WFS Deep Sea Engineering

MATE ROV

G-Karere

Stefan

Sarah

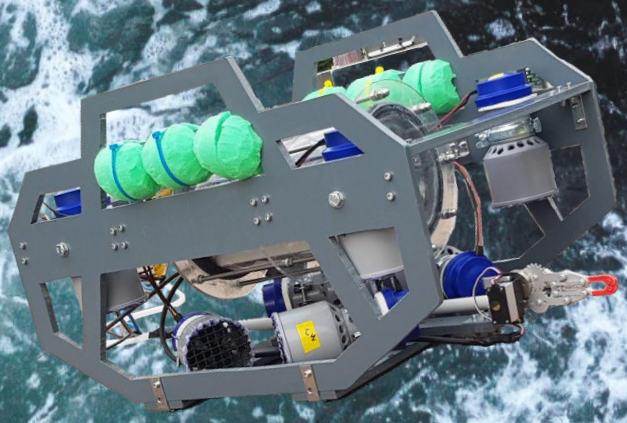
Jannis

Mikka

Ivo

Florian

Mr. Müller



Dr. Prinz

1. Abstract

The MATE´s ROV competition was established 2016 in our school, unfortunately, there is no other Team in Germany competing with us, so we could have exchanged our thoughts and expertise. But we would be happy to be a role model for other Germans Schools which could also establish the competition in their teaching and learning process. Although it is hard to get the resources for the construction e.g. inch PVC pipes or Anderson Power pole connectors. The unawareness of the Competitions didn't help with finding the right sponsors as well.

We are a Company consisting of 6 students and 2 mentors, who supervise us and council us, on our 2nd attempt to take part in international competition. For us it is important to work hand in hand and just have fun, while producing an awesome robot, improve our English skills and enhance or technological understanding.

Our robot is equipped with 8 motors to maneuver, a grappler to fulfill the tasks and a camera to stream the view from the robot´s perspective. The ROV also has a tube to fill e. g. lift bags underwater. The chassis consists of Polyvinyl chloride (PVC) which is easy to customize. The control system is compromised on an onboard Raspberry Pi. The custom control software is written in (python) language.

2. Company Info

The MATE ROV project was initiated by Dr. Prinz (who already had experience with the competition from his stay in Hong Kong) in 2016/17 in our School. In that year we tried to take part in the international competition, but our robot had problems with waterproofment, the steering and fulfilling the tasks in general. Then, in September we started working on the ROV MK II.

Our last robot which we started building in 2016 was ready in June 2017, but in the end, we still had some problems with the waterproof compartment. Because of this we couldn`t participate in the competition 2017 (despite how many hours we worked on weekends and in our vacations), as we didn´t finish fulfilling all needed criteria in time.

We started working on ROV MARK II. in 09|2017 additionally we acquired one new member.

G-Karere's headquarter is set the town of Wolfhagen in our School's Science Building. Wolfhagen is a small town in northern Hesse in the center of Germany.

You can reach us by visiting our website g-karere.de, on YouTube G-Karere and sending us an e-mail on g.karere.wfs@gmail.com.

To reach the international competition, we must travel approx. 8175km. Therefore, we decided to come by plane.

3. Need

Our Oceans are one of the most important aspects in our Ecosystem. They supply us with water, control our weather and are the habitat for thousands of species. Unfortunately, we as the human race have influenced the Ocean in a bad way by overfishing, polluting and changing the climate as a whole. Causing the extinction of species and more.

To counter those affects the people started to count on ecofriendly products and renewable energy.

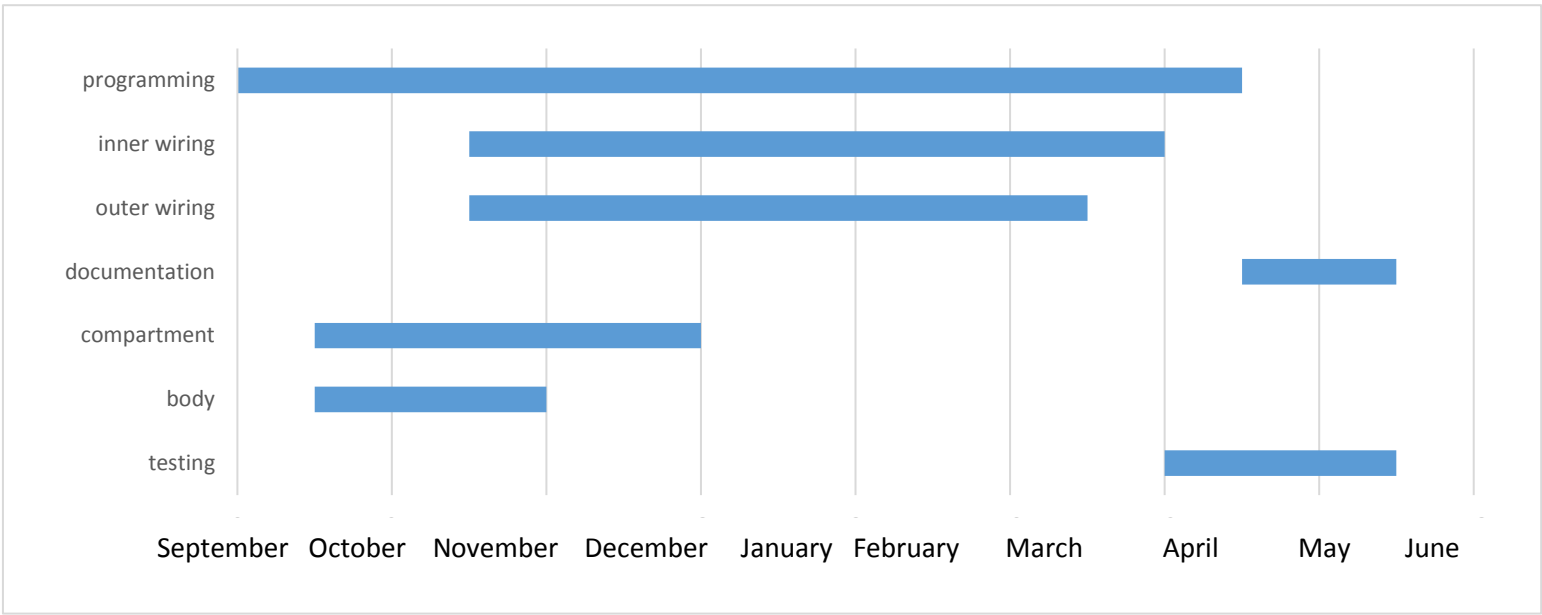
To contribute to the help of the Oceans, we would be glad to sign the contract (between G-Karere, the APL and UW) and fulfill the proposal of locating the aircraft wreckage and returning the engine to the surface, Installing the Ocean Bottom Seismometer and installing the tidal turbine and instruments to monitor the environment.

