Nonpneumatic Wheel

International Space Education Institute

School: International Space Education Institute

Team Advisor: Yvonne Heckel (yvonne.heckel@spacepass.de)

Team: Rovernauts – Highschool

a. Who were the team members and helpers?

Team members:
Firine Bugenhagen (15)
Leander Weihrich (15)
Lennox Jones (14)
Lili Teetz (17)
Katja Trusheva (19)

Pit crew:
Cosma Heckel (13)
Tara Heckel (10)

Team leader:
Nadin Rößler (25)

Responsible Teacher
Yvonne Heckel

Who was responsible for the Wheels?

Firine Bugenhagen (Project leader, Sponsoring)
Leander Weihrich (Mechanic, Production)
Cosma Heckel (Mechanic, Production)
Katja Trusheva (Mechanic, assembly)
Lili Teetz (Mechanic, assembly)
Lennox Jones and his father (CAD-Design)

c. Why did the team choose this solution?

As a fundamental principal we have used firm but flexible segments, which are attached around a center point to create a wheel. Over the past few years, we have gained a lot of experience, all of which has contributed to the final product of this wheel. We are convinced that the nature of the single segments increases the fail-safe running functions of the wheel. Every year we have tried to optimize these segments in their design, stability and flexibility. In 2016-2019 we used the same rim and hub construction. In 2017-2019 we tried to optimize the segments and the tread of the wheel. The successes of 2018 (2nd place) and 2019 (1st place) showed us that we were on the right track. The changes to the current 2020 design consist of the complete redesign of the wheel using all our previous experience. Firstly, we have revised the hub-rim assembly (scope, stability, weight; aluminum). In addition, we have increased the number of segments from 18 to the prime number 19 in order to reduce the vehicle's innate vibrations and to achieve better running properties due to the increased scope. Here we also chose a lighter and more flexible material, especially in the inner segment ring. The tread and the tire were adjusted from the point of view of weight (see further details below).

Wheels 2014
They consisted of a bicycle rim and a flexible tube stretched around it. We used a bicycle tire as a tread.

Experience: The flexible tube wore out very quickly. However, the bicycle rim and the bicycle tire worked very well.

Wheels 2015
As the flexible tube did not work very well in the previous year, we replaced it with segments cut out of pressure pipes used for fresh water. The rest of the construction remained the same.

Experience: The wheels worked better and for longer than the previous year. We did not find any disadvantages.

Rad 2016:
For the first time the rules required that bicycle parts should no longer be used. We therefore had to come up with a completely new construction. The new rim consisted of a lasered steel construction with pre-tensioned leaf springs made of S-Ply.

Around it, a wheel profile made of 12 segments from a 2-component injection molding serves as the tire.

Experience: The steel construction worked well, however, the pre-tensioned leaf springs jumped out of their bracket from time to time and the tire was not rough enough and therefore offered little road grip. Added to this was the heavy weight, so the wheels proved to be somewhat impractical.

Wheels 2017/2018:

We used the steel construction from the previous year. Around it we screwed 2 rows of water pipes. The inner row consisted of freshwater pressure pipes, which we also used in 2015 (are stable) and the exteriors were from drainpipes (are flexible). This created a stable, yet springy wheel. As a cover, we sewed on a mesh that prevents stones from entering the pipe structure. The tire was made of rubber door stoppers.

Experience: The wheel was very stable, but the tire wore down quickly.

Wheels 2019:

Wheel 2019:

The construction was the same as in previous years and we only changed the tire. We used sheets of rubber that we cut into the shape of tractor tires. With this tire we were able to overcome all of the obstacles and it did not wear down as quickly as it did in previous years.

d. How much did it cost?

Material contribution, cost breakdown per wheel (see table)

Amount	Article	Term	Obtainment	Costs
2	Igus Sliding bearing	Iglidur	Donation	00,50 €
1	hub	Homemade	Donation	63,00 €
2	Wheel discs	Homemade	Donation	41,20 €
1	2,5 m aluminum pipes		Purchase	10,25 €
13	Nut		Purchase	03,77 €
13	carriage bolts		Purchase	04,32 €
1	2m drainpipe (10 cm)		Donation	10,00 €
1	2m drainpipe (9 cm)		Donation	10,00 €
1	Carbon Fiber Net		Donation	30,00 €
1	Rubber strips		Purchase	05,00 €
76	Screws (3,5x16)		Purchase	01,98 €
76	Screws (3,5x25)		Purchase	02,43 €

In total: **182,45 € (154,70 € Donation)**
201,20 $ (170,60 $ Donation)

e. Where was the construction carried out?

Under our supervision, the parts were produced by various handicraft enterprises in the region:

- Günter Jacob turning shop, Leipzig
- Holl laser cutting, Leipzig
- Kübler Schkeuditz Saddlery
- Berg metal construction, Leipzig
- Plastic welding technology Kainath von Thommy Knabe (former Roverchallenge member with own company)

The assembling of the parts took place mainly in our workshop.

f. What materials were used to build the wheel?

