UNIVERSITEIT TWENTE.

# SMART ENVIRONMENTS PROJECT

## DOCUMENTATION REPORT

**Dora the Explorahh**

Marnix Lueb
Dennis Bitoiu
Ewoud Janus
Gracy Nedev
Thijs Deunk
Daniel Mitev

## Table of Contents

# Chapter 0: Introduction

Once upon a time in a distant land there was a small city called Enschede with 7 pioneers/explorers who took it upon themselves to fix the world and all of its disasters. This group did not get together by accident. They took a hard and rigorous test that was supplied by the university to make the best group humanly possible. The group that formed, consisting mostly of explorers, became the explorers: Dora the Explorahh's!

All fun and games aside, in this second module of CreaTe we got assigned to one major project we can work on during the entire module. The course coordinators, Andreas Kamilaris and Antoine Moghaddar told us in the first conference that the theme of the project this year would be 'Disasters'. They explained that there are not just natural disasters, but also a lot of situations we encounter in our day to day lives that could be improved by a smart solution we have to come up with.
As mentioned before, all students had to fill in an online form to discover what type of teammate we are: A team leader, innovator, executive, explorer, driver, analyst, completer and expert. Based on these results the coordinators made teams that checked the most boxes in all categories, and that is how our wonderful team had formed.
In the following weeks we had a conference every friday morning by Andreas explaining what we had to do for the coming week and giving us some examples on how to tackle that part of the project.

The main problem that we are going to tackle is traffic safety. A lot of crazy drivers are not following the speed limits on the road. So, it is very difficult to estimate the distance between you and a car that drives really fast. For example, this is a situation you encounter when overtaking vehicles. To avoid accidents we should come up with a solution. Our main solution is an electric system, you put on the left car mirror. This product is called LiCar. LiCar is measuring the distance between the cars around you and gives you a signal when a car is coming closer with a higher speed. The signal will be a led that goes on. So, you can be extra careful with overtaking or other maneuvers to avoid accidents.

This document was divided into those steps we had to go through to identify what it is we want to do our project about.

Every step contains one or two chapters, these being:

- Literature review: This chapter contains twenty publications on the general subject and a short summary of each publication, we will use these to identify problems in the next chapter.
- Identification of general problems and challenges:
  Here we will list ten problems and challenges we identified from the publications in the literature review.
- Identification of relevant problems:
  In this chapter we narrow the amount of problems to solve down to the five most relevant problems.
- Problem selection and motivation:

Here we chose the problem we will be working on and explain why this problem is a good choice.

- Potential solutions:
  This chapter shows several solutions we came up with and ideas on working out these solutions.
- Solution selection:
  Here we select and explain the solution we are making: an alarm that can warn drivers for overtaking speeders. Drivers trying to overtake at a high velocity are a common cause of traffic accidents, a device that warns other drivers could make for a reduction.
- Methodology:
  Our methodology shows the organization behind this project.
- Results and conclusion:
  The most important part, containing the results, findings and conclusions we have gathered.

# Chapter 1: Literature Review

Find 20 meaningful publications on the general subject of disasters. Make a summary of each publication

1. https://www.pbs.org/wgbh/frontline/article/katrina-10-years-later-three-documentaries-to-watch/
   Early in the morning on August 29, 2005, Hurricane Katrina struck the Gulf Coast of the United States. The event started with a Category 3 on the Saffir-Simpson Hurricane Scale storm with wind of 100-140 miles per hour. The storm was followed by a Category 3 Hurricane, which led to a dezastruos aftermath (~1200 deaths and a cost of $14.6 billion to rebuild New Orleans)

2. https://www.inyourpocket.com/bucharest/The-Bucharest-Earthquake-of-1977_71569f
   At 21:22, on the evening of March 4, 1977, Bucharest (the capital city of Romania) was hit by an earthquake measuring a whopping 7.3 on the Richter scale. The earthquake lasted for about one minute and the aftermath, for a small country as Romania, was enormous. Around 1500 people died that day, 35.000 buildings were destroyed in just 56 seconds and the estimated cost to rebuild the city was around $2 billion dollars.

3. https://pubs.er.usgs.gov/publication/70162500
   The Tangshan earthquake of 1976 was one of the largest earthquakes in recent years. It occurred on July 28 at 3:42 a.m, Beijing (Peking) local time, and had magnitude 7.8, focal depth of 15 kilometers, and an epicentral intensity of XI on the New Chinese Seismic Intensity Scale; it caused serious damage and loss of life in this densely populated industrial city.

4. disasters:https://www.tandfonline.com/doi/full/10.1080/00076791.2015.1086342
   The **Oaks explosion** on 12 December 1866 killed 361 miners and rescuers at the Oaks Colliery at Hoyle Mill near Stairfoot in Barnsley, West Riding of Yorkshire. The disaster happened when a series of explosions caused by a firedamp ripped through the workings. It is the worst mining accident in England and the second worst mining disaster in the United Kingdom, after the Senghenydd colliery disaster in Wales.

5. .https://www.mdpi.com/2073-4433/11/1/47
   The CampFire was reported on November 8 2018 in Butte County. The fire grew rapidly and became the deadliest and more destructive wildfire in California history. It burned 153 336 acres, destroyed nearly 19 000 homes and killed at least 85 people. It was contained on November 25.

6. https://www.jstor.org/stable/4634648?seq=9#metadata_info_tab_contents
   The Peshtigo fire was a very large forest fire that took place on October 8, 1871, in northeastern Wisconsin, United States, including much of the southern half of the Door

Peninsula and adjacent parts of the Upper Peninsula of Michigan. The largest community in the affected area was Peshtigo, Wisconsin.

7. www.sciencedaily.com/releases/2019/10/191007180051.htm
   Our planet has been baking under the sun this summer as temperatures reached the hottest ever recorded and heat waves spread across the globe. While the climate continues to warm, scientists expect the frequency and intensity of heat waves to increase. However, a commonly overlooked aspect is the spatial size of heat waves, despite its important implications.

8. https://en.wikipedia.org/wiki/2010_Haiti_earthquake
   On the 24th of january 2010 Haiti faced one of the biggest earthquakes ever recorded. Dozens of aftershocks caused major damage in Port-au-Prince and the whole world focussed their help and attention on Haiti. 92.000 deaths and billions of damages were a downfall in this already struggling country.

9. https://edition.cnn.com/2018/05/22/asia/pakistan-heat-wave-wxc-intl/index.html
   Because of climate change in 2018 a heatwave in Pakistan that lasted for a month reaching 40 degrees celcius together with the Ramadan and power cuts caused at least 65 Pakastanians casualties. Most deaths were from poor areas who didn't have the funds to battle the incredible heat.