To showcase the abilities of our ROV (and our Team), our great workmanship/engineering, we are drilled to participate in the set up 'product demonstrations'.

4. Project Management

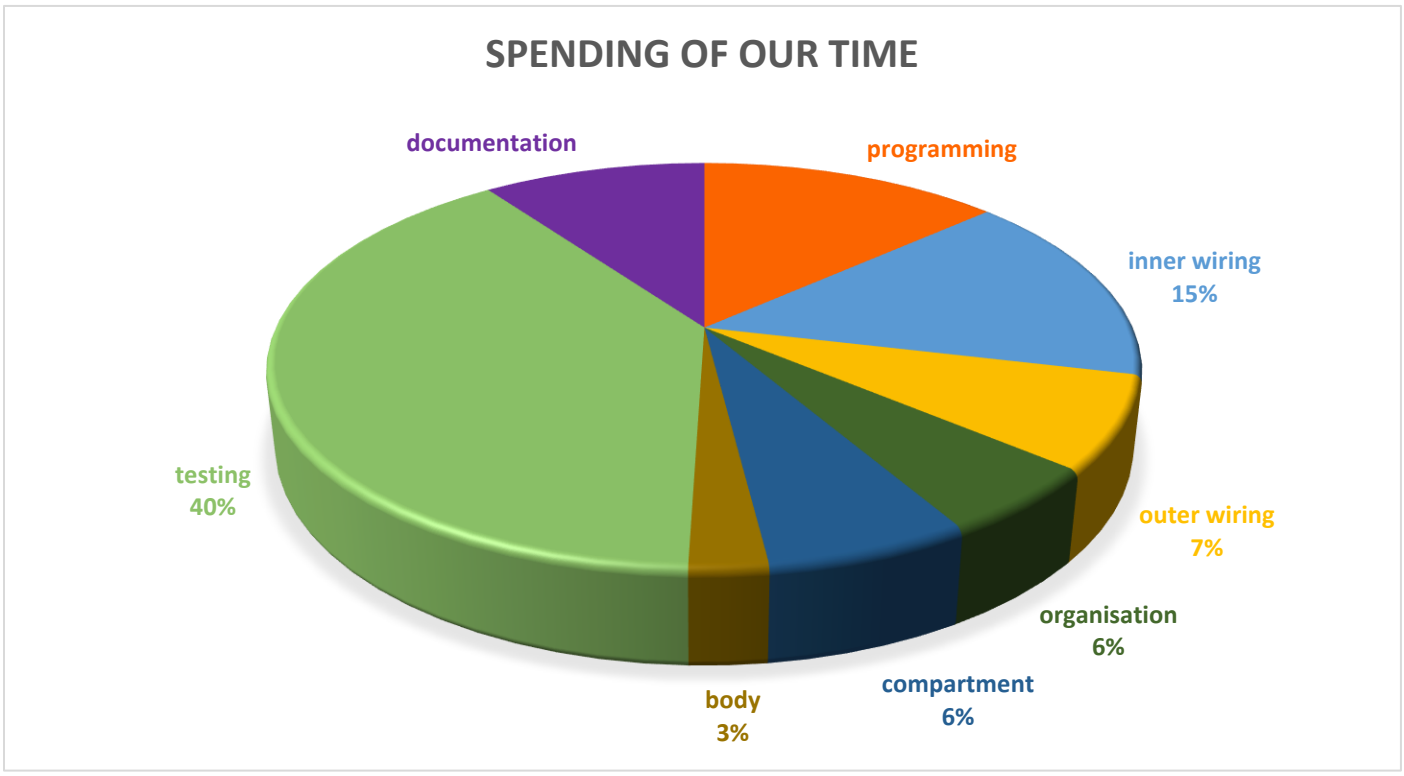
From last year we know, it needs to be organized carefully, if not it ends in chaos. We first meet on Wednesday, for 1 and a half hour and designed a timeline to organize our working, later we met for 3 hours on Wednesday, because not all worked out as planned. In testing phase, we met for 6 up to 13 hours on weekend to get it finished. We set up two deadlines, when we will begin with testing and when it all must be finished.

4.1 Time



This a chart which describes the distributions and concentration of time on certain tasks over the months. Of course, we weren't finished with the wiring and hard component engineering at a certain time because we keep fixing and improving our product at all time.

Looking backwards we probably should have planned more time for the documentation and testing due to the fact that we finished those parts on the last day. It was manageable but stressful.



