SZYMON MACZKA
maczka24@gmail.com

WARSAW UNIVERSITY OF TECHNOLOGY |
MECHATRONICS FACULTY |

Rover Vehicle Measuring Robot for Great Physical Experiments

PW | JINR | DUBNA 2018

main goals:

GPE Collider robot is an versatile measurement rover.
Rover will acquire complex data for physical experiments such as: magnetic field, radiation, and data from close environment.

Rover, controlled with easily understandable interface should let user to wirelessly ride on various surfaces closed to horizontal.

main goals:

- mechanics:
  - designing
  - durability
  - assembling
  - easy attachment various measuring intruments
  - adatpive suspension
  - suitable wheels

main goals:

- measurments:
  - magnetic field
  - radiation
  - thermal imaging
  - data from close environment i.e.: humidity, air pressure, lighting
  - distance

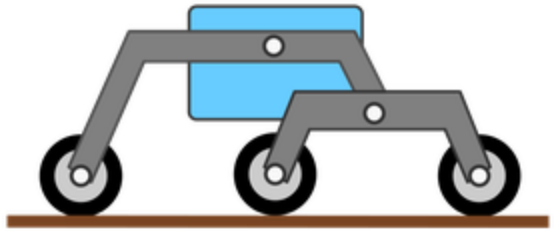
main goals:

- programming and control:
  - rover's control system standing on myRIO by National Instruments
  - propulsion
  - power supply module
  - wireless control
  - autonomous control by real time imaging camera
  - HMI

until now

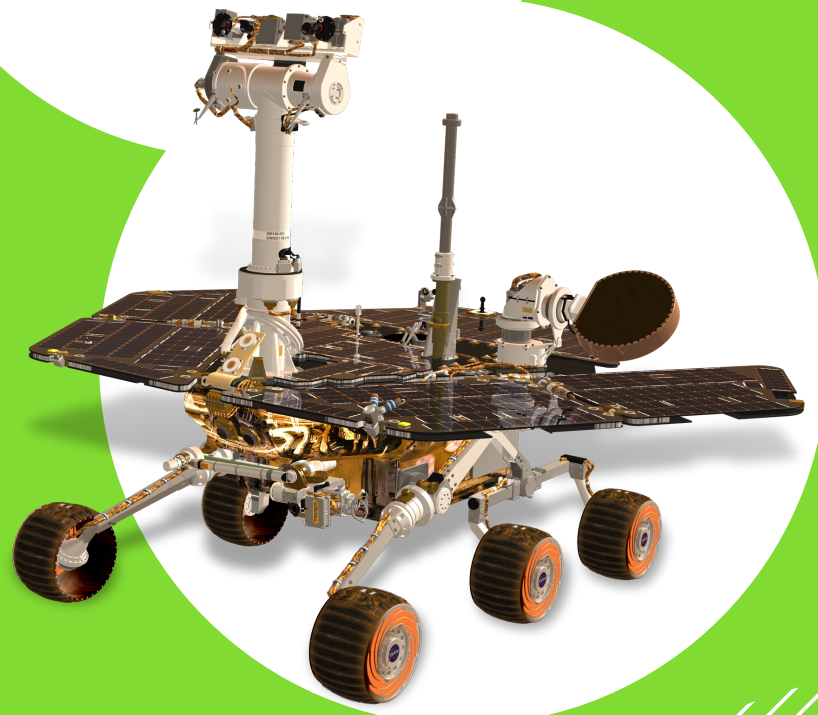
achivements

mechanics



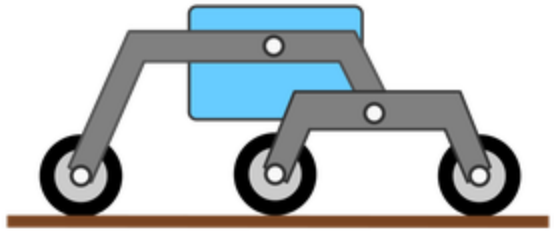
SUSPENSION

Due to assumption of rover's ability to move in various, even difficult surfaces closed to horizontal there will be used suspension of Rocker-Bogie type. Solution, commonly used in many rover's projects (i.e.: NASA Curiosity) allows vehicle to climb over obstacles, such as rocks, that are up to twice the wheel's diameter in size while keeping all six wheels on the ground.