10. https://www.nytimes.com/2018/12/23/world/asia/tsunami-indonesia-sunda-strait.html
    On december 22 Java was struck on the western coast by a huge tsunami. The waves got up to 5 meters high. Officials believe that the tsunami was caused by an undersea landslide. Because there was no seismic activity beforehand officials couldn't evacuate a lot of people and 280 people lost their lives because of this.

11. https://www.nasa.gov/mission_pages/sunearth/news/flare-impacts.html#:~:text=The%20explosive%20heat%20of%20a,be%20off%20by%20many%20yards.
    Given a legitimate need to protect Earth from the most intense forms of space weather - great bursts of electromagnetic energy and particles that can sometimes stream from the sun - some people worry that a gigantic "killer solar flare" could hurl enough energy to destroy Earth, but this is not actually possible.Solar activity is indeed currently ramping up toward what is known as solar maximum, something that occurs approximately every 11 years. However, this same solar cycle has occurred over millennia so anyone over the age of 11 has already lived through such a solar maximum with no harm.

12. https://journals.sagepub.com/doi/full/10.1177/0018720818786132
    Motor vehicle crashes involving emergency vehicles, such as police cars, fire trucks, and ambulances, have been recognized as a serious problem nationwide (Savolainen, Dey, Ghosh, Karra, & Lamb, 2009). The National Highway Traffic Safety Administration (NHTSA; 2011) reported that 559 law enforcement officers (LEOs) were killed by vehicle crashes during the

period of 2000 to 2008. This accounted for 53% of LEO work-related fatalities in this time period.

13. http://www.iitk.ac.in/nicee/wcee/article/10_vol10_5989.pdf
    In the period 1900-1992, earthquakes caused 1,528,000 deaths, 75% of these were caused by collapsing buildings. People located above the first floor of a building usually cannot get out in less than thirty seconds.

14. https://media.ifrc.org/ifrc/what-we-do/disaster-and-crisis-management/hunger-in-africa/
    Since the end of 2016, the African continent is facing an unprecedented rise in food insecurity. Millions of people are in urgent need of humanitarian assistance, particularly where consecutively poor rainfall, rising food prices and insecurity continues to worsen the situation. At no other time in recent history has severe hunger and starvation loomed so large.

15. https://www.pnas.org/content/111/45/15906
    Following the sinking of the *Deepwater Horizon* in the Gulf of Mexico an unprecedented quantity of oil erupted into the ocean at a depth of 1.5 km. The novelty of this event makes the oil's subsequent fate in the deep ocean difficult to predict. This work identifies a fallout plume of hydrocarbons from the Macondo Well contaminating the ocean floor over an area of 3,200 km2.

16. http://www.bbc.co.uk/sn/tvradio/programmes/supervolcano/article2.shtml
    If the supervolcano in Yellowstone erupts, about 90% of the people within 1000 km of the eruption are estimated to be killed. The biggest killer would be the ash, it spreads very far and can:
    - Kill and sicken humans and animals
    - Reduce sunlight
    - Trigger rainfall causing mudslides known as lahars
    - Severely disrupt air, road and rail transport
    - Crush buildings – 30 cm of dry ash is enough to collapse a roof
    - Contaminate water supplies
    - Kill crops and other vegetation
    - Clog machinery such as air filters.

    Sulphur gas released during the eruption can cause climate cooling, the eruption of Yellowstone would drop the global average temperature by up to ten degrees. The colder weather could cause the failing of harvests, resulting in mass starvation.

17. https://www.nationalgeographic.com/environment/natural-disasters/floods/
    The risk of floods worldwide and the amount of deaths caused by floods are increasing. Floods cause more than $40 billion in damage worldwide annually.
    Areas affected by floods can be contaminated with hazardous materials and there is an increased risk of outbreaks of waterborne diseases.

18. https://www.theguardian.com/environment/2020/aug/29/when-will-the-water-stop-britain-flood-victims-six-months-on
    A month before Boris Johnson gave an order to stay at home because of COVID-19 a flood appeared in East Cowick, a small village a mile south of the River Aire,the flood left families traumatised and homeless. In Earth Cowick and the nearby

town of Snaith flooded more than 100 houses. Britain was overdone with endless rain throughout the winter and a series of Atlantic storms, overwhelmed rivers across the country. Almost 5000 homes were flooded in four months. Then one disaster rolled straight into another. Receding waters left victims in limbo, facing a global pandemic, lockdown and indefinite delays to insurance payouts and building work. In the summer 2019 rivers raged. In November, the Don, which flows through Sheffield, Rotherham and Doncaster, reached record levels. The streets flooded. Roads, railway lines and schools were closed as multiple rivers burst their banks. In December, southern England, a tornado wrote off roofs and cars in Surrey. Then the Atlantic storms rolled in, propelled in rapid succession by an unusually strong and southerly jet stream. Ciara, Dennis and Jorge brought gales and yet more rain. East Cowick was among the last places to be struck as waters rose across a giant belt of northern England, the Midlands and Wales.

19. https://www.theguardian.com/us-news/2020/aug/22/california-farmworkers-wildfires-air-quality-coronavirus

    There are more destructive wildfires arriving with each coming year in California. Low-wage workers who pick up fruit and vegetables are out in the field through wildfire,pandemic, thich smoke(that even muted the sun), drought or storm putting their lives at risk. The workers aren't given protection or face covering, while working through grueling conditions. The safety protocols from the state regulations are often still not always followed.
    In Santa Cruz workers worked without protections for 10 hours when the first day of the fire happened and a lot of thick smoke was in the air. a N95 masker is the only mask that can give protection to wildfires, and after masks were given out to workers, there weren't the N95 maskers. Paid time off and sick days are not an option in this line of work. These days, the climate crisis escalates. Amid the various crises of 2020, we continue to recognise the climate emergency as the defining issue of our lifetimes.

20. https://www.livescience.com/3910-rip-currents-ocean-deadliest-trick.html
    Rip currents are a big problem for beachgoers. Just in the USA alone 100 people drown because of them every year. they are created by irregularities in the shore through which water flows more easily. The water usually reaches speeds of 1 to 2 feet per second, but can go up to 8 feet a second creating a current so powerful even an olympic swimmer can drown to them. These rip currents can be hard to spot for a normal person on the beach, so technical support can help lifeguards greatly. Also information on how to get out of a rip current would be a good idea to spread so people are better prepared if they end up in such a situation.