This Pi Chart shows how much total time we needed for each branch in percent.

4.2 Team

To work as efficient as possible, we decided to split the tasks (see figure above) evenly among us with each company member being responsible for their own part, but still helping each other out. We also made sure, that everyone is capable of being a substitute for everyone.

Stefan Schinköthe (12th) – CEO, Pilot

Sarah Engel (12th) – Dep. CEO, Rules & Governmental Affairs

Jannis Küstner (10th) Chief Engineer

Mikka Hiesl (12th) IT, 2nd Pilot

Ivo Müller (12th) Engineer, Safety Officer

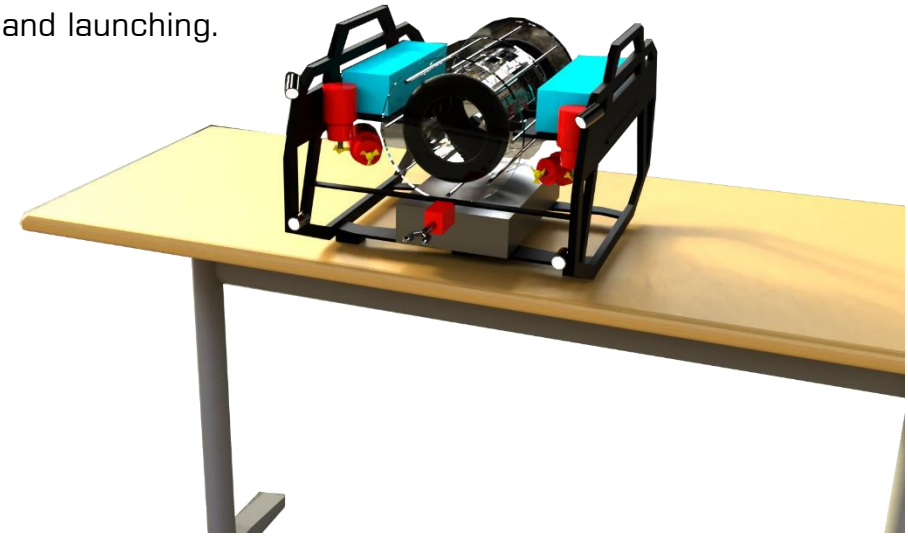
Florian Beinsen (12th) Engineer

Mentors: **Dr. Prinz & Mr. Müller**

Name, Grade, main tasks

5. Design

First, we met a few hours discussing and brainstorming about the design. We designed our robot to be most practicable and efficient, while working, with low budget. We discussed about taking the same Material as last year, but it has caused some problems. So, we had to use a new Material, it must be efficient in weight, but also must stable and not too expensive. After a few hours thinking, we concluded, PVC is our new material. On the side are on both sides handles, for easy transportation and launching.



First 3D rendering
of our Ideas.

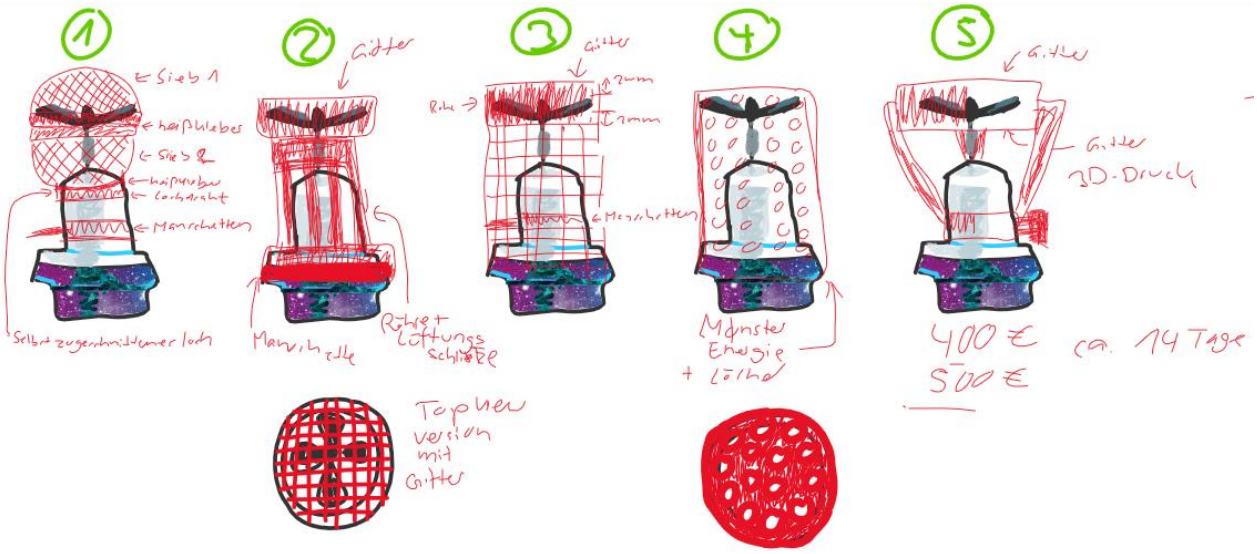
5.1 Compartment

We also decided to use a different compartment design, to make it more waterproof and to open it easier. It's built by 1 acrylic glass Cylinder, 3 round acrylic glass plates, two sealing rings and ten 30cm rods, that are used to connect the 3 plates with the Cylinder and the sealing rings. We use pressure on the sealing rings, to make sure it's waterproof. We put the technic on a plate constructed, a quarter above the ground of the cylinder to protect it from condensed water.

