Engineering Design 4WBB0 2017-2018 Group number: 96	
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1. Group Effectivity (max 2 pages).

2. Requirements, Preferences and Constraints

Requirements

The maximum height and width of the device:	30 x 30 cm
The device can reach a top speed of least:	2 m/s
The device can transport minimum of:	1 casualty
The battery life of the device is at least:	15 minutes
The device is able to turn:	360 degrees
The device can transport at least	500 grams.

Preferences

Transport of casualties	As safe as possible
Waterproof	Able to drive through small puddles
Weight	As light as possible

Constraints

Wireless communication	Wi-Fi using the Arduino
Manufacturing	Cost less than 70 euro's
Working environment	Ability to operate in disaster areas

3. Functions

Move in any direction The ROD can move and turn 360 degrees.	Option 1. Tracks Option 2. Wheels like a car Option 3. Flying using propellers Option 4. Flying using hot air Option 5. Hoover Option 6. Jump like a frog Option 7. Rolling like a ball Option 8. Wheels – three wheels on each side Option 9. Spider legs Option 10. Legs like a human

Boarding casualties The device can board a casualty	Option 1. Vacuum balloon gripper Option 2. V-shaped grapping arm Option 3. Fork lift Option 4. Shovels sideways Option 5. Grapping them with sponges Option 6. A stinking arm Option 7. Sucking up the casualties Option 8. Conveyor belt Option 9. A rope Option 10. Reverse windscreen wiper mechanism

Transport casualties The ROD can transport a casualty from the disaster area to a save environment.	Option 1. Holding the casualty in the boarding device Option 2. Net on top of the robot Option 3. Hammocks Option 4. Soft platform on which the casualties lie. Option 5. A storage compartment inside the ROD Option 6. Dragging along a soft pillow like platform Option 7. A ball pit with balls of foam Option 8. A big box on top of the robot with slots Option 9. A box with layers on top of each other Option 10. Bunk beds

Remove/avoid obstacles The device can clear an area of any other	Option 1. Blowing debris away Option 2. Broom/sweepers Option 3. Explosives Option 4. Sticks that push

restricting objects or debris or can avoid them.	obstacles away Option 5. Jump over obstacles Option 6. A shovel Option 7. A hammer Option 8. A grabbing device Option 9. Snowplow Option 10. Suction cup arm

Move in different velocities The device can move in different velocities to get to casualties fast but is able to approach them slowly	Option 1. Brakes Option 2. Block in fort of wheels to stop Option 3. Use a motor that can control its RMP's Option 4. Change the ROD's weight Option 5. A Gear box Option 6. Use different size wheels Option 7. Use a blower on both sides to slow down Option 8. An electronic resistor Option 9. Having two motors Option 10. Have different power sources with different max output.

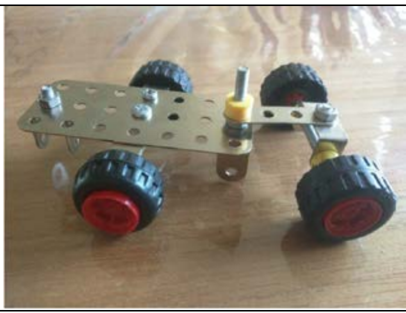
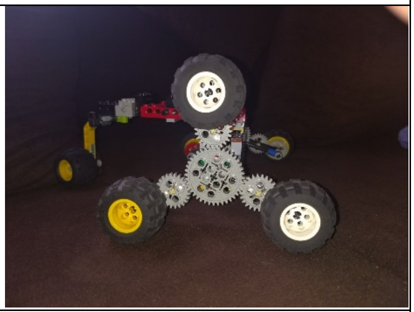
Search for casualties The ROD can scan the environment and find casualties	Option 1. Camera Option 2. Infra-red vision Option 3. High frequencies echoing like bats Option 4. Night vision Option 5. Lights Option 6. Heat sensor Option 7. Motion sensor Option 8. 360 degree camera Option 9. Radar Option 10. Drone that scans the environment from above.