# Chapter 2: Identification of General Problems and Challenges

Identify 8-10 general problems & challenges from the list of publications in Chapter 1

1. Collapsing buildings as a result of earthquakes cause a high amount of deaths.
2. Heat waves are becoming more common, causing heat stress, casualties and increased electricity usage.
3. Coronal mass ejections (CME's) can destroy or disrupt most electronics.
4. Few information about traffic ahead, causes multiple deaths.
5. People talking on the phone while driving, causing serious fatalities.
6. Starvation causes lots of deaths and problems in 3rd World countries.
7. Oil wells can get destroyed by waves or malfunctions, resulting in water pollution.
8. The eruption of a supervolcano can cause a very high amount of deaths, caused by the initial eruption, ash and the resulting change in climate.
9. The worldwide risk of floodings is increasing, and with it the amount of deaths caused by floods, contamination and outbreaks of waterborne diseases.
10. The health of plucking workers decreases when working in disaster times like wildfires and air pollution, but since the pandemic it got even worse.
    Also poverty plays a major role, because most of the time these workers are immigrants, who have no papers to stay and if they refuse once their work because of a disaster, which is plucking vegetables or fruits, they will be laid off.

## Chapter 3: Identification of Relevant Problems

Identify 5 new problems you find relevant, urgent and interesting, not yet been addressed effectively

1. Heat waves are becoming more common, causing heat stress, casualties and increased electricity usage.
2. Few information about traffic ahead, causes multiple deaths.
3. Starvation causes lots of deaths and problems in 3rd World countries.
4. The eruption of a supervolcano can cause a very high amount of deaths, caused by the initial eruption, ash and the resulting change in climate.
5. The worldwide risk of floodings is increasing, and with it the amount of deaths caused by floods, contamination and outbreaks of waterborne diseases.

# Chapter 4: Problem Selection and Motivation

Select off the list of the 5 problems identified in Step 1, one problem you would like to work on for your project. Motivate your choice

1. Few information about traffic ahead, causes multiple deaths.

**Why is this a problem?**

- When visibility on the road is very low due to sudden mist/snow or heavy rain the chances of a casualty tend to double.
- high speed vehicles like emergency vehicles are sometimes, despite their sirens/lights and bright colours, hard to spot and can be a surprise to drivers (a dangerous situation)
- Approximately 1.35 million people die each year as a result of road traffic crashes.
- Road traffic crashes cost most countries 3% of their gross domestic product.
- Road traffic injuries are the leading cause of death for children and young adults aged 5-29 years.
- (Road traffic injuries (who.int))
- In 2019, an estimated 22 800 road traffic fatalities were recorded in the 27 EU Member States.
  (https://ec.europa.eu/commission/presscorner/detail/en/QANDA_20_1004 )

**Potential Solution:**

During our brainstorming about this problem we had an idea to solve this problem: a device you can put in your car that has a connection with the same device in other cars. It can sense speed and distance in relation to other cars with this device, giving it the ability to tell if you are nearing a traffic jam with high speed or warn you about an emergency vehicle nearby and prevent collision or dangerous situations.
There are applications on your smartphone that tell some of this information, but not everybody has a smartphone or uses it all the time in their car. This device can be made mandatory in all road legal cars, giving everybody access to this information.

# Chapter 5: Potential Solutions

Find 5-8 potential solutions to your problem. Explain how these solutions could work

1. **Sensor that detects the radio volume in the vehicle.**
    - most of the vehicle crashes are caused due to a high radio volume. People are getting distracted by the radio, therefore they are not paying enough attention to the road. We will try to implement a sensor that detects the sound in a vehicle, and it will alert the driver to decrease the volume.

2. **A box or embedded software system in the car.**
    - The solution is a system that communicates with other vehicles. This is very important to prevent delays for emergency vehicles, like the ambulance, police, fire truck etc. Also, you can prevent traffic, bad roads, a closed road or incidents that are not given on the GPS, bad weather conditions.
    - We were thinking about a communication tool.
    - Lidar ? This uses lasers impulses to measure the distance between objects.
    - radar? antenne? This uses sound impulses.
    - bluetooth? 4g?wifi? infrared radiation? frequencies?
    - with the speed of light? There doesn't exist a device that uses the speed of light to measure distances or passing/sending signals yet.
    - A signal from the embedded software embedded box, that reaches a lot of car's boxes, instead of communication that only goes from one car to another.
    - These boxes can communicate with digital boards, to show what is going on the roads to other drivers.

3. **Radar gun to avoid collision.**
    - Radar gun mounted in front of the car that can detect if something is in front of you and warn you if the distance is rapidly decreasing between you and the object. This system can help with a traffic jam that is not that visible in e.g bad weather conditions. Some cars already have this system for adaptive cruise control and an emergency brake assistant (which is kind of similar to what we want to do with it), but maybe we can make a separate device that can be installed on all cars relatively inexpensive. The gun will give a signal to a LED on the dashboard to give you the information to respond and hit the brakes/slow your speed.
      (Universal adaptive cruise control)

4. **Color changing street lights.**
    - street lights that change color depending on the type and amount of vehicle under it. The lights could be blue when an emergency vehicle drives underneath it and be red above a lot of slow driving cars. This solution would make it easy to spot traffic stops and emergency vehicles easier and at longer distances.

(LED strip on the crash barrier lighting up the track and inform about ambulance)

5. **QR code scanning for detours due to construction work**
   - when you stumble upon a roadblock that was not in your navigation you have to take a detour. Usually there are boards placed to show you some routes to get to the destination you originally wanted, but this can be combined by a QR code which the auto can scan and you can select which detour you want to follow (eg. by voice activation), so your navigation system follows the same route the boards show you, making it impossible for you to miss a direction/ reduce the stress you get by suddenly having to look actively for your route. (Use google api to add points to follow the detour)

6. **Speeding alarm**
   - a velocity meter that makes noise when the car it's on is driving faster than 100 (or 120?) km/h. This would warn other drivers and possibly nearby police. The device would have to be obligated for it to work properly.
     (put a sensor in the mirror and measure the speed of an approaching car to measure if things are safe. )

7. **Information about freight traffic**
   - Trucks or other vehicles on the road that are transporting goods are usually slower and can block faster pace traffic when there is a one-lane-road. These trucks can share their location with a route planner like google maps so that the system can inform other people if there are a lot of slow moving trucks on a road they want to use and maybe give them an alternative route which could be faster. This could reduce the amount of cars on a particular road and improve traffic flow for trucks and normal cars.

# Chapter 6: Solution Selection

Select 1 solution. Motivate your choice. Explain why you selected this solution over the other candidate solutions you found

We approached the selection of our final solution and thus the project we will be working on for the next couple of weeks by the following points we came up with:

- The product must not rely on participation with all road-users because that would be an unrealistic situation. There will always be people who don't want to use the product and this will harm the user experience of people who do want to use it. An individual should be able to get the product and improve their own life with it.
- The project must be feasible for us and thus we should not choose something we, people who are mostly new to programming, cannot finish in the given time. of course we want to (and we are going to do :)) the best we can, but we have to choose wisely. A great solution to this is choose something we know we can work on and add things later to it if we have extra time, so we will have a final project either way and we can make it more challenging along the way.
- Finally the project must be presentable.