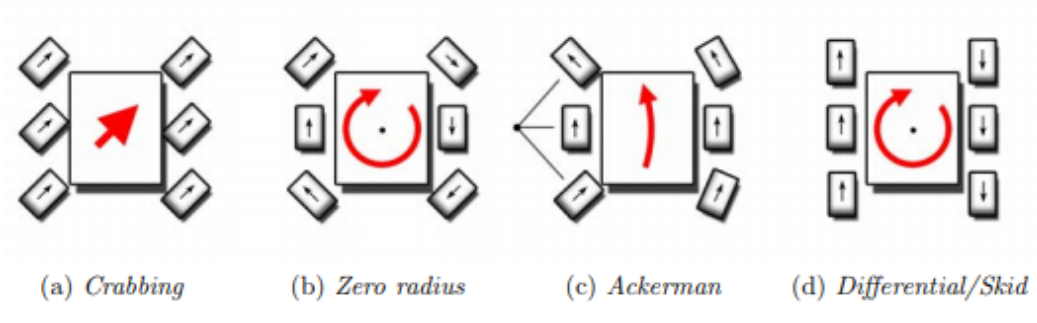


mechanics

SUSPENSION



Rocker-Bogie suspension demands using six motors.
Moreover, by sufficient power of used motors rover vehicle is even able to overcome stairs.



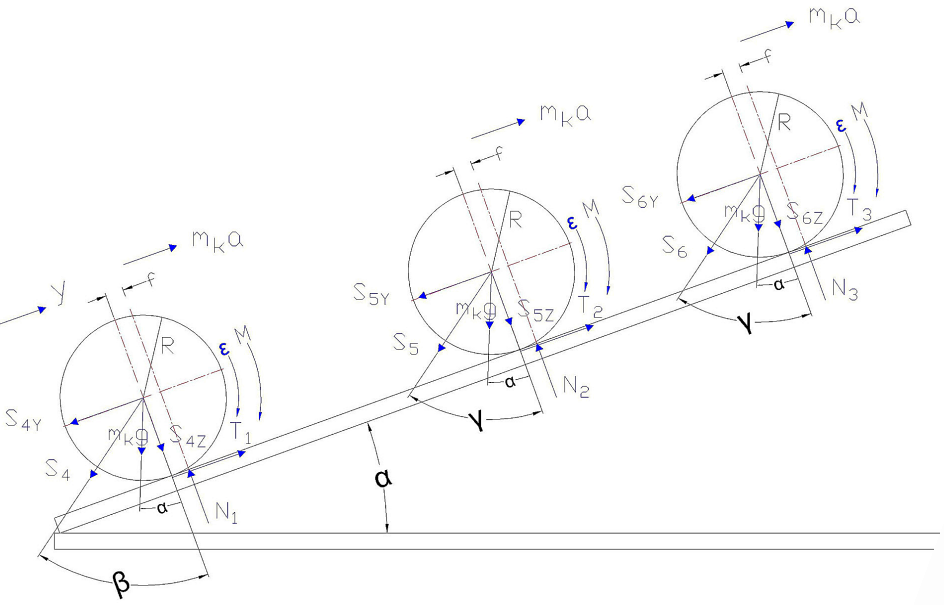
(a) *Crabbing* (b) *Zero radius* (c) *Ackerman* (d) *Differential/Skid*

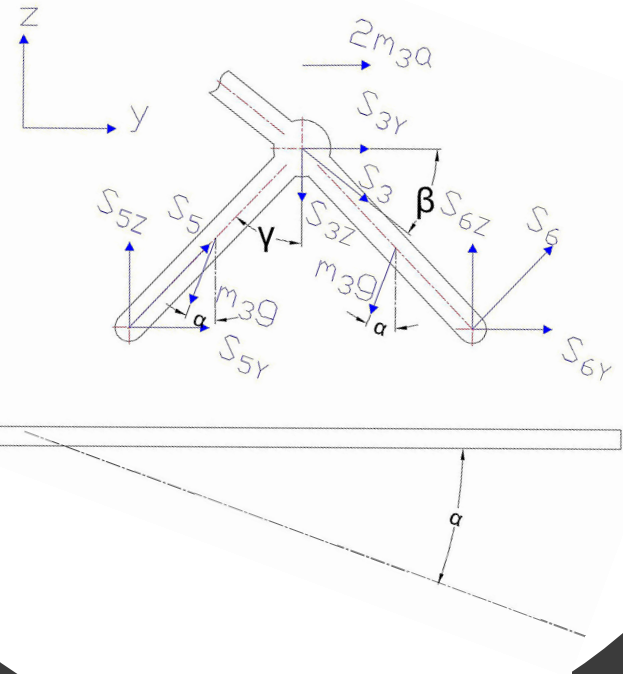
Turning of the rover will be provided by contrary rotation of motors each side- option (d) on the picture.

mechanics

MOTOR

To find appropriate motors which would be able to disperse rover to some velocity it is needed to do some math first...