Communication The device can communicate with the controller.	Option 1. Wi-Fi Option 2. Smoke signals Option 3. Morse code Option 4. Bluetooth Option 5. Infra-red sender Option 6. Radio signals Option 7. GPS Option 8. 3G/4G network Option 9. Using an electric field Option 10. Ultra sound sensor

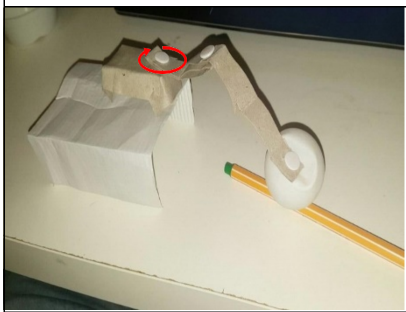
4. Concepts.

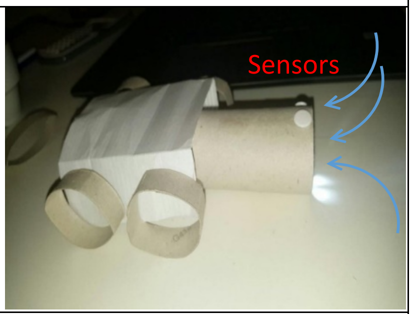
We each made 5 simple prototypes for each of the functions: move in any directions, board casualties, trasport casualties, remove obstacles, move in diffent velocities, find casualties.

Move in any directions:

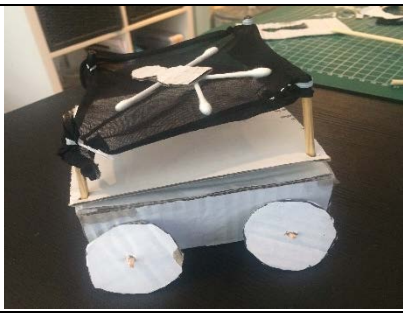
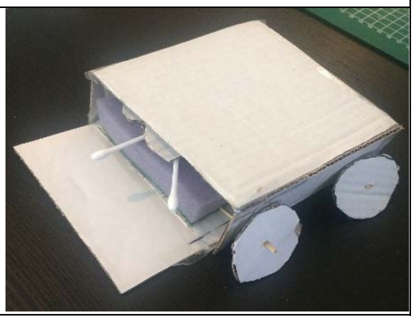




Board casualties

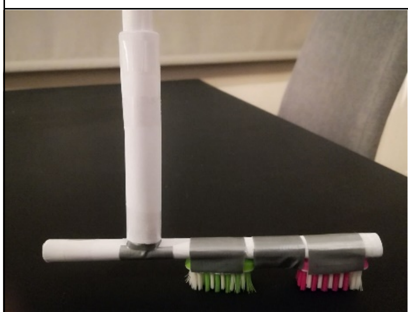
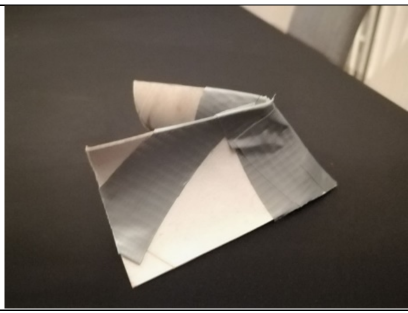