After receiving feedback and having a meeting with our course advisors/ teachers we came to the conclusion of choosing solution **number 6: the speeding alarm**. Now before we explain why we would like to show our thought process:

- For solution 7 our teacher mentioned that trucks should not share their location to other people all the time because they are shipping valuable goods and this would make them much more vulnerable targets to theft crimes.
- Solution 1 would be a too simplistic project on its own, and features like this already exist in some cars so it would not make a huge impact, but maybe we could do this as a bonus feature to another project.
- Solution 2 would rely too much on participation from every car on the road. If one car is not using it the sensors cannot detect it or send information to it and thus make the device useless.
- Google maps already finds a new road on its own when a road is under construction and is closed, so solution 5 wont make a huge improvement or impact and it is a bit difficult to demonstrate.
- Solution 5 we thought was a great idea, but maybe a bit too distracting for drivers. for example, when you suddenly see the lights of a highway turn red your most likely response would be to brake, and this behaviour can cause more harm than we would prevent in the first place. Also it would take a long time to change all the lights of the highway and other roads.
- Our teacher mentioned that most sensors are mostly as good as / worse than human senses, so solution 3 would not make that much impact, it is more important to keep their senses on the point of potential danger. Also we think this project is too simplistic to be a project on its own, but it can be a great feature to add to another project later on.

this proces left us solution 6:
We envision a sensor on the mirror(s) of and a device in the car that can warn you for a reckless driver on the road next to you.

- This project will be accessible for everybody that wants to improve their car and does not rely on participation of a person other than the user him-/herself.
- It is a project we think is feasible for us, and we can combine it later with for example the radar gun or the volume dimmer we mentioned above to further improve one's safety on the road.
- Also in terms of presentation we have some ideas: make a video on an empty parking lot with our own cars traveling at very different speeds (e.g. 10 and 50 km/h, and certainly not above 120!!!)

To measure the car we want to use an independent source like gps so we could use it for older cars, but we can challenge ourselves to connect with the digital speedometer of modern cars. The project can be modular in the way that some people find a solution to measure the speed of our own car and some find a solution to measure the speed of the approaching carWe all thought this would be a very interesting project and we are looking forward to working on it!

# Chapter 7: Methodology

Think of your methodology* to follow: Which equipment you need, data collection, data use/analysis

**Data plan 1:**

| needed: | collection: |
|---|---|
| speed of the car the device is on | GPS |
| speed of the overtaking car | LIDAR |
| what the results of using the product are | prototype and testing |

data usage: defining the relative speed between two cars (Vcar1 - Vcar2).

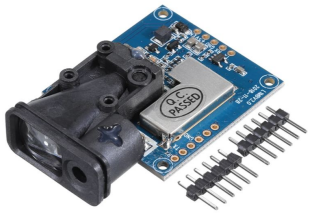
**Data plan 2:**

| needed: | collection: |
|---|---|
| speed of the car the device is on | simulation variable set on arduino uno |
| speed of the overtaking car | ultrasonic sensor |
| what the results of using the product are | prototype and testing |

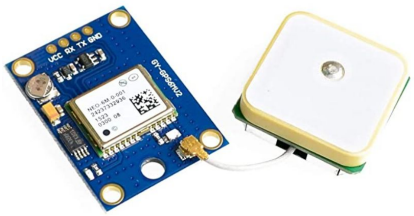
data usage: defining the relative speed with a formula for speed, with the use of a distance measurement of the ultrasonic sensor.

**equipment plan 1:**

LIDAR-Uses laser light and then measures the reflection with a scanner. Distances in laser return times and wavelengths and can then be used to make 3D representation.



GPS module: The car's positions will be measured with the GPS. The GPS will mainly locate the cars around your car , try to find out where exactly the cars are and measure the speed of the cars.



GPS antenna: This is a tool to help the GPS module locate the cars.
ICQUANZX GY-NEO6MV2 NEO-6M

arduino - we are going to use the arduino Uno we got in our Create-kit.
power source - a 9V battery with a connecter which can connect straight to the arduino
LED - a red LED to indicate danger
wiring
material for a case

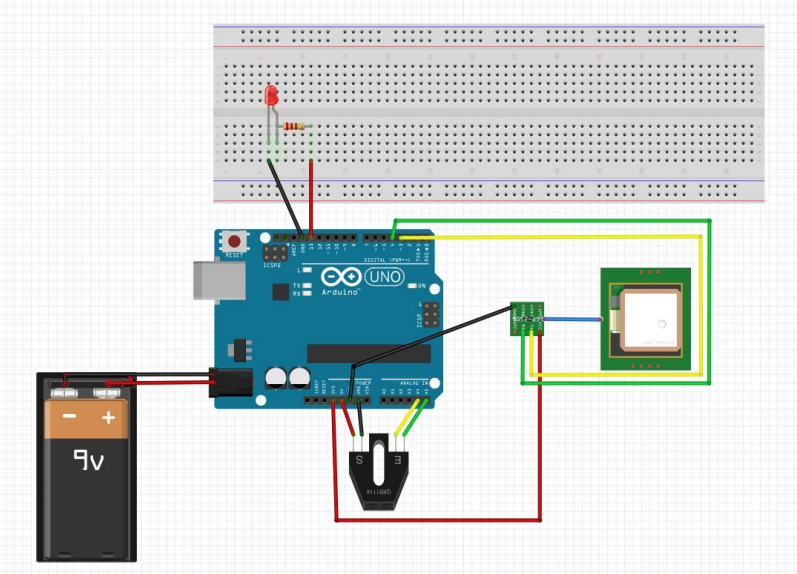
**equipment plan 2 :**

ultrasonic sensor - to measure the distance and speed of the passing car
arduino - we are going to use the arduino Uno we got in our Create-kit.
power source - a 9V battery with a connecter which can connect straight to the arduino
LED - a red LED to indicate danger
wiring

**Design:**
To measure the speed of the incoming car we have to measure the distance change between the car you are in and the incoming car. To do this we wanted to use a Lidar for the other car, GPS for our own car following our first plan, but in our real prototype we used an ultrasonic sensor and an indication light on the mirror to make the driver aware and thus warning them.
We discussed how we would want to mount everything in the car. We started with putting the ultrasonic sensor on the mirror and the arduino and LED inside the car on the dashboard, but this would mean we would have to route a wire from inside the car to the outside, which is a bit difficult without ruining the car. The better option in our opinion would be to mount everything in a small housing on the mirror outside the car. The LED would be clearly visible for the driver because the mirror is located in the field of view of the driver.
We made a sketch of this design which looks like this:

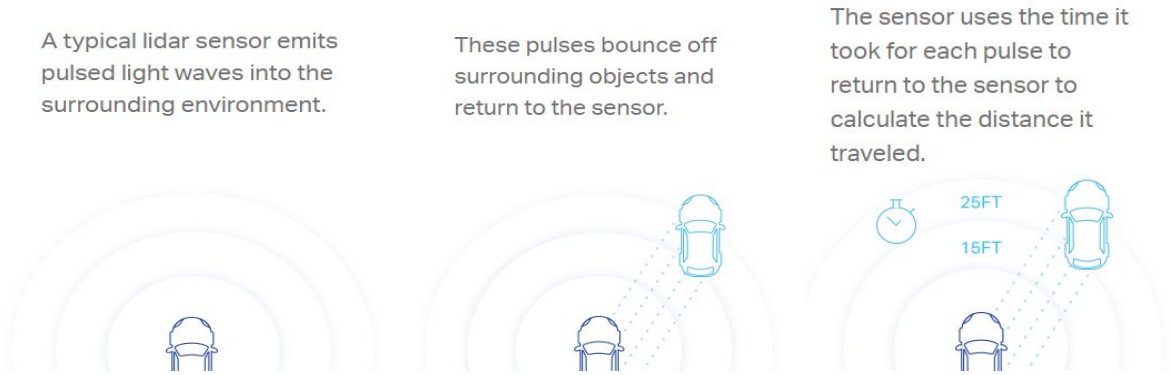
because we do not have access to the design lab or smart xp due to the lockdown we don't think we can make a nice housing, but if we have possibilities and some extra time we want to make this also.

the wiring of our project of plan 1 would look like this:




the GPS (green parts) will give us the data to measure the speed of our own car by the formula: speed = distance/time (v=d/t). The lidar will give us a distance between our car and the car that is overtaking us and we can measure its relative speed with the same formula. if the speed of the overtaking car is much higher, the LED will turn on to let the driver know a vehicle is going to overtake him with a high speed. the driver will be more alert and wont make a turn to the left without looking.

Here you can understand how the LIDAR sensor actually works:




**Team roles:**
To make our project we have the following team planning:

**Marnix**: Team leading, management, coordination /casing.

**Thijs**: Casing, Hardware purchase and wiring.

**Dennis**: Research on the way to measure distance: Radar/Lidar /programming

**Gracy**: Presentations Feedback and Documentation

**Ewoud**: Programming/ data analysis

**Daniel**: Programming/ prepare final demo

# Chapter 8: Results and Conclusion

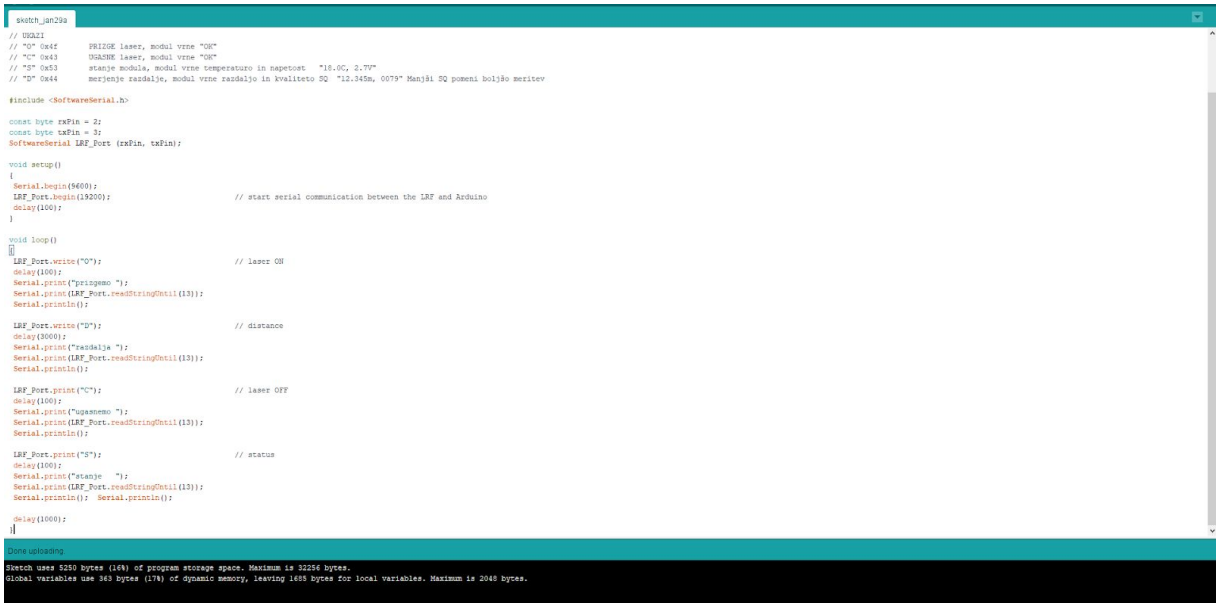
## Limitations

What a pity, we are not able to follow our planning entirely. We have some problems with our product LiCar. Our biggest limitation is the dysfunction of the most important elements, the lidar and GPS. Although its delivery took longer than we expected, and after we found out the lidar isn't working as well we had 2 days left for saving the project, we needed to change our plan as fast as possible. This means that we needed to change our planning and try to replace the lidar element with another element, and simulate the readings of the gps that would have given us if it was operational. So, we decided to use an ultrasonic sensor and a variable with the speed of 10 km/h to save our project.

We hoped the project would be fully operational the way we intended it by the time we have to present our project, but the circumstances were different than expected and a lot changed unexpectedly.

Our original plan was more like this:
The Lidar element should have arrived 2 week before so we could have used the Lidar to measure the distance between cars, which should be fast and accurate. With the GPS we then could measure the speed of your car to see if the relative speed of the other car is too fast compared to your own speed. The GPS and the LIDAR should be connected together with the arduino. So, when a car is driving with a high speed towards you, the led of the LiCar will go on and you will be aware of the possible danger of a car that will approach you with a fast speed.

In the picture below , you see a lidar code we found from the link Andreas provided us with. It didn't give us errors, but it also didn't show any coordinates. We have searched and looked for more information on the internet , but we weren't able to find a code that works. We don't know the correct part number and the correct library we need to use.



We had used a certain gps code without errors, but it didn't give us any coordinates. So, we have the same problem as the lidar code. The code works , but the sensor doesn't measure anything . Below, you can see the code we used for the gps.

picture of gps code which is not working

But after discussing our new plan arose :
We replaced the lidar with the ultrasonic sensor to measure the distance, and with the measurements of the distance we used a formula to calculate the speed of the passing car, which apparently worked. The speed of the slow car needed to be replaced as well. We replaced the speed of the slow car with a variable speed of 10 km/h in our arduino code.

Then, we were able to test our prototype.
When someone who drives with a high speed overtakes another car, a led light will warn you of danger. Our prototype worked. It was a big relief to have a prototype that works.