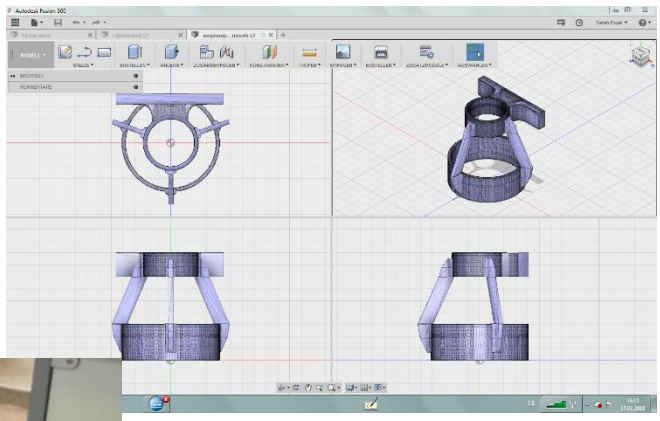
5.2 Thrusters

Last year we have used 6x 15V bilge pumps, to have more power. This year we used 8x 12V bilge pumps because we have4 limited power, 12V and to have the same power as last year we use 8 of them. We install them in another order to make it more efficient in moving right, left, for- and backwards. The motors can draw in 8 different steps, 25%, 50%, 75%, 100 % for- and backwards. They use up to 13A, by 100% power, underwater.

For safety and attachability reasons we had a long discussion on how to do the mounting and the safe guards.



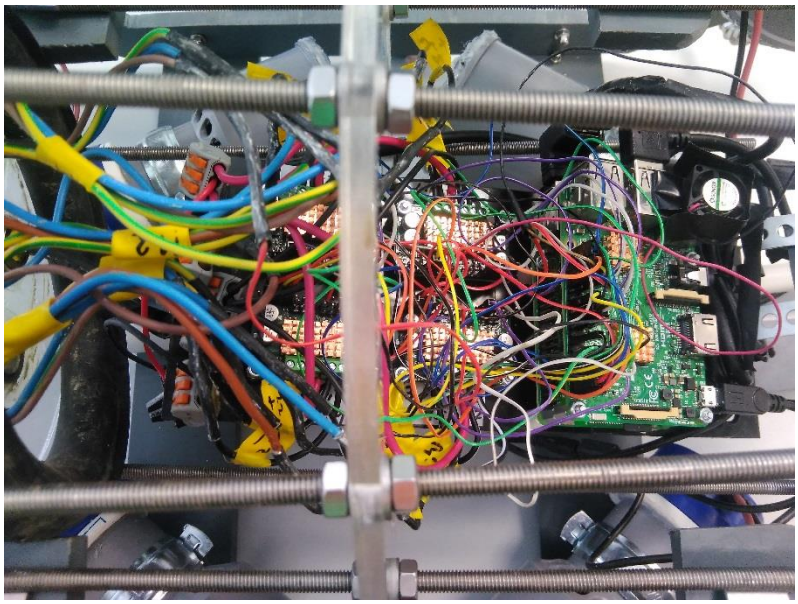
First, we considered 3D printing, but it was too expensive for our budget.



Then we looked around a crafting stores and found a pipe which could fit, so we modified it to fit our use.

5.3 Control box

The control box includes 2 Raspberry Pi's, 1 Camera and 4 motor-control units. The main part consists 2 Raspberry Pi's, one to control the motors and one to display the Camera, they're connected with two Lan cables to two Laptops, on



the outside. The 4 motor-control Units are connected with 16 pin cables to one Raspberry, every motor-control Unit is also connected to two Motors and to one Power- supply cable. Every motor has two pin cables on the mcU to control, one for forwards, one for backwards.

5.4 Grappler

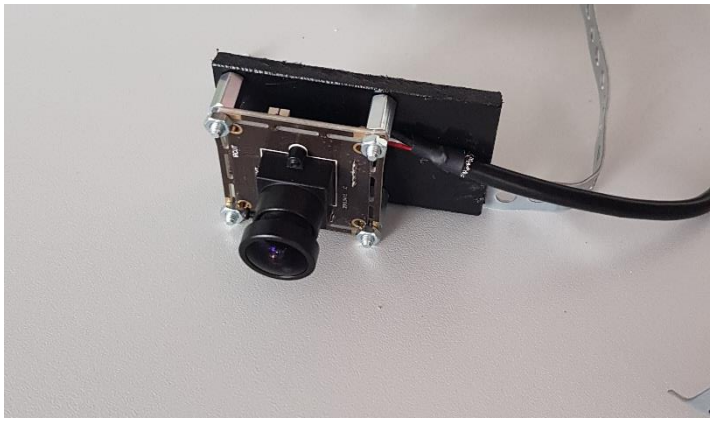
Our Grappler is controlled has a servo Motor, that allows us to control opening and closing of the Grappler by the mcU Raspberry. The Grappler receives its power by the 5V pin from the Raspberry. It's designed to work in horizontal and vertical direction. We can adjust its position forwards and backwards and add small rubbers to the grappler, so that it can grab flatter and more smooth objects. Its positioned in front of our 'Robot, to easily grab our lift bag and to be in the sight angle of our camera.

5.5 Buoyancy

The waterproof compartment of our ROV is responsible for most of the buoyancy. We added swimming noodle pieces to balance out the weight of the tether in the back and small weight differences of the outer body. The decision of using swimming noodles instead of air tanks (as shown in our first render) came from the easy workability, you can just cut of pieces if too buoyant.

5.6 Camera

One 1080x720 60fps Camera is used to have high-quality content on our Screen to make it easier for our Pilot to control the ROV. The camera is an USB camera plugged in a separate RaspPI which is connected by a Lan-wire to the camera laptop on which we use Team-Viewer to stream an image.



