

A Comparison of American & Dutch Engineering Students' Views on Safety & Sustainability for Ultra-lightweight Vehicles

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Motivation

- SUCCEED grant designed to pair international junior scholars for engineering ethics case development
- Case developed about a multidisciplinary design effort at the Delft University of Technology
 - Design of an ultra-lightweight vehicle
 - Focus on safety and sustainability
- Case given to University of Virginia and Delft University of Technology engineering students
- Case and responses to questions posted on onlineethics.org website

The onlineethics.org case

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The Online Ethics Center For Engineering and Science
at Case Western Reserve University

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Ethical Issues in the Design of Ultra-Lightweight Vehicles

Introduction

[Missy Cummings](#), *Massachusetts Institute of Technology*
[Anke van Gorp](#), *Delft University of Technology*

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A multidisciplinary design team consisting of undergraduate and graduate students from Aerospace Engineering, Applied Earth Sciences, Industrial Design and Mechanical Engineering at the Delft University of Technology in the Netherlands is designing a lightweight, sustainable car.¹ Their goal is to design a family car with a maximum mass of 400 kg. Mass is an important factor in the fuel consumption of a car, a light car can be very energy efficient. The target mass is less than half of that of normal cars. (European family cars usually weigh about 1200 kg and the average American car weighs 1360 kg). Another requirement is that the car should be manufactured at affordable mass production costs.²

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Safety & Sustainability Issues

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Safety Issues in the Design of Ultra-Lightweight Vehicles

Ethical Issues in the Design of Ultra-Lightweight Vehicles

[Missy Cummings, Massachusetts Institute of Technology](#)
[Auke van Gorp, Delft University of Technology](#)

The goal of reducing the mass to 400kg has generated a debate over safety concerns when building a lightweight car. A car that is relatively light always has a disadvantage in collisions with larger cars in that it will always experience the greater acceleration. Traditional automobile safety considerations have resulted in designs of very heavy and stiff vehicles, protecting the driver and passengers in a collision but at the same time constituting a hazard for other road users in lighter vehicles because of their significantly reduced stiffness and mass. In addition, heavier vehicles are not as fuel efficient.

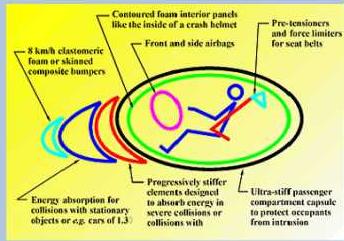


Diagram illustrating safety features in a car design:

- Centered foam interior panels like the inside of a crash helmet
- Front and side airbags
- Pre-tensioners and force limiters for seat belts
- 8 km/h elastomeric foam or skinned composite bumpers
- Energy absorption for collisions with stationary objects or e.g. cars of 1.3
- Progressively stiffer elements designed to absorb energy in severe collisions or collisions with
- Ultra-stiff passenger compartment capsule to protect occupants from intrusion

Recent developments in automobile safety have led to the increasing use of passive safety systems¹ such as subaugs and active systems like Anti-lock Brakes. conventional way means that safety systems are included as much as economically feasible. In a car of 400 kg or less it is very difficult to include extensive necessities a reconsideration of the ideas of what constitutes adequate car safety. Is it a car that performs well in crash tests, or is it a car that helps the driver

There is a theory within safety science that states that people have a target risk that guides their behavior, and this is called risk homeostasis. People will try and protected by her car will speed more. This could lead to accidents with higher speeds involved and therefore more injuries and damage. The same driver: more vulnerable. Therefore, there might be good arguments to build a car with less active and passive safety systems. The Delft student designers have chosen the driver feel a bit vulnerable. This choice is inspired by the lightweight criterion and the risk homeostasis theory.

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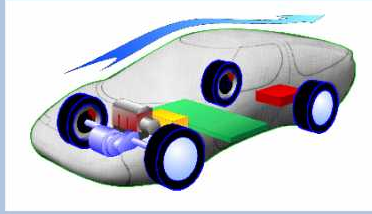
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Ethical Issues in the Design of Ultra-Lightweight Vehicles

[Missy Cummings, Massachusetts Institute of Technology](#)
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The World Commission on Environment and Development, the Brundtland-commission (WCED, 1987) proposed the following definition of sustainable development: Sustainable Development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

1. The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given.
2. The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.



When following the Brundtland definition it is not clear what makes a car sustainable - should the car be recyclable, be lightweight, or should it not be built in the first place in order to be sustainable? Designers within the same design team interpret the term sustainability differently as can be seen in the answers given when asked what sustainability means. Some refer to the closing of the material cycle by recycling, others refer to energy and resource efficiency during production and use, and some focus on the energy consumption during the use phase (90% of the total life cycle energy is used during the use phase) of the car.