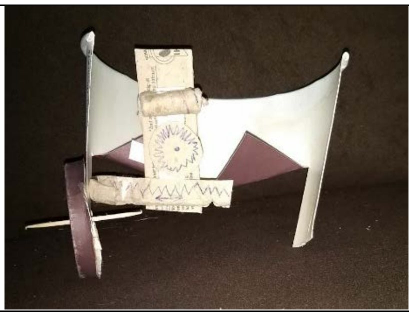
Transport casualties

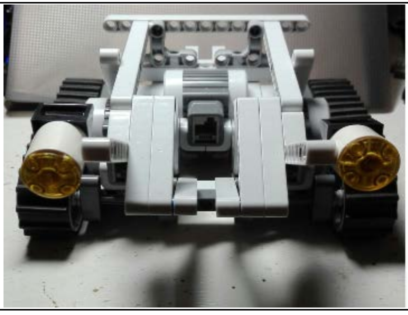
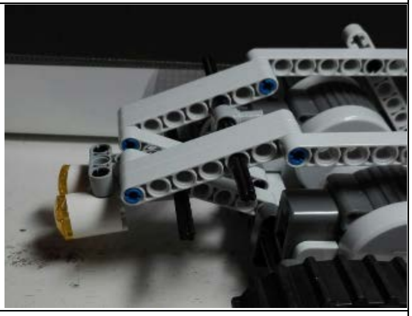
Remove obstacles


Move in different velocities

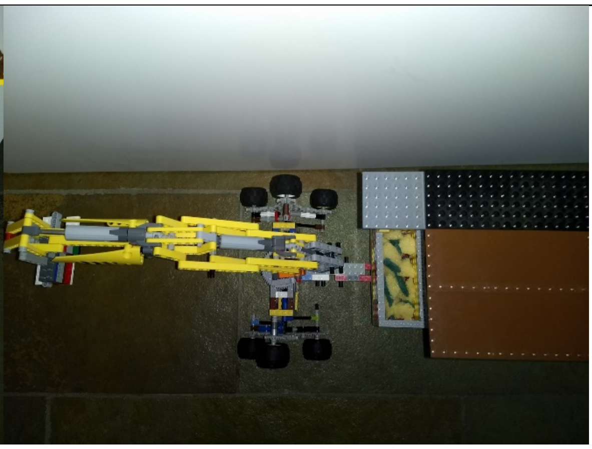



Find casualties

We choose transporting the casualties as our specialization function, because we felt this function has the most space for creativity. Possible solutions are: a drag-a-long platform, a storage space inside the ROD, hammocks, a large net and a ball pit.

5. Preliminary design

Our preliminary design is a ROD that picks up the casualties with a grabbing device that can stick to the victim and push them off into the storage box. The storage box is a ball pit, but instead of hard plastic balls it contains soft cushion like foam balls, to make the transportation more humane. The ROD travels two set of three wheels and one swivel wheel. The sets of three wheels can turn around its axis. When the ROD bumps into an obstacle the wheels turn and will ‘climb’ the obstacle, the swivel wheel gives the ROD balance. Because we will build our ROD with an earthquake environment in mind, there is a roof above the foam pit to make sure the casualties we will transport in the ROD will stay safe.

Arguments for our movement function:
Three wheels make for a stable construction that moves well around rough terrain.

Due to the two sets of three wheels the vehicle is stable, and moves well around rough terrain. This also creates the possibility to move over obstacles and get to different levels of height.

Arguments for our boarding function:
The sticker arm can pick up victims precisely and move them to the foam pit, with the push off mechanism on the sticker arm the robot can transport multiple victims.

Arguments for our specialization function, transportation:
A Foam pit is a good way to transport victims since it is comfortable and has enough space. Inside the foam pit each casualty will have his on separate foam pit, which gives the casualty privacy and makes sure each casualty has enough personal space. The roof can protect the robot and the casualties against falling rocks as well as bad weather conditions.

The RPC's can all be satisfied according to our preliminary design:

Requirements

The height and width of the vehicle do not exceed 30cm.	The design was 32 x 25 cm but this was only because the Lego prohibited us from making the roof lower in the final design this will not be the case.
The device is able to reach a top speed of at least 2 m/s.	In the preliminary design there were no motor, therefore we cannot say we will achieve this with certainty. However with a motor strong enough this will not be a problem.
The device is able to transport at least 1 casualty.	The foam pit can board more than 1 casualty.
The battery life of the device is at least 15 minutes.	The preliminary design did not need any power therefore this is still uncertain.
The device is able to turn 360°.	By giving each set of wheels its own motor, the controller can only power one set of the wheels and the device will be able to turn 360 degrees.