We are not able to follow our planning entirely. We have some problems with our product LiCar. Our biggest limitation is the lack of a certain element, the lidar. We bought the lidar element, but its delivery took longer than we expected and it still hasn't arrived yet. This means that we need to change our planning and try to replace the lidar element with another element, or maybe even better to simulate the readings the lidar would have given us if it was operational. In this way we can check if the other components and the code is functional and will give good readings, and we can easily add the lidar later this week when it will arrive. We hope the project will be fully operational the way we intended it by the time we have to present our project.

Our original plan was:
The Lidar element should have arrived this week so we could have used the Lidar to measure the distance between cars, which should be fast and accurate. With the GPS we then could measure the speed of your car to see if the relative speed of the other car is too fast compared to your own speed. The GPS and the LIDAR should be connected together with the arduino. So, when a car is driving with a high speed towards you, the led of the LiCar will go on and you will be aware of the possible danger of a car that will approach you with a fast speed.

```
int speedCar1;
int speedCar2;
float currentLidarMeasurement;
float previousLidarMeasurement;
float timeInterval = 1/30; //because of the 30 HZ measurements of the Lidar
float distanceTraveled;
boolean recklessDriver;

 currentLidarMeasurement = Lidar.meassure();
 previousLidarMeasurement - currentLidarMeasurement = distanceMeasured;
 speedCar2 = distanceMeasured / timeInterval
 previousLidarMeasurement = currentLidarMeasurement;
```

This way by taking two different moments in the measurements of the Lidar we can see what distance the car has traveled in the time interval the Lidar measured it. Dividing that by the time interval gives us the speed of the second car. We made this code for the lidar, but later on we used this code and changed it a little bit for the ultrasonic sensor.

## Discussion

There are always ways to improve our product. One of the ways to improve our product is to involve an expensive lidar and GPS . We had two days left after we found out the lidar didn't work as well, we were able to save our project within 2 days.
I think we all underestimated how much collaboration will be limited due to the corona situation we are in. Wiring and coding is difficult to discuss together online and it took more time to realize the project we would have liked. We are trying to get the best out of it despite the corona crisis and its limitations. Also for the late lidar part: we could have ordered the Lidar earlier, but we didn't expect the shipping to take 3 weeks. due to corona shipping is delayed in a lot of ways, but we did not account for it because we ignored the fact that in december many people order online and this would also give a delay to shipping.

Another way to improve the product drastically is to use a lidar with higher capabilities and which is able to measure distances far greater than the current module we use(which measures a distance of 40 metres). If you can measure from a greater distance the driver will be notified even sooner of an approaching car and this will enhance the experience and safety even more. The reason why we didn't use such a better lidar sensor is because they are very expensive and the budget did not allow this.

Because we were so tight on the budget, we decided to use a somewhat cheap GPS unit and Lidar. one downside of this will be that it won't be as accurate as a more expensive one, but we thought we could work with this inaccuracy, but it turned out that these elements weren't working at all.

In the end we used a less accurate ultrasonic sensor. The car will be traveling at a high speed on the highway, so small inaccuracies won't be that noticeable and if you drive a constant speed, which is most likely the case, the sensor will be accurate enough to make the project work. If we had more budget it would be better to use a more expensive accurate GPS unit and lidar in a real world product, but for this showcase-project the cheaper one ultrasonic sensor will be fine.

We think if we had more time and resources we could have used some extra steps to remove noisy/incorrect measurements. For example a camera could be used with A.I. technology to recognize cars so we can be sure that is the only thing being measured. A buffer could be added so when the car hits a bump and the lidar measures something

different for a split second it disregards it. The GPS could also be connected to google maps so it recognizes when the car is driving on more than multiple lanes so the lidar only has to be on where it needs to be, saving battery and lifespan of components. Another improvement would be an interactive touch screen in the mirror of the car, which also contains A.I , where you can add a camera in the mirror to recognize other cars as in the previous improvements.

There are always ways to improve our product. One of the ways to improve our product is to involve the lidar. When the lidar arrives on the weekend, we will try to connect it with our product if there is time left and we will try to connect the Lidar before the demo presentation. I think we all underestimated how much collaboration will be limited due to the corona situation we are in. Wiring and coding is difficult to discuss together online and it took more time to realize the project we would have liked. We are trying to get the best out of it despite the corona crisis and its limitations. Also for the missing lidar part: we could have ordered the Lidar earlier, but we didn't expect the shipping to take 3 weeks. due to corona shipping is delayed in a lot of ways, but we did not account for it because we ignored the fact that in december many people order online and this would also give a delay to shipping.

Another way to improve the product drastically is to use a lidar with higher capabilities and which is able to measure distances far greater than the current module we use. if you can measure from a greater distance the driver will be notified even sooner of an approaching car and this will enhance the experience and safety even more. The reason why we didn't use such a better lidar sensor is because they are very expensive and the budget did not allow this.

Because we were so tight on the budget, we decided to use a somewhat cheap GPS unit. one downside of this will be that it won't be as accurate as a more expensive one, but we think we can work with this inaccuracy. the car will be traveling at a high speed on the highway, so small inaccuracies won't be that noticeable and if you drive a constant speed, which is most likely the case, the sensor will be accurate enough to make the project work. if we had more budget it would be better to use a more expensive accurate GPS unit in a real world product, but for this showcase-project the cheaper one will be fine.

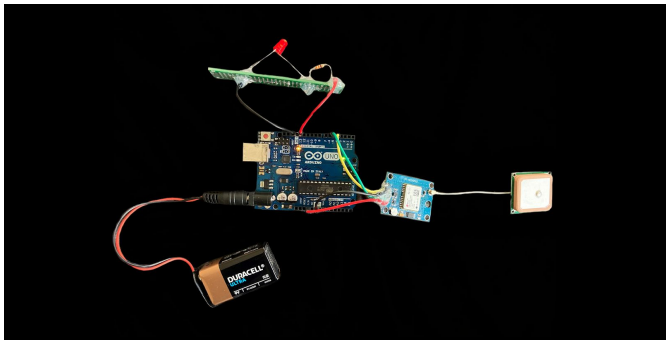
We think if we had more time and resources we could have used some extra steps to remove noisy/incorrect measurements. For example a camera could be used with A.I. technology to recognize cars so we can be sure that is the only thing being measured. A buffer could be added so when the car hits a bump and the lidar measures something different for a split second it disregards it. The GPS could also be connected to google maps so it recognizes when the car is driving on more than multiple lanes so the lidar only has to be on where it needs to be, saving battery and lifespan of components.