mechanics

MOTOR

$$M = M\left(v, A, m_i, R, J_k, \rho_p, S_D, C_D, \alpha\right)$$

$$M = \frac{\frac{S_D C_D \rho_p}{2(6m_k + 2m_1 + 2m_2 + 4m_4 + m_b)} v^2 \left[A\left(m_k R + \frac{J_k}{R}\right) + (2m_1 + 2m_2 + 4m_4 + m_b)\right] + gsin\alpha[Am_k(R + fctg\alpha) + (2m_1 + 2m_2 + 4m_4 + m_b)]}{A} [Nm]$$

$$A(\beta, \gamma) = 2\left(\frac{tg\beta}{f + Rtg\beta} + \frac{tg\gamma}{f + Rtg\gamma}\right)\left[\frac{1}{m}\right]$$

There was formulated needed motor's generated moment to reach above-cited velocity, dependently on wanted acceleration and physical parameters of the rover.
Model accepted for calulation was simplified.

mechanics

MOTOR

$$M = M(v, A, m_i, R, J_k, \rho_p, S_D, C_D, \alpha)$$

$$M = \frac{\frac{S_D C_D \rho_p}{2(6m_k + 2m_1 + 2m_2 + 4m_4 + m_b)} v^2 \left[A\left(m_k R + \frac{J_k}{R}\right) + (2m_1 + 2m_2 + 4m_4 + m_b)\right] + g sin\alpha [A m_k (R + f ctg\alpha) + (2m_1 + 2m_2 + 4m_4 + m_b)]}{A} [Nm]$$

$$A(\beta, \gamma) = 2\left(\frac{tg\beta}{f + Rtg\beta} + \frac{tg\gamma}{f + Rtg\gamma}\right)\left[\frac{1}{m}\right]$$

Main parameters are given:

- total mass of the body - 4kg
- total mass of the instruments - 4kg
- J_K - wheel's moment of inertia (stated with Autodesk Invetor program)
- v - maximum velocity (3m/s)
- γ,β - parameters related with geometry of suspension
- α - slope angle
- S_D ,C_D - geometrical parameters related with air resitance
- f - coefficient of friction durng rotation

