MARS

Mobile Agricultural Robot Swarms

Technical Description of MARS Robot

Deliverable D3

Dissemination Level: Restricted

Delivery Date: 31.07.2016

AGCO Your Agriculture Company

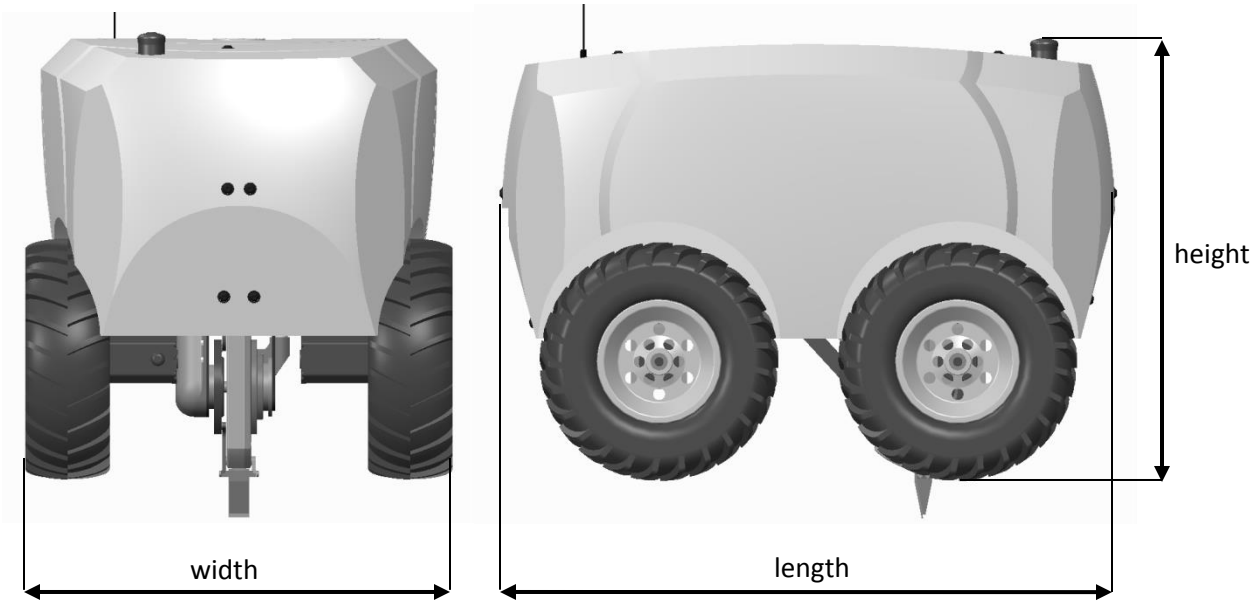
ECHORD++

Hochschule Ulm University of Applied Sciences

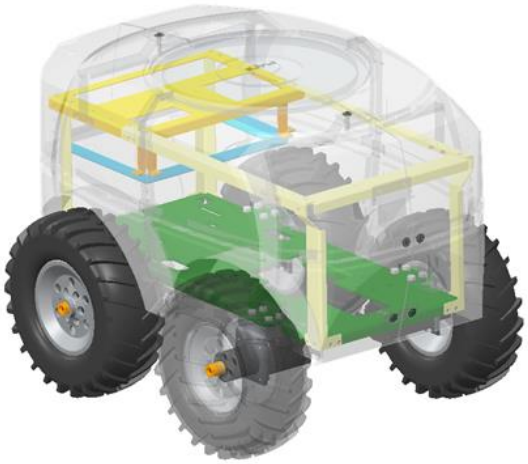
1 Hardware

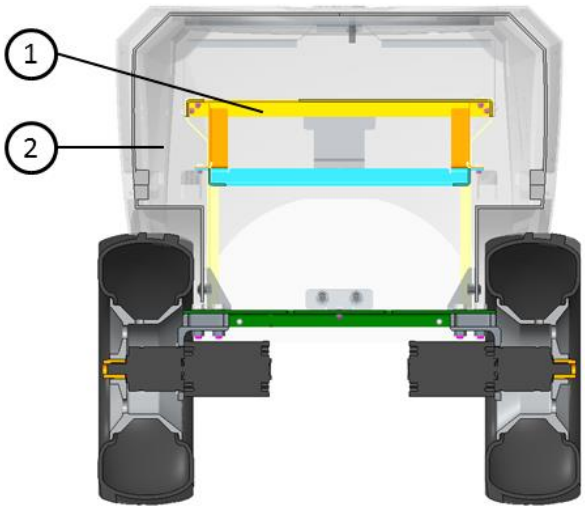
1.1 Technical Data

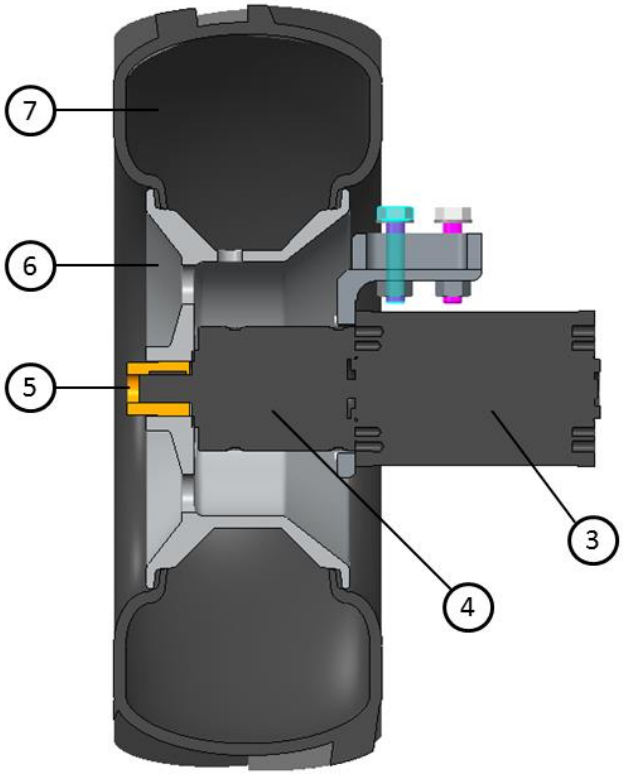
Description	Details
Geometric dimensions	Length: 825 mm Width: 567 mm Height: 718 mm
Wheelbase	412 mm
Track width	455 mm
Max. weight	ca. 58 kg
Max. power (drive)	short term (<10 s): 960 W long term (>10 s): 480 W
Max. Torque (drive)	short term (<10 s): 80 Nm long term (>10 s): 40 Nm
Max. speed (drive)	6.5 kph
Max. speed (seeding)	3.7 kph
Turning radius	0 m (zero turn)
Steering system	Skid steering with single – wheel drive
Ground clearance	55 mm (under seeding unit)