## Results and findings

**The first idea was to use a lidar and GPS, but that didn't work out. So after the first plan didn't succeed, we came up with a second plan. This second plan is to use an ultrasoon sensor to measure distance and the speed of the car.**

**First plan :**

**Setup:**
This is the current setup including arduino, power source, LED indicator, GPS module and GPS antenna:



**GPS:**
"If we assume normal walking speed is around 3kph, the GPS gave us an output of 3,43358 kph, which is fairly accurate"

```
void loop()
{
  while(serial_connection.available())//Whi
  {
    Serial.println("GPS Start1");
    gps.encode(serial_connection.read());//
  }
  if(gps.location.isUpdated())//This will pr
  {
    //Get the latest info from the gps objec
    Serial.println("GPS Start2");
    Serial.println("Satellite Count:");
    Serial.println(gps.satellites.value());
    Serial.println("Speed MPH:");
    Serial.println(gps.speed.mph());
    Serial.println("");
  }
}
```

The Gps Tracker is set to measure the speed in MPH per hour by default so we use a small calculating operation to transfer in to kph.The code above is fairly simple it goes into the first while loop when there is an available satellite to transfer information into the GPS unit about its current altitude Latitude and speed, however for our project we simply use the speed readings.The Gps then receives the information and prints out the desired readings which in our case is only the speed and the number of available satellites.

**Lidar/code:**

It is a real bummer that we do not have a Lidar module to test the functionalities of it and get some results, but as mentioned before we opted to simulate the readings a lidar would have given us. in our code at this point in time, you can set the speed of the approaching car to a fixed value in a variable ‘speedCar2’. to make testing easier to do and being able to run these tests for the rest of the code whilst being stationary behind a desk, for now we are giving the speed of your own car (normally measured by the GPS module) also with a fixed value in a variable ‘speedCar1’.

if we simulate a dangerous situation, where you are driving on the highway with a normals speed of 100km/h and the other overtaking car is driving recklessly at 130km/h (over or equal to 30km/h faster), the LED will turn on:

```
  speedCar1 = 100;
  speedCar2 = 130;
  recklessDriver = false;
  pinMode(13, OUTPUT);
}
```

```
if(speedCar1 +30 <= speedCar2){
  recklessDriver =true;
} else{
  recklessDriver = false;
}

if (recklessDriver){
  digitalWrite(13, HIGH);
} else{
  digitalWrite(13, LOW);
}
```

speedCar1 will be less or equal to speedCar2, which will set the boolean 'recklessDriver' to true, and if this is not the case anymore because the car slows down or has passed you the boolean will be set back to false.

if the boolean is set to true, pin 13 of the arduino will get a high output, turning on the LED. if the boolean goes back to false again then pin 13 will get a low input and the LED will turn off.

| **'speedCar1' value** | **'speedCar2' value** | **LED behaviour (On/Off)** |
|---|---|---|
| 100 | 100 | Off |
| 100 | 130 | On |
| 100 | 129 | Off |
| 130 | 180 | On |
| 130 | 100 | Off |
| 130 | 140 | Off |

This testing shows that the code works and that the LED will turn on in dangerous situations (over 30 kmph more) and will stay off in normal overtaking conditions (10kmph more).

because we took a speed margin of >= to 30 kmph, this behaviour will also scale in the lower speeds. For example:

| **'speedCar1' value** | **'speedCar2' value** | **LED behaviour (On/Off)** |
|---|---|---|
| 50 | 55 | Off |
| 50 | 80 | On |

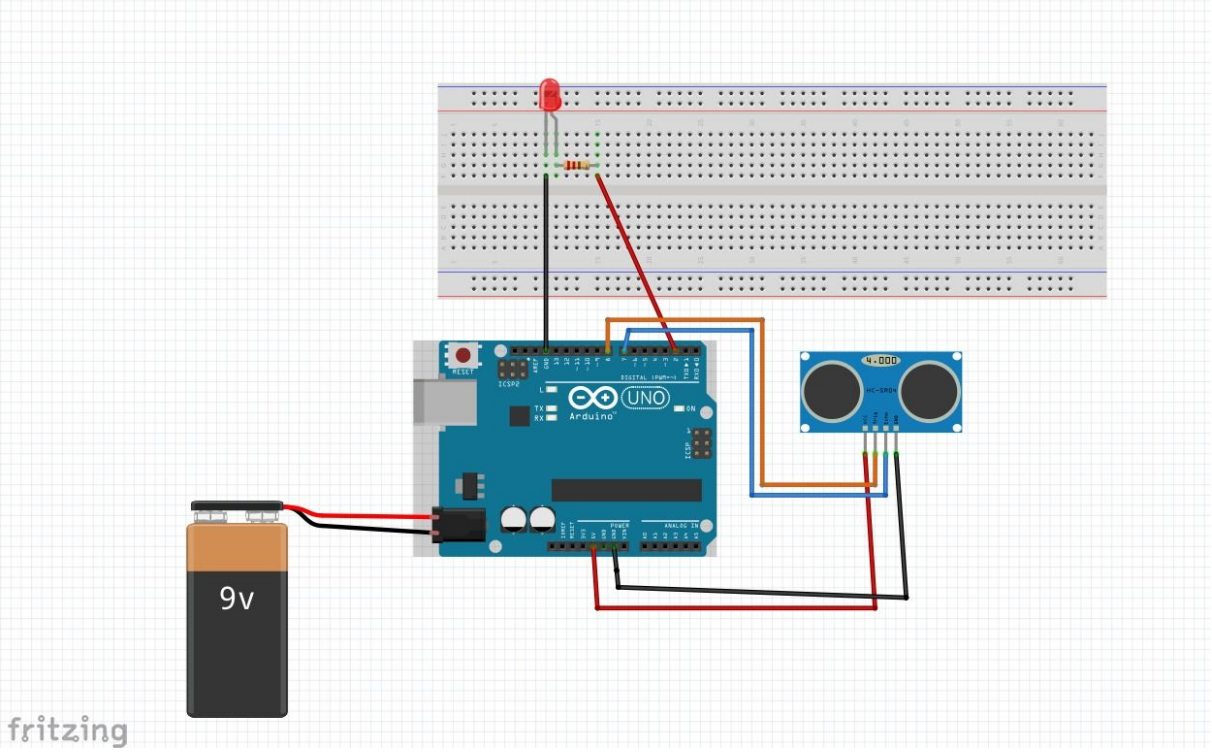
| | | |
|---|---|---|
| 50 | 100 | On |
| 50 | 45 | Off |
| 30 | 40 | Off |
| 30 | 65 | On |

even though these results considered dangerous for the ones with the LED on and relatively safe for the ones with the LED off we don't think these result matter too much, because the lidar will sense the speed of the car that is overtaking you and there aren't many roads where the maximum speed is 50kph and consists of multiple lanes where you can be overtaken, and even in those situation people tend to not drive that much faster as they would on a highway. So on those multiple lane roads where you can go 50kph people would most likely drive 60 or maybe 65 kph, but this isn't as dangerous as on the highway where people tend to drive much faster.

**Second plan :**

**Setup :**

This setup of plan 2 works, including a 9 V battery, Led, resistor, ultrasonic sensor.