These different definitions are not always compatible. Lightweight materials are often difficult to recycle, but the energy consumption of a very light car is very low. European legislation requires that within ten years 95%¹ of the materials in cars should be recyclable. The design team does not want to comply with this percentage; they would rather build a very light "throw-away after use car" than a heavy steel car that can be recycled. Their

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Safety Questions

Ethical Issues in the Design of Ultra-Lightweight Vehicles

[Missy Cummings, Massachusetts Institute of Technology](#)

[Anke van Gorp, Delft University of Technology](#)

These are the questions that correspond to the safety portion of the ethics case study. You can have them sent to any e-mail address you choose which could be a professor, yourself, or even your mom and dad! (Note: Your IP address will be logged in case of abuse.)

1. Enter your email address in the space provided below.

2. Enter the e-mail address of the person you want your answers sent to in the space provided below.

3. Are the fundamental responsibilities of safety engineers compromised in the design of this lightweight car?

4. Risk and cost benefit analyses are critical components of any engineering process. Describe the ethical issues that a



Moral Exemplar:
Fred Cuny
1944-1995

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Sustainability Questions

Ethical Issues in the Design of Ultra-Lightweight Vehicles

[Missy Cummings, Massachusetts Institute of Technology](#)

[Anke van Gorp, Delft University of Technology](#)

These are the questions that correspond to the sustainability portion of the ethics case study. You can have them sent to any e-mail address you choose which could be a professor, teaching assistant, or potential employer.

1. Enter your email address in the space provided below.

2. Enter the e-mail address of the person you want your answers sent to in the space provided below.

3. Are engineers ethically obligated to consider sustainability in their designs? Why or why not?

4. Defining sustainability is the first critical step in developing a plan for a sustainable product. This definition is not ethically neutral because such a determination implies a choice to include some aspects of sustainability, while ultimately rejecting others. Discuss the ethical dilemmas that could be faced by designers of lightweight cars attempting to define automobile sustainability.



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Response Comparison

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Comparison of Answers to Safety Questions¹

Ethical Issues in the Design of Ultra-Lightweight Vehicles

[Missy Cummings](#), Massachusetts Institute of Technology

[Anke van Gorp](#), Delft University of Technology

1. Are the fundamental responsibilities of safety engineers compromised in the design of this lightweight car?

University of Virginia

- The fundamental responsibility of a safety engineer is compromised by the design of this lightweight car. If you specify that a case should be designed so that it is light as possible regardless of safety concerns, then a safety engineer has to essentially dream up reasons why the car he is designing is safe, i.e. risk homeostasis theory, instead of actually implementing safety devices.
- The fundamental responsibilities of safety engineers are not compromised in the design of this car. By merely designing this car, a safety engineer has not compromised himself because there is still no conclusive evidence that the car is unsafe.
- The design of this lightweight car without the standard passive and active safety systems is a definite compromise of the fundamental responsibilities of safety engineers. The general public relies upon these individuals to make sure that a safe reliable product is put on the market, yet for this car that is not the case.
- I do not believe the fundamental responsibilities of safety engineers are necessarily compromised by this project. The safety criteria applied to the design of the car are merely different, or non-conventional. If this car design were to be implemented in the United States, this may pose more of a problem. Since the car is to be applied to Europe, where car designs in general are smaller, more compact vehicles, the lack of active safety features is not as big of a concern.

Delft University of Technology

- Yes. The fundamental responsibility of a safety engineer is to provide a safe car. This safety does not depend only on the driver's abilities and risk homeostasis, but on other drivers as well. Thus, a safe car not only protects a driver from his/her own mistakes but also from other driver's mistakes.
- It depends on what is of two parts: 1) try to drivers when accidents account. By emphasizing
- Yes because drivers of
- Whether or not the res amount of accidents de responsibility is not co
- The government should

2. Risk and cost benefit analyses are critical components of any engineering process. Describe the ethical issues that a de

University of Virginia

- The major ethical difficulty in conducting a cost-benefit analysis where human life is at stake is that one can sometimes find oneself in the moral gray area of putting a price on human lives.
- The best guideline is to rationally ask oneself if they would use the product or let their family, and friends use the product.
- The most significant ethical dilemma that the designers must face is whether it is acceptable to make a car lighter in order to reduce cost despite the fact that this would increase the risk of danger for its passengers.