Hub: Aluminum
Rim/Wheel discs: Aluminum
Wheel/Wheel segments: Plastic
Tire: rubber
Dust protection: Carbon fiber net/rubber strips

g. Which processes were used?

Turning, Laser cutting, drilling, sawing, handiwork (see e)

h. How were the wheels built

In the summer holidays we covered about 1,000 km during extensive training. We also participated in races locally as often as we could to further test the existing construction. In Autumn 2019, we revised, discussed and produced new CAD-Designs. These were commissioned by our sponsors in December 2019. A former team member (2007, 2011, 2013), Thommy Knabe, supported us by providing plastic pipes for the wheel segments. In

February 2020, we sawed and reworked these into the corresponding segments at the firm Berg metal construction. During the winter holidays 2020, we produced 150 segments for six wheels. We assembled two wheels as a prototype in Leipzig and tested them in March 2020. We will be packing the parts for another four wheels in our luggage and will assemble them in Huntsville Alabama. This is necessary because of the volume restrictions for baggage. (Pictures see p. 9)

i. How did we pay for it?

The material was mostly donated.

The necessary service work for processing and production using machines that were not allowed to be used by the students (occupational safety) was taken over for us by partner companies, in our presence. (See also breakdown d.)

j. What design features improve the stability of the wheel to survive the course?

We have a flexible outer ring made of plastic tube segments (110 mm diameter). These are strong enough to cope with the strain on the rear axle. In the front axle we have additionally installed an inner ring made of plastic tube segments (90 mm diameter) as a stabilizer. These segments double the stability of the wheel and prevent the outer wheel segments from breaking. The following test shows the stability of the outer tube ring with and without the stabilizer:

In addition, the two wheel discs have 26 spokes stabilized to each other, which ensure a good power balance. Our tire is soft, but due to the screws it cannot detach from the pipe ring.

k. Which parts could break the fastest? Why?

The tires could get small holes from sharp stones as they are soft.

l. What can/could be done to prevent this error as much as possible?

If the tires get small holes, it won't be a problem for us.

m. What is the most important thing you have learned when building the wheels?

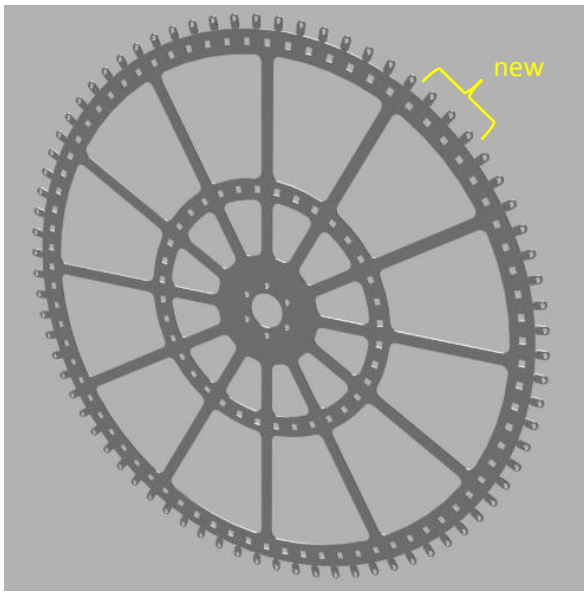
1. Everyone on the team must adhere to the following rules:

   - Teamwork
   - Integrity
   - safety
   - Excellence
   - patience
   - Training

2. We have understood how different machines (e.g. laser machines) work and have also visited various companies.

What did we change?

Size: The diameter of the wheel was increased, because we are using 19 wheel segments instead of 18.

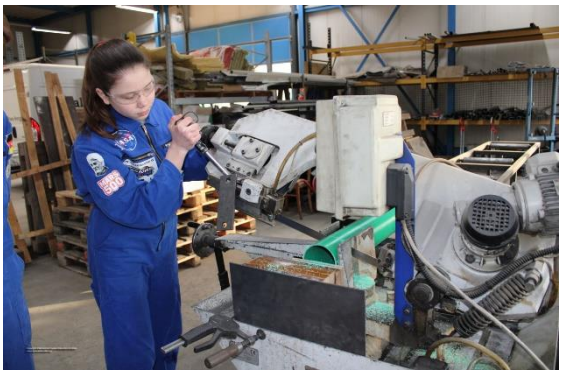


Self-resonance: The self-resonance is eliminated, because the number of wheel segments (19) is a prime number and all wheels are going to run differently.

Weight: Because we use aluminum rims instead of steel rims and because the inner wheel segments are made of thin pipes and the profile of the wheels is made from thinner rubber, we save a lot of weight.

Construction of the new wheels:

Production of the segments:



Assembly:

A picture of the final wheel doesn´t exist yet, because we are still working on the wheel profile. We are going to present the final wheel to the jury in Huntsville.

Editorial:

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