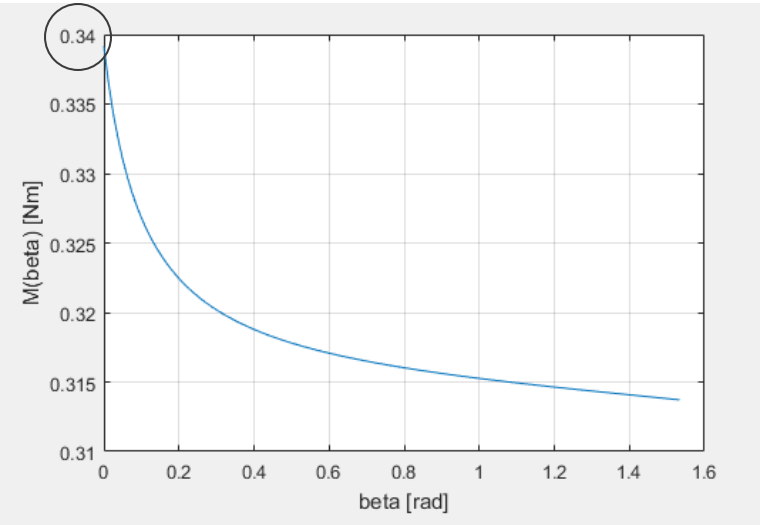
mechanics

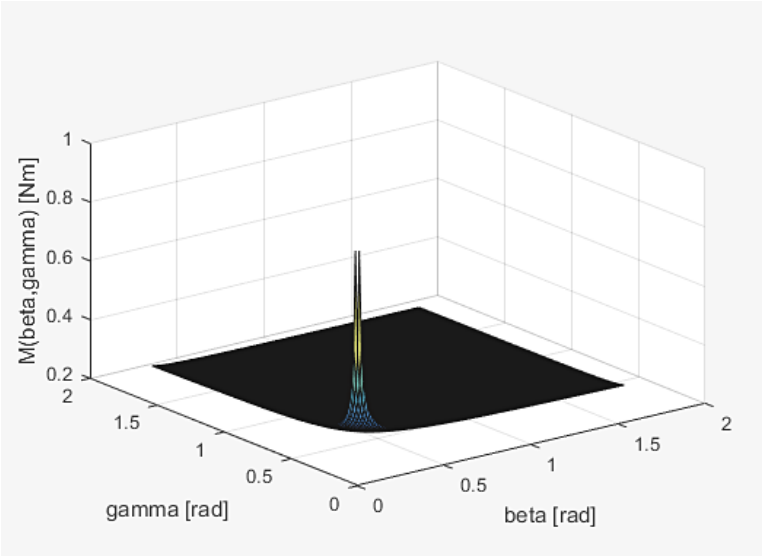
MOTOR

$$M = M\left(v, A, m_i, R, J_k, \rho_p, S_D, C_D, \alpha\right)$$

$$M = \frac{\frac{S_D C_D \rho_p}{2(6m_k + 2m_1 + 2m_2 + 4m_4 + m_b)} v^2 \left[A\left(m_k R + \frac{J_k}{R}\right) + (2m_1 + 2m_2 + 4m_4 + m_b)\right] + gsin\alpha[Am_k(R + fctg\alpha) + (2m_1 + 2m_2 + 4m_4 + m_b)]}{A} [Nm]$$

$$A(\beta, \gamma) = 2\left(\frac{tg\beta}{f + Rtg\beta} + \frac{tg\gamma}{f + Rtg\gamma}\right)\left[\frac{1}{m}\right]$$





mechanics

MOTOR

Metal Gearmotor specifications:

- diameter / lenght - 25 mm / 52 mm
- nominal speed - 110 rpm
- nominal torque - 423 mNm
- stall current - 1100 mA
- voltage - 12V DC
- reduction ratio - 46.85 : 1
- motor type - 1.1A stall 12V (LP 12V)

Magnetic encoders used.

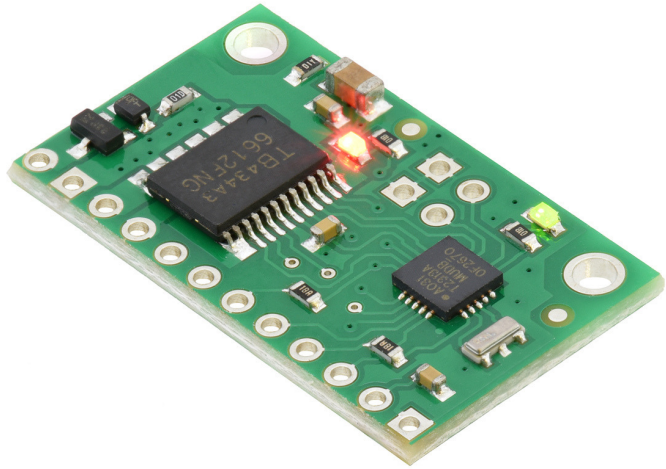
Metal Gearmotor 25Dx52L mm LP
12V by Polou
Engine with planetary gear motor

programming and control:

MOTOR CONTROLLER

Drivers provided by producer's electronic circuit (H-bridge).

- motor channels - 2
- minimum operating voltage: 4.5 V
- maximum operating voltage: 13.5 V
- maximum PWM frequency - 32 kHz
- LP motor control