5.7 Tether

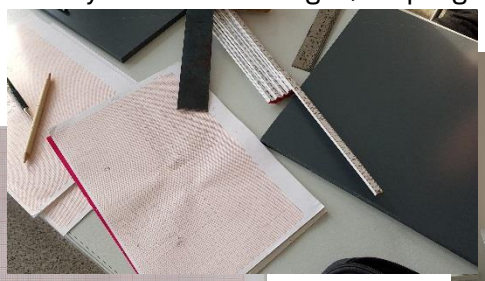
The tether is the connection between us and the vehicle. To store the cable

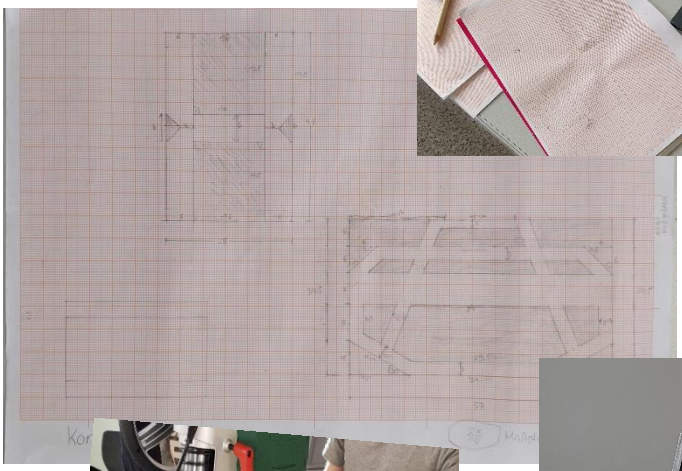
securely we rolled them up on an object meant for rolling up gardening tubes.
We got 2 Lan-wires leaving the ROV, a blue one for the camera and a red one for the motor controls, then two smaller connected brown cables which are our power connection, a black one for our PS4 controller and a tube.

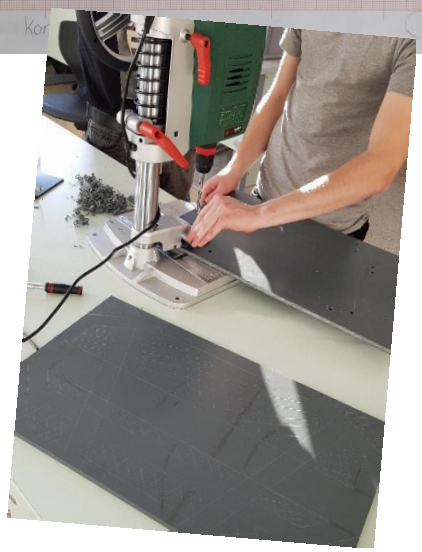
The tether is secured on the back on to robot, so we are not able to just pull out all the electronics. On the side of the Pool the wire constellation is held by a company member.

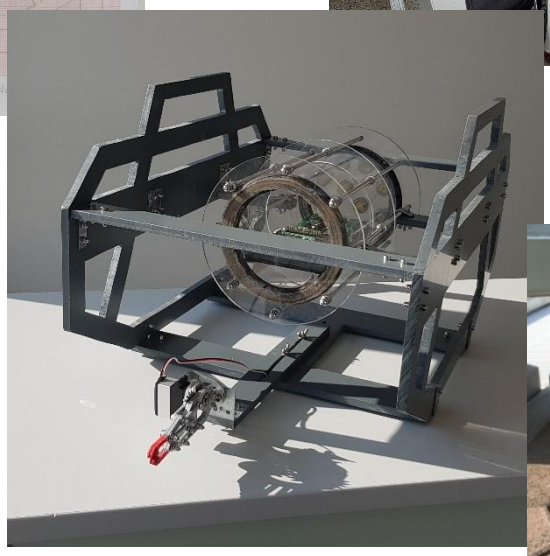
5.8 The ‘Shell’

The Shell was designed to meet both: the MATE safety standards and Practicality. We wanted to make sure that our Robot won’t damage the pool or the hurt the divers/team members. To help lifting it out of the water we added easy accessible handles and decided to cut off the lower corners.
In case we would need more buoyancy, we left space on the bar to attach swimming noodles.
Moreover, holes were cut into the walls, that the ROV can turn with less water resistance in the way, so less energy is needed.
The configuration, we wanted the thrusters to be were especially considers while in the thought process. From last years’ experience we knew that it would be hard to cut the pieces identical, therefore we tried to compensate those inconsistencies by adding two more thrusters in horizontal direction and rotating them that they are on an angle, hoping to gain more stability in water.









6. Finances

6.1 Budget

Our first budget draft set by our principal was about 500€
If we would need more, we could ask for more if it is a reasonable spending.
Additionally, the Deutsche Bank supported us with 200€

6.2 New vs. Reused

First of all, it is a financial consideration if you have to reuse and deconstruct your old projects. On the one hand buying only new products guarantees you that their products are working, you can open your package and start building, you receive a description of the object and it will fit your needs on the other hand buying new objects are often more expensive, Reused objects often easier to modify due to the fact that you already know the technology and while your looking for reusable objects you might get inspiration and/or learn how to improve it this time, besides that it is normally more environment friendly because it doesn't need to be shipped/produced.

6.3 Build vs. Buy

Same Economical and Ecological Reasons as mentioned in 6.2. The bought Objects are produced by professionals in a professional environment, thus they are more likely to works as they should, you are faster done, but the experience of building a ROV by yourself is lost and you don't learn as much as if you would have build it from scratch. In addition to that building makes the object unique, easier customizable for your specific needs and the robot becomes its own character.