- The ethical issue faced injuries due to an accid which is probably one
- The essence of a lighty and costs give restrict conventional safety sy
- A clean massa vehicle

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Comparison of Answers to Sustainability Questions¹

Ethical Issues in the Design of Ultra-Lightweight Vehicles

[Missy Cummings](#), Massachusetts Institute of Technology

[Anke van Gorp](#), Delft University of Technology

1. Are engineers ethically obligated to consider sustainability in their designs? Why or why not?

University of Virginia

- If everyone, more specifically engineers, were obligated to seriously consider sustainability to every degree, many, if not all things would not be built.
- Engineers should be ethically obligated to consider the sustainability in their designs. Engineers should not simply meet consumer demand, but also consider the needs of society as a whole. The government should also offer some monetary incentives for engineering contractors who incorporate sustainability in design.
- The consideration of sustainability should not be burdened on the design engineer. Instead the consideration of sustainability should be with those who are responsible for protecting the environment and its resources...to consider sustainability might limit the creativeness of the design. Sustainability in engineering is typically a by-product of the need to be economical. The only obligation of an engineer is to consider sustainability as if it was a specification of the design.

Delft University of Technology

- According to me it is obvious that engineers should take sustainability into account in their designs. They should at the consequences of a design for environment and society. Especially in designing mass products like cars it is absolutely necessary that these consequences are investigated.
- Only to some extent. The first task of engineers is to design a product of process that meets the set requirements. If this leaves room for sustainability considerations, so much the better.
- An engineer can and should contribute to a sustainable future. Especially in the design phase a lot of choices regarding sustainability can be made, therefore an engineer has a special obligation regarding sustainability.
- Sustainability should not be the most important design criterion.

2. Defining sustainability is the first critical step in developing a plan for a sustainable product. This definition is not ethically neutral because such a determination implies a choice to include some aspects of sustainability, while ultimately rejecting others. Discuss the ethical dilemmas that could be faced by designers of lightweight cars attempting to define automobile sustainability.

University of Virginia

- A sustainable, lightweight car is fuel efficient but not very recyclable. A conventional car, on the other hand, is not as fuel-efficient but it is highly recyclable. It is therefore up to engineers to decide what's more important: fuel or materials.
- Is there a better way of designing more environmentally friendly cars other than making them lightweight? Does a sustainable car have a small environmental footprint?
- The problem of whether to focus on recycling, resource dependency, or energy consumption is a significant problem in defining sustainability. [engineers] also face the dilemma of creating cars that aren't as safe as heavier cars, and could therefore lead to more deaths, even though they may be better for the environment.

Delft University of Technology

- A first dilemma is of course whether a car should be produced in the first place. Perhaps an engineer should try to develop a more sustainable public transport medium instead. A second question is whether fossil fuels should still be used perhaps hydrogen is a better source of energy. A third question is whether materials that increase safety but are environmentally unfriendly should be used (for example the explosive tablets used in airbags). Do the saved lives of some humans outweigh the environmental degradation?
- An ethical dilemma in the definition of sustainability is the way in which different sustainability aspects are weighed. It is, for example, very difficult to decide what the more sustainable option is: a light and fuel efficient or a heavy recyclable car.
- A first dilemma is whether a car like this should be designed in the first place. Perhaps the engineer should design more sustainable public transport systems.

If the theory of risk homeostasis is correct, is it ethical to design cars for perceived levels of risk? Why or why not?

- DUT: It is ethical “when the consumer is informed that he/she [will] not only feel more vulnerable but is more vulnerable in an accident. [This is comparable to] driving motorcycles.”
- UVA: “Assuming that the theory of homeostasis is correct, it is still unethical to design cars for perceived risk levels...the driver of a lightweight car would have no way of surviving, because his one and only defense was his perception, and he cannot perceive the negligence of others.”

Are engineers ethically obligated to consider sustainability in their designs? Why or why not?

- DUT: “According to me it is obvious that engineers should take sustainability into account in their designs. They should look at the consequences of a design for environment and society. Especially in designing mass products like cars it is absolutely necessary that these consequences are investigated.”
- UVA: “The consideration of sustainability should not be burdened on the design engineer. Instead the consideration of sustainability should be with those who are responsible for protecting the environment and its resources...to consider sustainability might limit the creativeness of the design. Sustainability in engineering is typically a by-product of the need to be economical. The only obligation of an engineer is to consider sustainability as if it was a specification.”

In your opinion do you think sustainable cars are feasible? Why or why not?

- DUT: “It will be difficult to create sustainable cars because very different aspects need to be compared. I think, however, that the question is wrong. I think that it is impossible to find an ideal and perfect sustainable solution for cars, this does not mean that we should not try to attain such a solution. I think it is possible to improve existing cars with existing technology and this process should be repeated. The question is not sustainable or not sustainable, but to what extent a car is sustainable.”
- UVA: “In my opinion, the market for sustainable cars is very small relative to the market for big trucks and SUVs (sport utility vehicles). Sustainable cars are not feasible, especially in the United States. Generally the consumers’ attitudes towards cars are that bigger means better, stronger, and more durable. Sustainable cars do not have the market for mass production.”