pedestrian be struck by a vehicle simply to avoid cuts and scrapes to vehicle occupants, but how should risk be allocated in the innumerable serious collision scenarios?


To borrow from medical ethics, the well accepted principles of medical triage prioritizes resources for individuals who are most likely to be spared death and disability. Prioritizing the preservation of any life over the risk of moderate injury is in keeping with the first Fundamental Canon and should be in agreement with public sentiment.

Therefore, while driverless vehicles should be programmed to preserve the occupants' lives in the event of a life-threatening incident, they should also be programmed to preserve life overall. There must be an approach for prioritizing allocation of the vehicles resources in an emergency.

Order of Precedence

- The following order of precedence is determined as an attempt to address the aforementioned concerns:

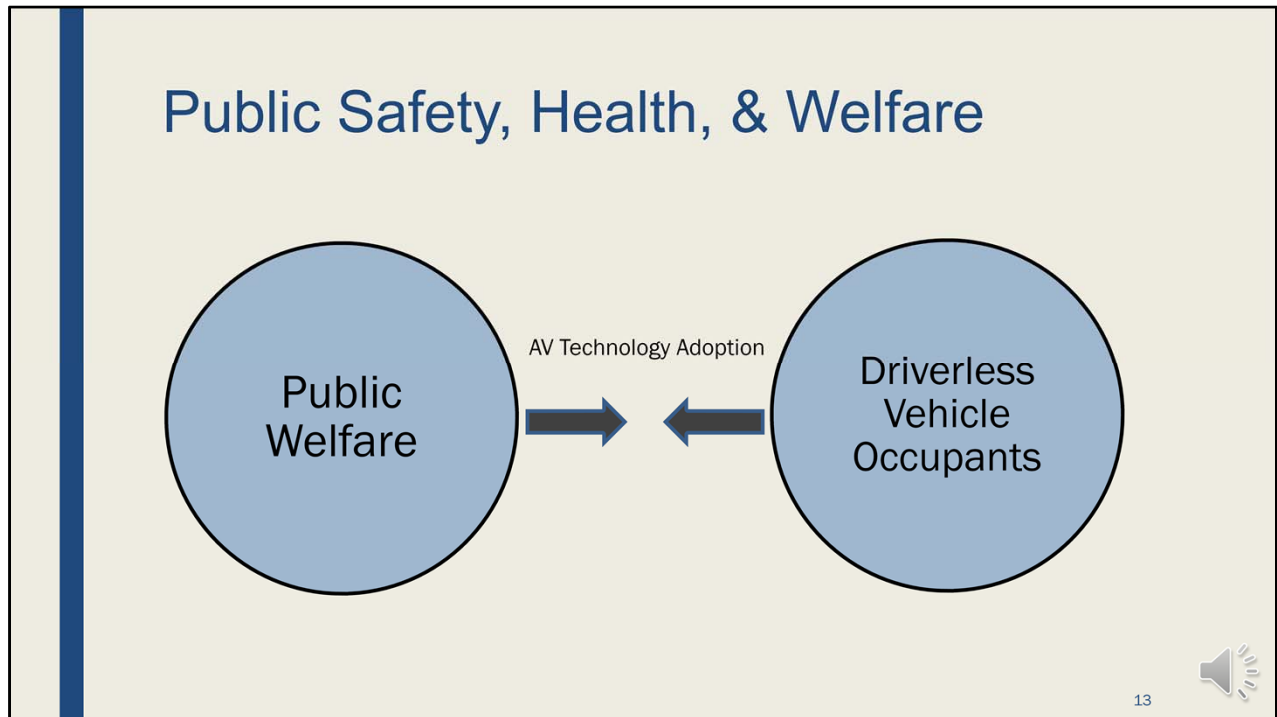
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graph TD; A[Avoid death/dismemberment to occupants.] --> B[Avoid death/dismemberment to anyone.]; B --> C[Avoid other injury to occupants.]; C --> D[Avoid other injury to anyone.];
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From all of this we arrive at an order of precedence that respects the need to maintain the safety of driverless vehicle occupants as well as prioritizing life overall.

In the very rare occasion that death is likely to occur to either the driverless vehicle occupants or to people outside of the vehicle, the vehicles should be programmed to prioritize the lives of its occupants. While this situation is unlikely to be a frequent occurrence, it should reassure occupants to know that their car is not going to kill them if it can be avoided, and thus also respects their desire for self-protection.