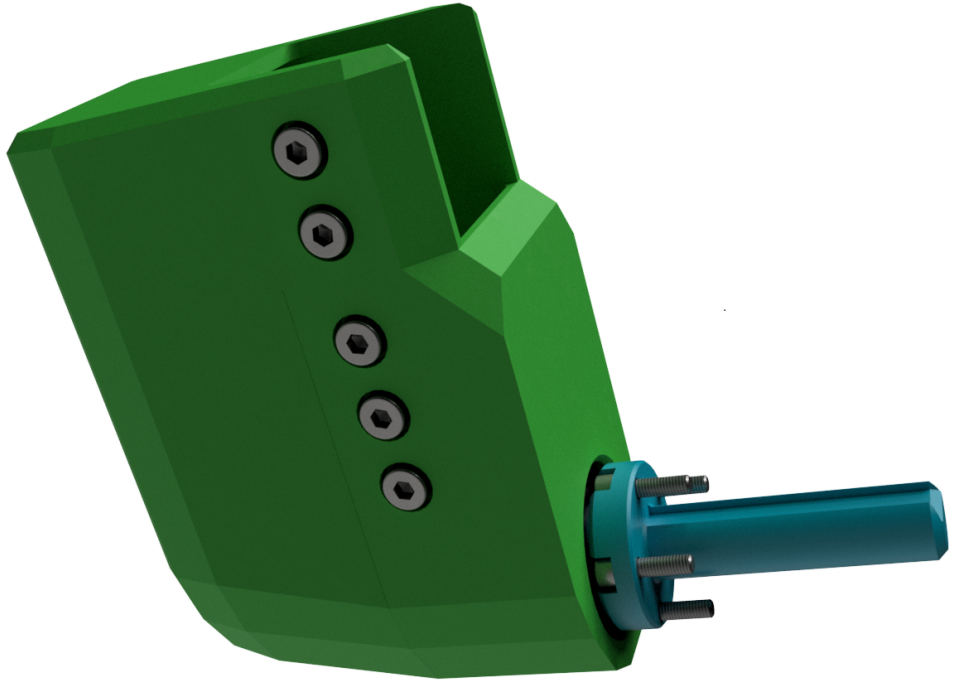


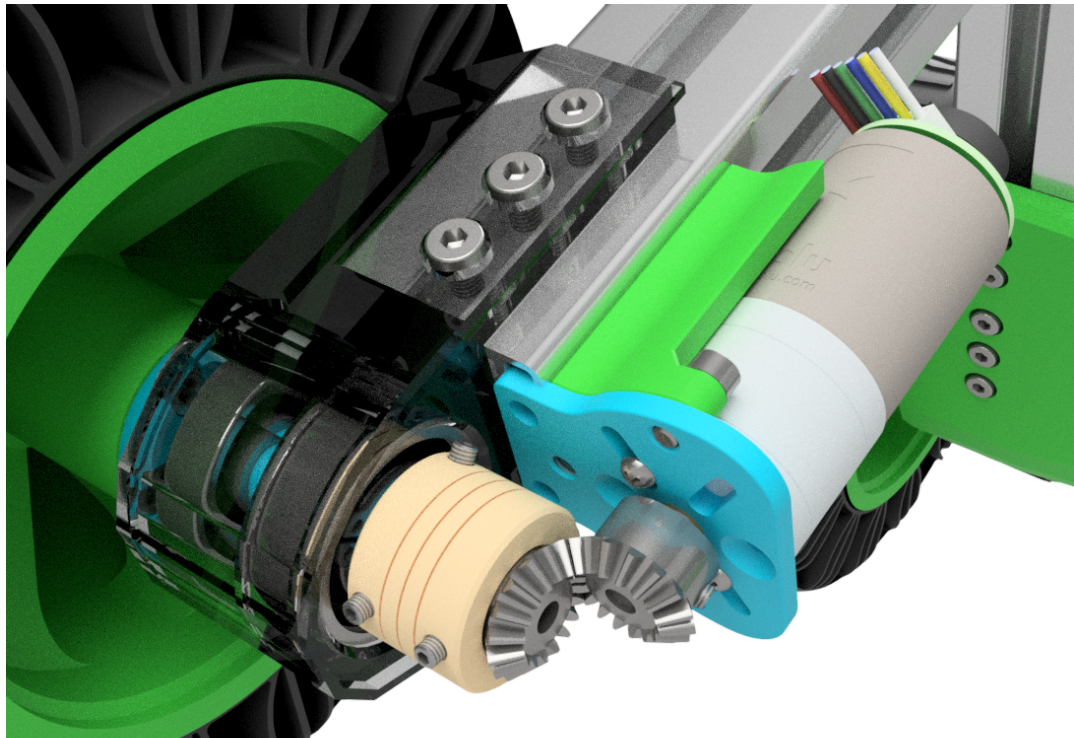
Pololu Qik 2s9v1 Dual Serial Motor Controller

mechanics

DRIVE MODULE

To build compact drive module ready components, chosen motor and 3D printed materials was used. Propulsion, given by the motor affects the clutch through angle gearbox (1:1). Clutch by its design prevents occurrence of lurch while motor's skidding. **(watch)**





mechanics

DIFFERENTIAL BAR

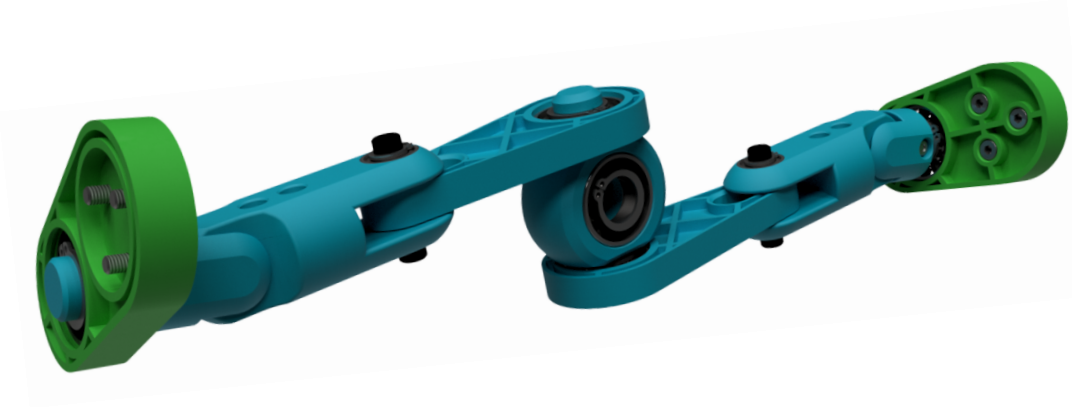
Body of Colldier is attatched to only one axle. Of course, there occures posibility body will fall forward or back. To counteract this fact differentail bar was design.
Thus, it was needed to attach additional mechanism which could help to keep body in constant and crontroled position undependatly of body's center of gravity.

watch

mechanics

DIFFERENTIAL BAR

Developing above ideological model there was created compact mechanism attached directly to top axies of suspension.