1.2 Chassis and drive train

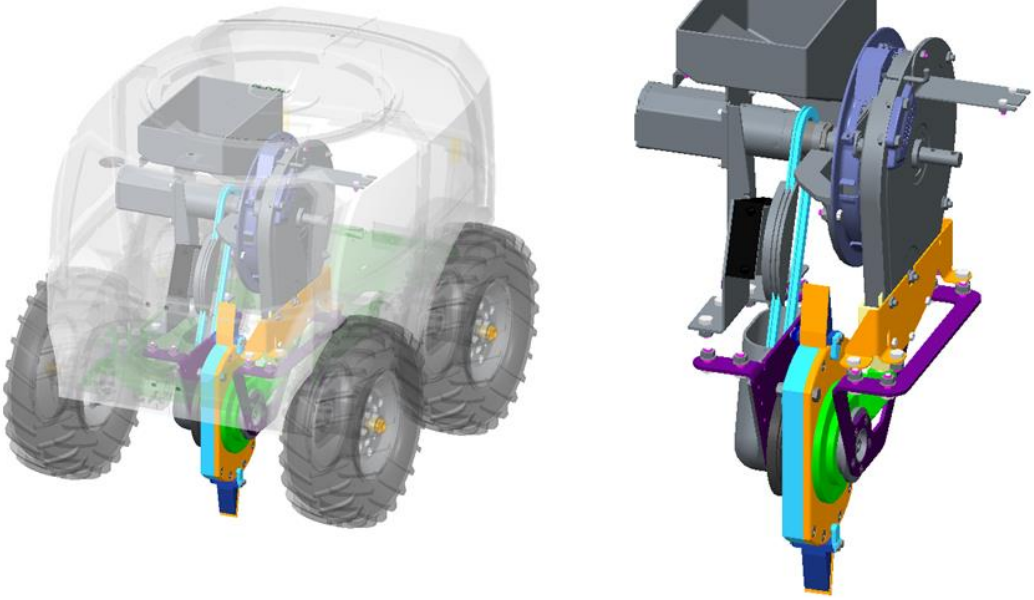


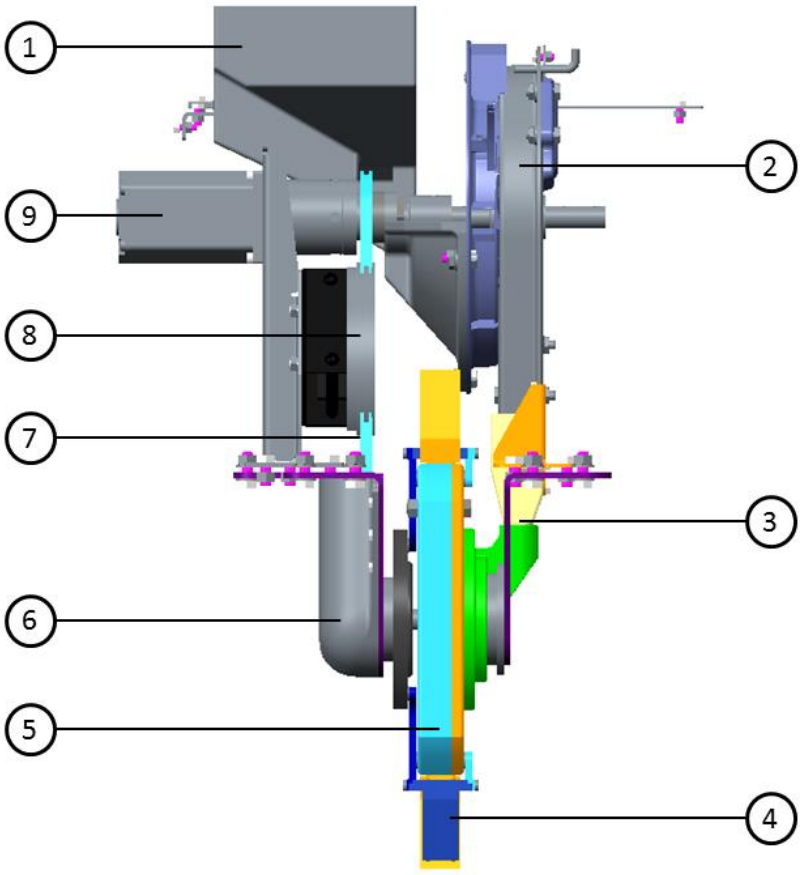




Position	Description	Details
1	Chassis	Sheet metal design
2	Body	Laminate
3	Motor	Dunkermotoren BG 65x25, 92.2 W at 24 V, nominal rpm: 3100
4	Gear	Planetary gear Dunkermotoren PLG 52, i = 50
5	Clamping set	
6	Rim	Diameter: 6” (151 mm), rim width: 3” (73 mm)
7	Tire	Width: 110 mm, diameter: 325 mm, rim size: 6”