In situations in which the driverless vehicle must choose between a probable fatality to a pedestrian and recoverable injuries to its occupants, the vehicle should choose the option that most likely preserves everyone's lives.



Until now we have generally considered two groups: the driverless vehicle occupants and the general public. However, as driverless vehicle technology is increasingly adopted, these two groups will gradually become the same.

If we imagine a scenario in which driverless vehicle technology is fully adopted, any time someone gets in a vehicle - whether it be a personal automobile, taxi, public transportation, or school bus - that person will be in a driverless vehicle.

Public Safety, Health, & Welfare




Driverless
Vehicles
for all
Society

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At that point it is conceivable that virtually every person in society will at some time be a driverless vehicle occupant. The issue of keeping driverless vehicle occupants safe will not be separate from holding paramount the safety of the public.

Engineer A's Ethical Dilemma



Risk assessment team must make recommendations for potential incidents

- In the event of an unavoidable crash, does the vehicle's system choose:
 - 1) *Greatest potential for safety for the occupants?*
 - Vehicle hits and kills pedestrian, cyclist, or motorcycle rider
 - All occupants are unharmed
 - 2) *Least amount of potential harm?*
 - Vehicle crashes into a stationary object but avoids a pedestrian, cyclist, or motorcycle rider
 - Some occupants may receive non-life threatening injuries

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Now that we have a basis for engaging in moral reasoning about driverless vehicle ethical dilemmas, let's address the problem posed in Fact Situation number 3.

The specific ethical dilemma outlined in the problem statement for this competition involves Engineer A, a professional engineer acting as a consultant to a driverless vehicle manufacturer who is on the risk assessment team and must recommend a solution to potential ethical situations the driverless vehicle may face. In this case, Engineer A must decide whether, in the event of an unavoidable crash, the vehicle's software should choose to navigate a course with the greatest potential of leaving the vehicle's occupants unharmed while likely causing a fatal injury to non-occupants outside the car, or to steer a path that probably results in the least harm done to anyone involved, but likely causing some recoverable injuries to its occupants.

To restate, the outcome in the first scenario means that the vehicle might hit and kill a pedestrian, cyclist, or motorcycle rider but leave all vehicle occupants unharmed. The outcome with the second scenario results in the least potential harm done to everyone involved, but the vehicle's occupants are likely to sustain some non-fatal injuries.

Scenario 1: Safety for Occupants



The diagram shows a top-down view of a road. A blue driverless vehicle is positioned in the upper half of the road, moving downwards as indicated by a large yellow arrow. On the left side of the road, a red pedestrian is walking. On the right side, there is a blue barrier. The road is flanked by grey walls.

- Pros
 - *The safety of the vehicle's occupants will always be protected*
 - *Driverless vehicles will save more lives in the long run*
- Cons
 - *A pedestrian, cyclist, or motorcycle rider would die*
 - *The consumer is protected above the public*
 - *Potential for negative perception of driverless vehicles*

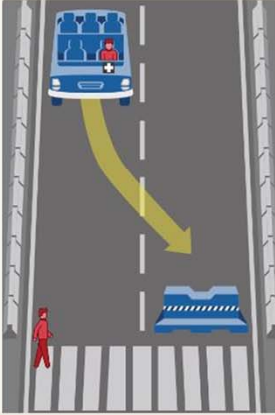
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The first scenario ensures the utmost safety of driverless vehicle occupants. This solution would put buyers at ease that the car they are purchasing will protect them no matter what. This scenario is ethically supported by Fundamental Canon #4, since the engineer is acting as a "faithful agent or trustee" with the manufacturer's best interests in mind.


One positive outcome of this scenario is the rise in driverless vehicle sales when people are confident the technology will protect the occupants to the fullest extent. This widespread adoption and use in turn will help protect and save more lives in the long run.

The major downside to this scenario is that a member of the public would die in the event of a serious accident, and the general public may have a negative perception or distrust of driverless vehicles. In addition, this scenario could set a precedent of preferential treatment for preserving the lives of those who have the finances to buy and use driverless cars over those who may not be able to use driverless cars.

Scenario 2: Least Potential Harm



- Pros
 - *All human life is treated equally and will be protected*
 - *No one would die*
- Cons
 - *Wary consumers, if they feel they are not 100% protected*
 - *Puts consumers at risk and financially responsible for irresponsible pedestrians*

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The second scenario ensures that human life is protected and the least potential harm is inflicted on all parties involved in an accident. Choosing this scenario is supported by the first Fundamental Canon, that engineers shall "hold paramount the safety, health, and welfare of the public."