**Arduino code :**

LiCar_Smart_Environments_project_module_2

```
/* LICAR
-- This code uses an HC-SR04 module to measure the distance between an overtaking car and you. With use of the time interval between 2 readings we can determine the speed of the other car.
-- Licar can inform the driver, with use of an LED, if a car is going to overtake them with a huge speed difference so the driver is allerted and can be aware of the dangerous situation.
-- Licar is made by:
----Dennis Bitoiu
----Ewoud Janus
----Gracy Nedev
----Thijs Deunk
----Daniel Mitev
----Marnix Lueb
This is a project we made for the Smart Environments project in CreaTe module 2, assisted by Andreas Kamilaris and Antoine Moghaddar.
date: 11 November 2020 till 28 January 2021
*/

#include <SR04.h>

#define TRIG_PIN 8   //the send signal pin is connected to pin 8
#define ECHO_PIN 7   //the receive signal pin is connected to pin 7
SR04 sr04 = SR04(ECHO_PIN, TRIG_PIN);
long thisDistance;
float previousDistance;
float measuredDistance;
float speedCar1;
float speedCar2;
boolean recklessDriver;
unsigned long time;

void setup() {
  //Serial.begin(9600);   All the commented serial code in this code can be used to see in the serial monitor what data you are getting, ideal for troubleshooting.
  //delay(1000);
  speedCar1 = 10;   //the speed of our car is 10km/h (ideally we would have used a GPS module to detrmine our speed, but ours didn't work so we have to set it to a default value)
  recklessDriver = false;
  pinMode(2, OUTPUT);   //an LED is connected to pin 2
}

void loop() {
  thisDistance = sr04.Distance();
  //Serial.print(thisDistance);
  //Serial.println(" cm");
  measuredDistance = previousDistance - thisDistance;   //with this simple formula we can determine the speed of the other car
  speedCar2 = measuredDistance / 0.1;   //we use 0.1 because we measure every 100ms (0.1s).
  //Serial.print(previousDistance);
  //Serial.println(" cm");
  previousDistance = thisDistance;

  //Serial.print(speedCar2 / 100);
  //Serial.println(" m/s");

  //Serial.print(speedCar2 / 100 * 3.6);
  //Serial.println(" km/u");

  if (speedCar1 + 50 <= (speedCar2 / 100 * 3.6)) {   //this determines if the other car is going 50 or more kilometers an hour faster than our car.
    recklessDriver = true;
  } else {
    recklessDriver = false;
  }

  if (recklessDriver) {
    digitalWrite(2, HIGH);
    time = millis();   //this resets the timer meganism we use in the else statement
  } else {
    if (millis() >= time + 5000) {   //this line lets the LED only turn off after 5 seconds of it being on to make shure the driver can see it.
      digitalWrite(2, LOW);
    }
  }
  delay(100);   //we measure every 100ms (0.1s) to easily determine the timeinterval between 2 measurements
}
```

In this arduino code, we measure the distance and the speed of the car. If the speed of the passing car is bigger or equal to 60 kilometers per hour ( or 50 km/h faster than the slow car) the led lamp will light up for 5 seconds. All comments explain the code more in detail. We are able to measure the distance and the speed of the car that is passing with the ultrasonic distance sensor, so we replaced the function of the lidar and gps by the ultrasoon sensor and a variable. The GPS should measure the speed of the slow driving car, which we now replace by a simulation variable of 10 km/h. The ultrasonic sensor senses the distance. We use a simple formula to measure the speed: (distance 1 - distance2) / time. We measure the time every 100 ms.

## Conclusion

In conclusion, we think our product would be of great value for real world everyday use. In the time passed during this module and thus during the time we were working on the project 2 of the members of the team who drive to school regularly have had multiple occasions when they got overtaken by cars that were going at least 30+kph faster than themselves. a small notification in your field of view would be enough to be notified and ready on such occasions and would reduce the shock you get from them. We think it is Important to be able to drive as calmly as possible and we need to eliminate such surprises during high speed travel.

We tried to make the best of it, without the 2 most important components of our project. We have been struggling with the GPS and the lidar. Our budget was not that big, so we assume we bought the cheapest elements and that results in a not working gps and lidar. One member of our team also assumes that we have put the GPS in a 5 V, while it should be a 3,3 V in the arduino, so maybe we burned the GPS component, because it has never shown coordinates. But that member of our team wasn't there when we tried the gps component and the bigger part of our team thinks it has never shown coordinates, even before trying out different methods of trying to get it work. We should have taken into account that cheap elements are not always reliable, but we didn’t want to exceed the budget. We were even more disappointed when we found out that our lidar wasn’t working as well. So, we needed as fast as possible a new solution in this emergency situation. We had lost hope and were so disappointed until we found out that we have an alternative solution for this problem.

God bless that one team member who had a distance sensor with echo at home . Instead of losing courage, we needed to think like a team and come up with a code for the ultrasonic sensor as fast as possible and to figure out how it works, because we didn’t have time to buy more expensive gps and lidar components and the end date of the project was getting closer and closer. We stayed calm very professionally and gathered our knowledge together to finish our new plan as fast as possible. The solution to save the project was an ultrasonic distance sensor and we did save the product with this new plan. The most important part was that our new product worked, it measured the speed of the other car that was passing the slow car. The speed measurement of our ultrasonic sensor is accurate, the speed of the car can be 3 or 2 kilometers less or more than the real speed of the car. But this is also a prototype with a cheap sensor, if we used a more expensive sensor we should have measured a more accurate speed. This works quite good for a cheap sensor.

As a team we were very happy and proud how we solved this problem quickly. Because of our research and trying to get the gps working, we were able to figure the code easier out. So, in the end this big problem was solved.

The new product we have created functions really well in real world situations (with the ultrasonic instead of the lidar and the simulation variable instead of the gps). The ultrasonic sensor is capable of measuring speed accurately enough for us to be able to use the reading

properly and The LED we are using  is bright enough to be clearly visible in broad daylight and notify you if a potential danger occurs.

We have mounted it to the car on the left mirror with our own improvised casing.
It is a real shame that we could not complete our first plan and we needed a new plan in the hope that the new plan will work, but after simulating the gps measurement it has given us the new product which works really well. It gives an accurate output with the warning LED and we think that if we used more expensive lidar and gps , our measurements would be really accurate.
After all, we are really proud of what we came up with/made and maybe Licar will become a new standard on cars in the future. We are also surprised how fast we came up with another solution and worked as a team. We went through a lot of problems, but in the end we made our solution as best as we could despite being limited with the most important elements who were not working. We all learned a whole lot from this module's project and we are looking forward to another challenge.

The product we have created functions really well in real world situations (except for the lidar part of course because we don't have that).It is a real shame that we could not complete our build due to the missing lidar, but after simulating the measurements it would have given us the product works really well. it gives an accurate output with the warning LED and we think the lidar would really finish the build off.