Preferences

Casualties are transported as safe as possible.	It is still unclear if this preference is satisfied because the safety of the grabbing device is not determined.
The device is waterproof enough to drive through small puddles.	The wheels can handle puddles and thus this preference is satisfied

The device is as light as possible.	This depends on the materials used and is therefore uncertain.

Constraints

The device can be manufactured for less than 70 euro.	All the material needed are not incredibly expensive and it is expected that this constraint will be easily satisfied.
The device is able to operate in a disaster area.	Because of the wheels and the roof the ROD is able the operate in a disaster area

Out of the preliminary design we can conclude that our ROD has three critical points which will need special attention in the detailing and realization step. The three critical points are as follows:

Sticking arm

The first critical point in our design is the sticking arm which will be difficult to make but crucial to our ROD. Our challenge is to find a material that sticks enough to hold a doll but not so much that it would be hard to remove the doll. This material also needs to be able to pick up other dolls, meaning that it still needs to stick. This arm mechanism is a critical point too, because this arm need to be able to move very slowly and carefully and should also be flexible. Additionally, it needs to be able to drop the doll in the foam pit and therefore needs to fit between the ball pit and the roof.

Wheels

Another critical point is going to be the wheels. These wheels will need a strong motor to work. This might be hard to find and could be expensive.

Camera

A third critical point is placing the camera. This will be hard because the camera needs to be able to scan the environment to find casualties. Furthermore, the camera also needs to see inside the foam pit to be able to see if it can drop the casualty.

6a. Risk management
Give a maximum one page table for the risk management of the function solutions in your chosen Preliminary Design on the three dimensions (probability, impact, control).

6b. Detailing

The three most important parts of the ROD are the grabbing arm, wheels and the frame which contains the foam pit.

For the frame we started with two layers of 20 x 30 cm. The bottom layer will act as chassis and all the batteries and motors will be placed on this layer. The sides of this layer are 5 cm. The second layer is the bottom of the ball pit and the platform on which the grabbing arm will be stationed. According to a picture in the course manual, we can conclude that the dolls are smaller than 12 cm in height and smaller than 6 cm in width. In our calculations we assumed that each doll would need 15 cm in length and 8 in width for comfortable transportation. We would like to transport 3 casualties at the same time. In width we would need at least 3 times 8 cm and 15 cm in length. This means the box need to be as least 24 x 15. This meant the first design was to small in width, the new dimensions became 25 x 30 cm. The wheels take up at least 5 cm in width, the first layer will have notches for the wheels, this is to make sure the ROD does not exceed the 30 cm width limit.

Explain the most important steps taken in the detailing process. Do this for at least three of them in more detail and include basic calculations.
Show the use of the detailing results in the optimization of the design.

6c. Assembly

Show how you performed the fittest of the components and how you did test the component functionality using a breadboard.
This must clearly show the steps taken in the development you're your Preliminary Design towards final ROD.
Provide adequate pictures and drawings of these steps.

7. Realization

Give a maximum three page description of your final, optimized design by:

- Table of parts with budget (Bill of Materials)
- Table of used manufacturing techniques
- Use drawings and picture to show both your design and important details.

The given description must be adequate to reproduce your ROD.

8. Test Plan

Describe and explain a set of experiments to test several critical functions of your design.
Present the results of the tests and compare the results with the original RPC's.

9. Design evaluation

Evaluate your design in the context of the original assignment.
Point out the most critical step in the design procedure.
Show how you used risk management to optimize the result.
Suggest at least three improvements in the design and at which point of the design cycle these should be implemented.

The major challenge in this step is to not be defensive: being open to criticize your own results is a valuable skill!