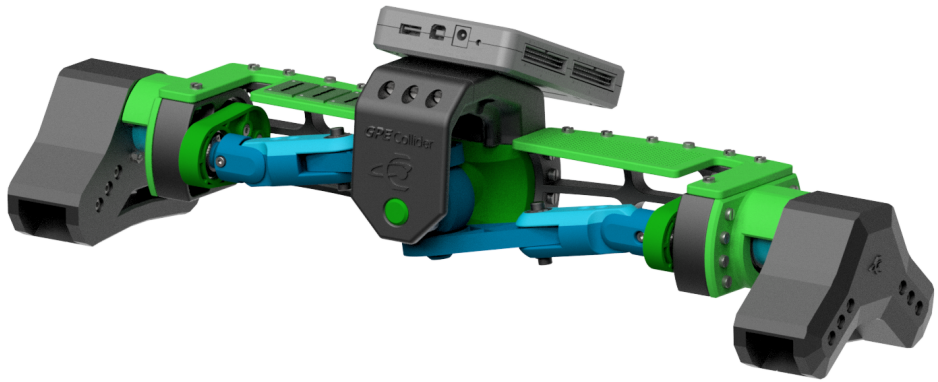
Differential bar with 11 degrees of freedom.


what next?

mechanics

CHASSIS FOR THE PROTOTYPE

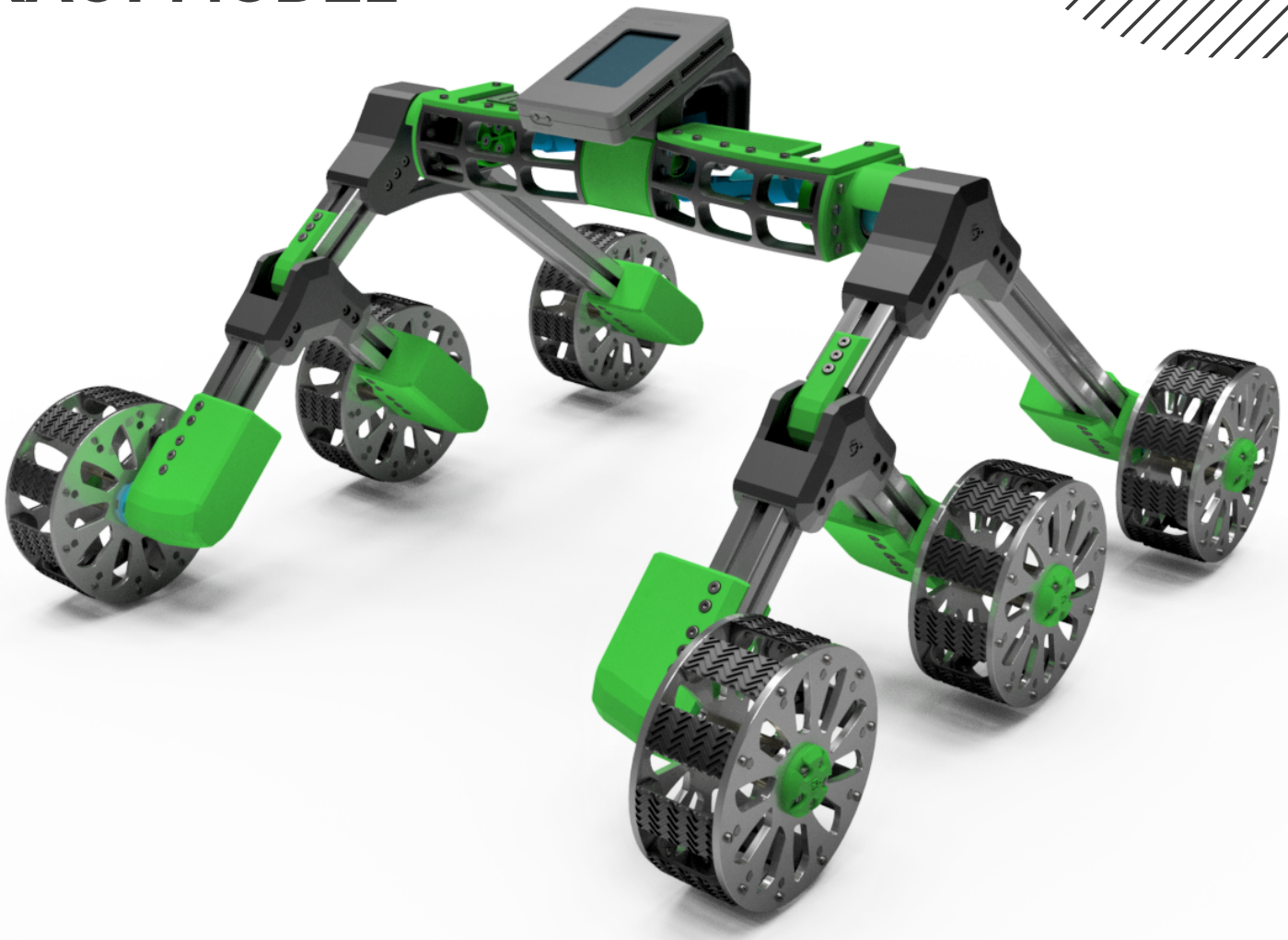
To move forward with work I replaced more sofisticated box for all the measuring instruments with chassis for the prototype. Thanks to that propulsion control and it's primary tests could be realised on forming model of suspension.