The "public" here includes both the occupants *and* the pedestrians, so the engineer would uphold his ethical obligations under this Fundamental Canon by recommending Scenario 2. Choosing Scenario 2 is also arguably the more ethical choice in a broader sense, because this option protects *all* lives, not just the lives of driverless vehicle consumers.

As discussed earlier, the downside here is that consumers may be wary of buying or using an driverless vehicle if they aren't confident the car will protect them at all times. This option also may make consumers of driverless vehicles financially responsible for irresponsible or unavoidable pedestrian behavior.

Engineer A's Decision

- Scenario 2: Least potential harm
 - *Engineer A must protect the public, not just the consumer*
 - *This is the only option that protects all human life*
 - *Injuries are preferable to death*




As a professional engineer, Engineer A is obliged to uphold the NSPE Code of Ethics for Engineers in his professional duties. The Order of Precedence for addressing driverless vehicle ethical dilemmas developed earlier in this presentation is a simple calculus that provides a tool to Engineer A for evaluating these two alternate scenarios in a manner that respects the NSPE Code of Ethics, specifically Canon 1 and Canon 4 as expanded upon in this presentation.

Neither scenario involves a potential loss of life among the driverless vehicle's occupants, so the first point in the Order of Precedence "to preserve the life of driverless vehicle occupants" is not relevant.


The second point in the Order of Precedence is to prevent loss of life to anyone involved in an accident. Since scenario 1 allows for potential fatal injuries to pedestrians, cyclists, and motorcyclists, scenario 1 does not accord with the second point in the order of precedence.

According to the order of precedence, Engineer A should recommend Scenario 2 because it adheres to NSPE Fundamental Canon 1 (protection of the public) rather than 4 (protection of the client).

Summary



- Driverless vehicles are the future of driving
 - *Usage will save many lives in the long run*
 - *Ethical decisions must be made with regard to cases of unavoidable collisions*
- In general, driverless vehicle design should protect human life whenever possible, but favor occupant safety in collisions where death is inevitable
- The engineer's ethical obligations mean they must recommend the choice that maintains public welfare overall.

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Driverless vehicles are the near future of driving, with publicity and interest increasing every day. In addition, statistics and research show that widespread adoption and use of driverless vehicles can dramatically reduce the number of lives lost each year in vehicular accidents.

If these vehicles are perceived to be potentially harmful by the general public, then the adoption process is likely to be very slow, thus delaying the significant but long-term benefits of driverless vehicle use. With the possibility of driverless vehicles becoming the norm, there is the reasonable expectation that they will be safe to use.

Therefore, how the vehicles are programmed to operate – particularly in situations such as unavoidable collisions – is crucial to the perception and use of driverless vehicles. Such situations present an ethical dilemma for those programming the cars, as Engineer A in this example faced.

As a general rule of thumb, driverless vehicles should be designed to protect human life whenever possible. Only in the instance where death is inevitable should the vehicle favor the preservation of its occupants.

It is Engineer A's primary ethical obligation as a professional engineer to recommend the

choice that best upholds the public health, safety, and welfare while being faithful to employers, clients, and other stakeholders. The ethics of driverless vehicles must be considered not only in terms of every possible nuanced highway incident but also in terms of their impact on society as a whole.

As such, Engineer A should choose the second option where the least amount of potential harm is done to any of those involved in an accident, such as having the car crash into a stationary object (e.g., telephone pole, etc.) with the probability of causing some passengers serious but non-life threatening injuries.

Sources

- “Moral Machine.” *Moral Machine*, <<http://moralmachine.mit.edu/>> (Apr. 17, 2017).
- Bonnefon, J.F., Shariff, A., Rahwan, I. (2016) “The Social Dilemma of Autonomous Vehicles.” *Science*, 352, 1573-1576.
- DOMRES, B., et. al. (2010). “Ethical Aspects of Triage.” *Military Medical Science Letters*, 79.2, 76-82.
- Giarratana, C. (2016). “Navigating the Future with Care” *Safety Resource Center*, <<https://www.trafficsafetystore.com/blog/autonomous-cars-prevent-traffic-deaths/>> (Apr. 21, 2017).
- Rosekind, M.R. (2016). “Remarks: Automated Vehicles Symposium 2016.” *Speeches and Presentations*, <<https://www.nhtsa.gov/speeches-presentations/remarks-automated-vehicles-symposium-2016>> (Apr. 13, 2017).