6.4 Total Costs

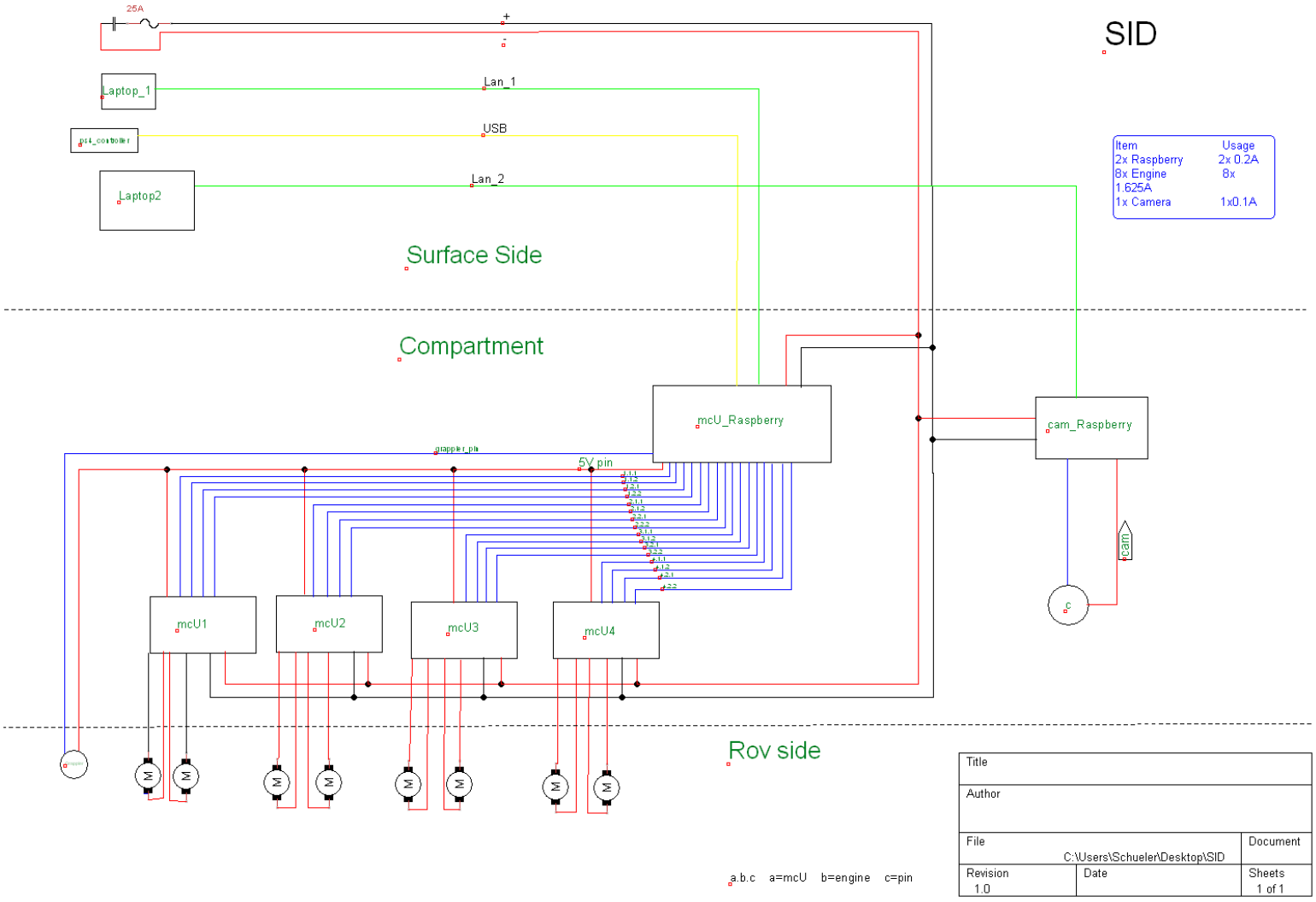
Our totals costs are about 830 €
We used interne research to determine the approximate value for the items, we had no receipt for.

	A	B	C	D	E
1	Products		Costs in Euro		Total
2	4x Motosteuerung		100		827,1
3	RasPi Kamera Modul		35		
4	Greifarm		35		
5	Polystryolglas		34		
6	Winkelverbinder		12		
7	Lochband		5,5		
8	Sechskantmuttern		4,5		
9	Innensechskantschrauben		13		
10	Inbusschrauben		2,5		
11	Inbusschrauben		3		
12	Stichsegeblatt		5		
13	Schrauben		6,5		
14	Micro SD-Card		20		
15	2xRollring		14		
16	Gleitmittel		2,1		
17	8xBilge Pump		160		
18	PVC-Platte		75		
19	4*Raspberry Pi 3		160		
20	Neofermit		5		
21	Zylinder		25		
22	Seitenplatten		30		
23	2xDichtring		20		
24	ps4 controller		35		
25	div. Kabel		10		
26	Lötstation		15		

Tabelle1

To reduce our costs, we reused many parts from our last robot and used the tools which our physics department already had.