mechanics

SUSPENSION EXACT MODEL

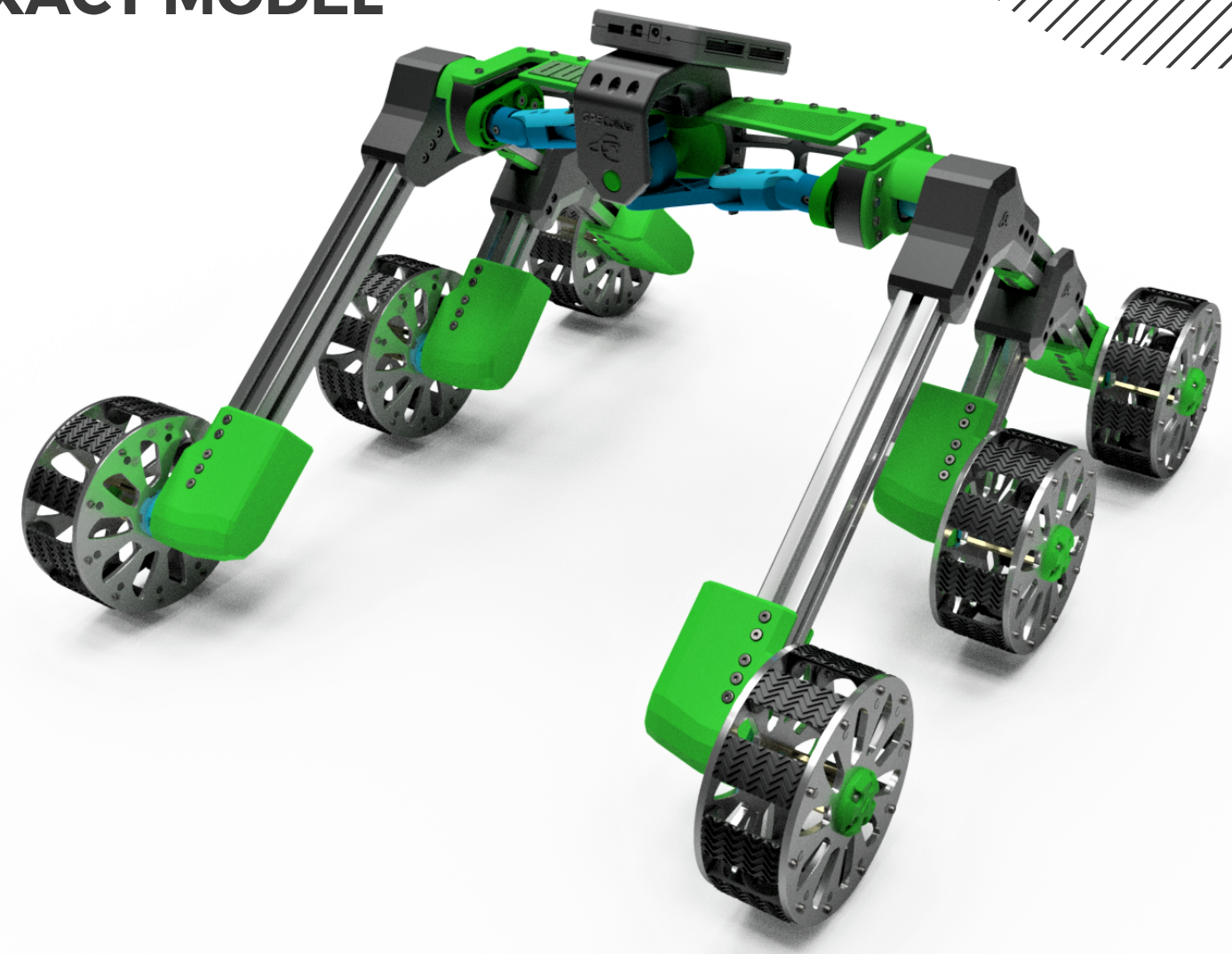
By using Autodesk Inventor program visible 3D model of suspenpension was created.