7. SID

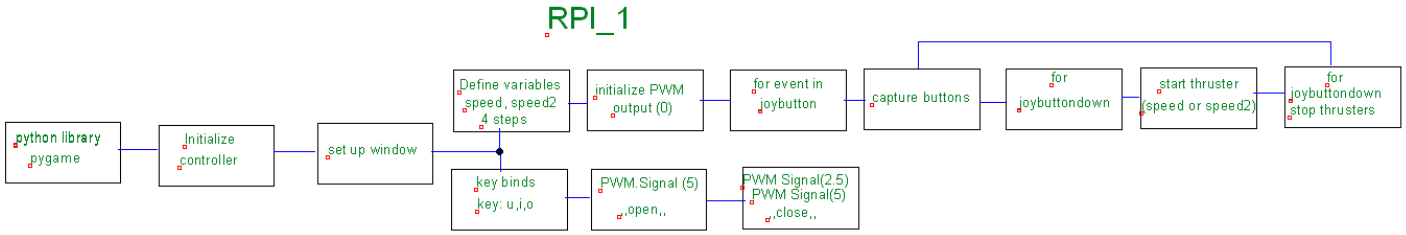


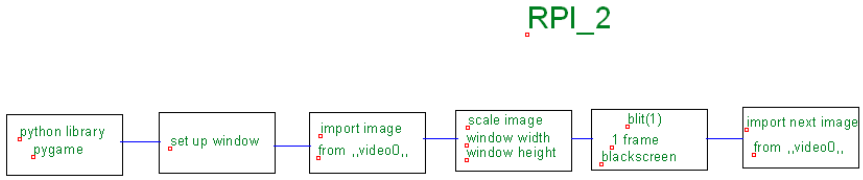
Calculations of the right amount for the fuse are shown in the blue Box in the upper right corner. For clarification: 2x0.2A (RaspPi) + 8x1.625A (Engines) + 1x0.1A (Camera) = 13.5A * 150% = 20.25=> 25A Fuse

Software used: TinyCAD

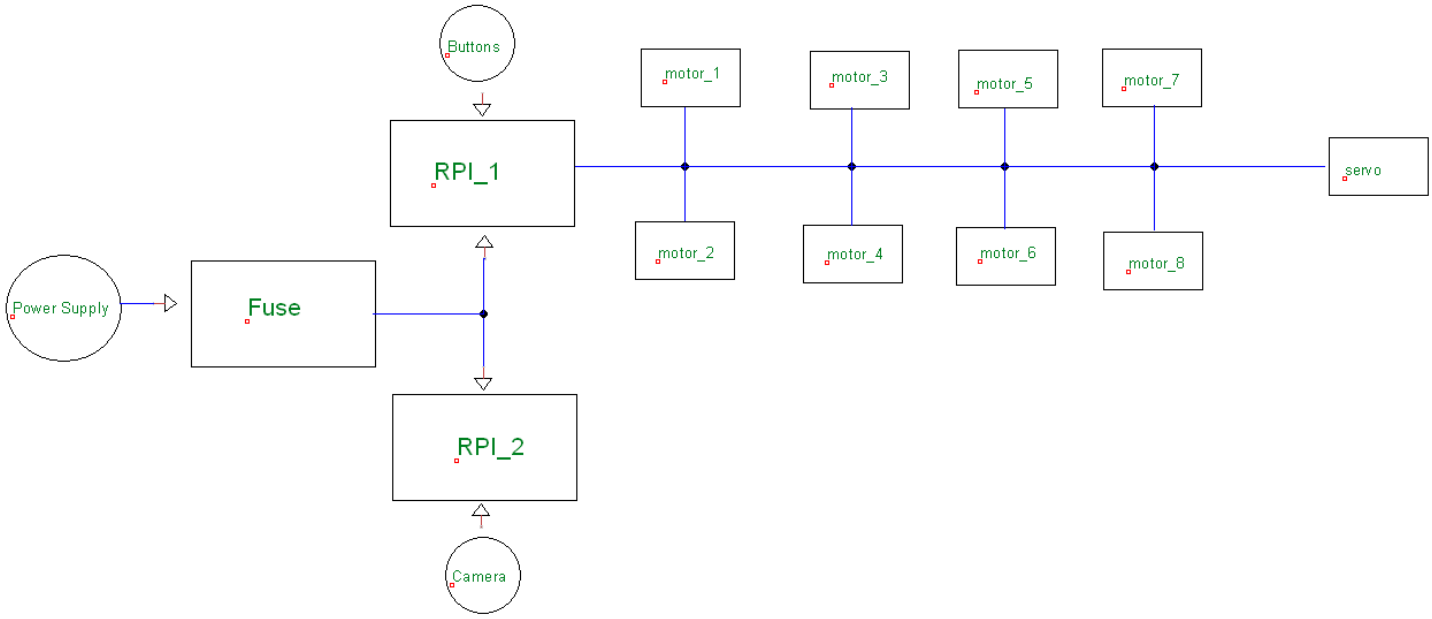
8. Flowcharts

Software Flowchart





Hardware Flowchart



9. Safety

9.1 Philosophy

Our safety philosophy is about safety is the most important part.

Always safety first! That's why we had at all time a teacher to supervise as, no matter if working with a special chemical glue or with the drilling machine.
We payed attention to e.g. wear goggles if needed and tried to keep our company members safe.

There is no ‚I do it alone', always together.

9.2 Features

- Grids to protect fingers from getting cut off by the rotors of the thrusters
- Wires are fixed at the rear end of the ROV to protect them from getting pulled out
- Our ROV is waterproof to protect the electronics from getting wet which would cause them to brake
- The holes in the thrusters which are meant to guarantee the intake of water are small enough that no human extremity can be stuck inside
- All edges are rounded off so neither the pool or the team members get damaged

*No AC used

*No fluid power used

9.3 Safety Checklist

Check	Description
✓	All ROV components are secured by screws or other kinds of attachmentt.
✓	There aren't sharp edges.
✓	All wiring is secured.
✓	No loose clothing.
✓	Proper workshop behavior.
✓	The tether doesn't serve as a tripping hazard.
✓	The ROV isn't pulled by the tether.
✓	All rotors are secured by a grid.
✓	The tether is untangled when the ROV is underwater.
✓	There are no kinks on the tether.
✓	Nobody is working on the ROV while electricity is running.
✓	All wiring is secured.
✓	All team members are aware of emergency procedures.

10. Critical Analysis

10.1 Testing

Camera

While testing we had some Problems with our camera, first our camera angle doesn't show our grappler. During transportation to the testing Area, the angle changed, cause our camera wasn't fixed, in its position. That could be fixed by building a Mount. Later, in testing we've got some Problems, with our connection between camera raspberry and Laptop, Our Lan Cable was damaged a bit, so we don't have a Camera input on our Laptop. ….

Motors

Throughout testing our company had some problems with our motors. After some time, the motors don't draw, while we sent an output. First, we think the problem is caused, by our main power, that has a maximum by 12A, but sometimes we use 13A. After buying a new power supply, the problem still exists. The motor control Units caused the problem, they cannot handle ampere above 12 for long time.

Lift bag

By testing the aircraft task, we can't release the lift bag, from the debris, caused by our release. It can be released manual, because our debris was too heavy, for our robot to pull the rod out of the Release, the robot power level can't be changed, without adding some motors. In the end we've built another release, to finally release our lift bag.

Grappler

During testing we had some problems with our grappler, sometimes it didn't work, because a screw between servo and grappler stucked causing, that I can't be opened anymore.

10.2 Working Phase

Programming

During building phase, we had some troubles with´, first getting our controller to work. We use a Ps4 Controller, this causes some Problems with joysticks, when they w2ere moved and then moved back to start position, we've got a delay about 1 sec, this can't be solved, so we only control it by buttons. Second our Raspberry can't display a video, direct from the Camera, on Raspberry the video is saved in a file, couldn't be streamed to the laptop, causing a solution, where we must set up our own stream, with less fps.

Low budget

Because we're the first and only German team, we've got some problems with sponsoring. Nobody knows, in Germany of this competition, so it was nearly impossible to find any sponsors. Another problem was that we haven't got people fixed on finding Sponsors. But we have a school that pays our budget, but we should not spend too much.

11. Reflections

11.1 General

How would you characterize the company´s success?

The company is very happy about its success with the ROV. We had tried to participate in MATE one year ago but had failed because of technical issues (a bad control system and insufficient water resistance). But the company had learned from its mistakes and had developed solutions for the problems it had had with its first ROV, e.g. the company had constructed a new system to make the ROV water prove. The company had reached many of the goals it had set, especially his greatest goal, the successful participating in MATE. The company members had learned much about constructing ROVs and solving the problems that comes with it.

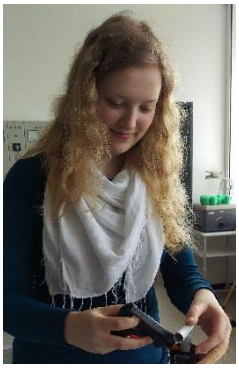
11.2 Team

What do you consider the strengths of your company and the ROV it designed?

The strength of our company is our ability of working in a team. We respect each other and everyone complement the company with his skills. Over this season we had become good friends, motivating each other working hard on our goal and finding solutions for the problems that comes up constructing the ROV. In our company everybody is free to tell the other members what his/her opinion is related to different discussions. Another strength of our team is that everyone is working concentrated and focused and if somebody is done with his work, he starts helping others at their tasks. When we are working there is always a productive but nevertheless relaxed atmosphere.







What was the most rewarding part of this experience?

The most rewarding part of this experience are the many things we had learned e.g. how it is to work in a company and how to organize things that are important for improving the ROV. Many of the things we had learned will be important to know in our future lives and we are happy that we had got this opinion.

Another very rewarding part was to see how the ROV dived and how he worked. Every time we had tested the ROV, people had come and had asked us what we were doing. When we explained them what we are doing and what MATE is, they were impressed, interested and wished us good luck.

11.3 Improvements

What areas do you see a need improvement?

Even if our ROV is the best we have ever constructed, there are still some things we would like to improve. The water resistance of our ROV is much better than last year, but still not completely satisfactory. We are confident that we could fix it next year by changing the wires. The manipulator we use rusts and he act not always reliable. Another area needing big improvements is our Public-Relations-Department. This year we had only a few sponsors because we were focused in constructing the ROV, but we are sure that we could improve this area.

What would you do differently next time?

Next time we would give more attention on our PR-Department because we had learned that this is an important part too. In relation to the water resistance of our ROV we would change the wires we use at the moment, because they are not completely water resistant. Another important point we want to change is that we work faster so that we have more time to test the ROV and to search for donators. We learned that we should work more careful and accurate in building the ROV so that he looks more professional.

12. Acknowledgements

We would like to thank the following for supporting our team and making our participation possible:

- Dr. Prinz & Mr. Müller – motivating us to participate in the MATE competition, giving us tips and advices in technical as well as mental support
- Mr. Brinkmann – providing resources to build our ROV
- Erlebnisbad Wolfhagen – pool services
- AquaPark Baunatal – pool services
- Deutsche Bank – sponsoring
- MATE – for the MATE program, through we have learned very much about working in a Team, learning about electronics, hardware crafting, computer science, developing a company and gaining interest in maritime technologies

And last but not least a thank you to our parents who supported our ideas, supervised us at the pool and picked us up late in the evening from school.

13. Sources

Marinetech.org, wfs-wolfhagen.de, g-karere.de, stepmap.de, wikimedi.org, apl.washington.edu, pixabay.com