mechanics

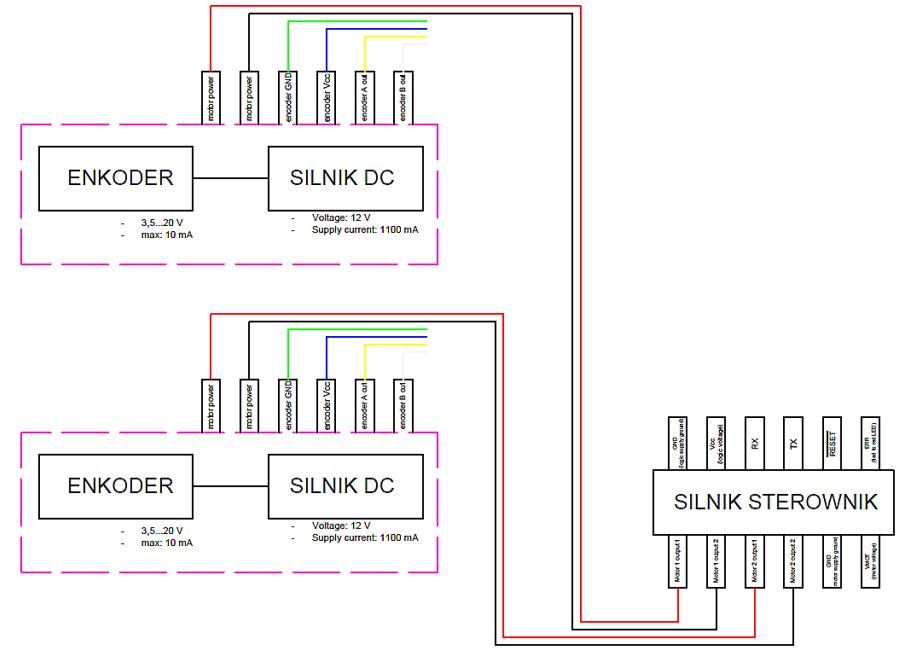
SUSPENSION EXACT MODEL

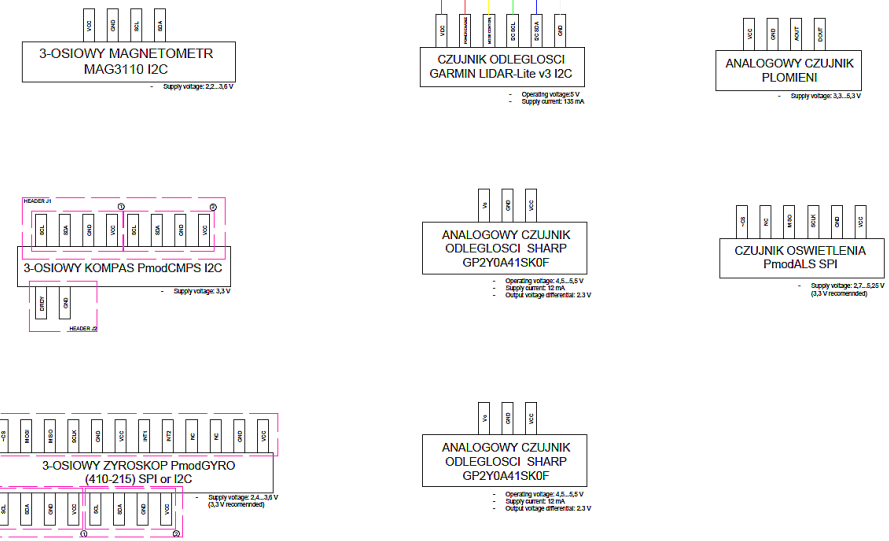
By using Autodesk Inventor program visible 3D model of suspenpension was created.



programming and control:

Next step is to create complete logical and eletronical circuit which conisist of motors, motor's controllers, interface elements and power supply module. Whole hardware will be based on NI myRIO. This step is indispensable to start creating a control software and make our rover drive.





SZYMON MĄCZKA
maczka24@gmail.com

THANK YOU