1.3 Seeding unit and periphery

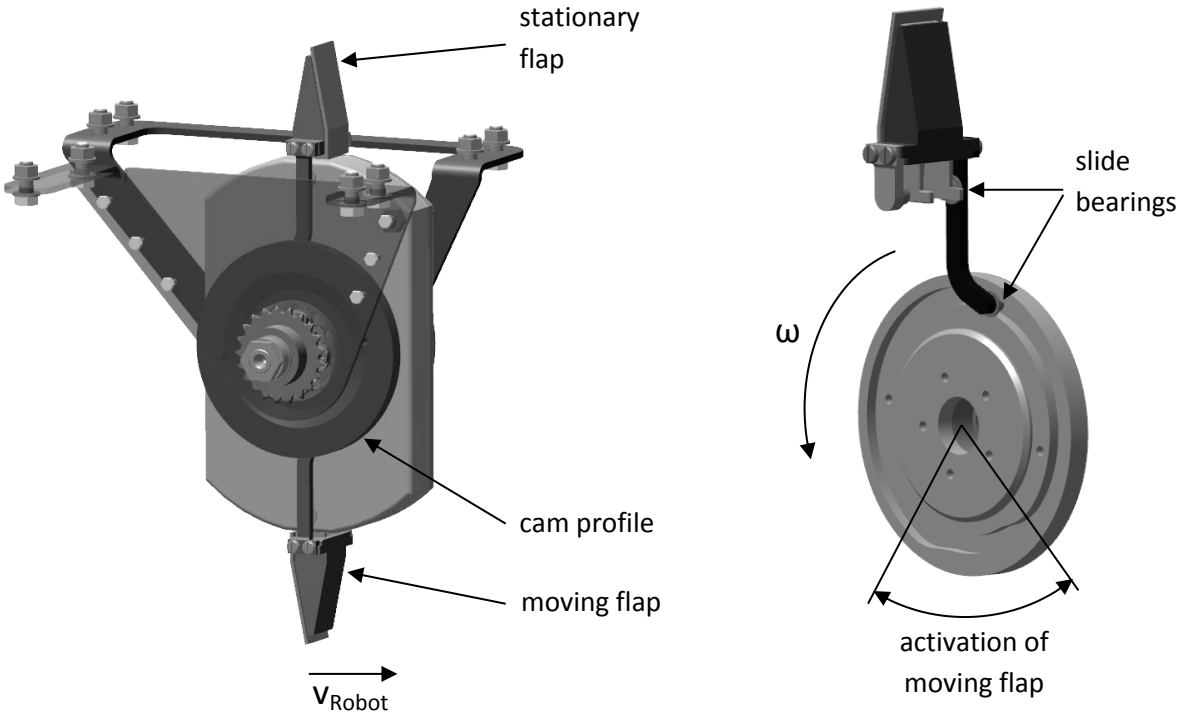




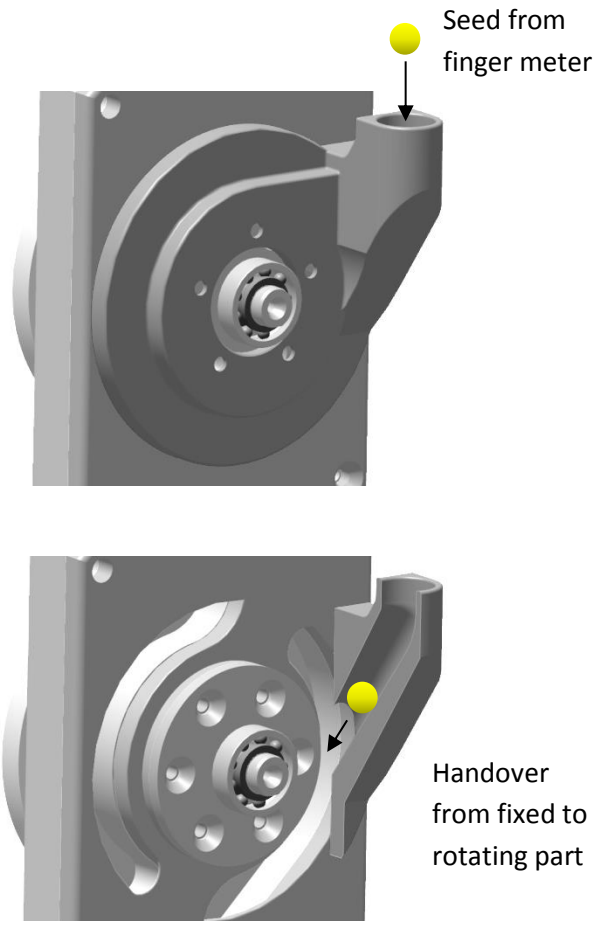
Position	Description	Details
1	Seed reservoir	Approx. 3 liters
2	Seed singulation	Precision Planting Finger meter for seed singulation
3	Supply system	Seed channel for handover between fixed and rotating parts.
4	Shovels	Shovels for punch seeding
5	Seeding unit	Seeding unit with internal seed channels Speed: 3 seeds per second (typical: 0.11 ha/h)
6	Chain guard	
7	Chain	Drive system for seeding unit
8	Chain tensioner	
9	Motor	Dunkermotoren BG 65x25, 92.2 W at 24 V, nominal rpm: 3100 with planetary gear PLG 52. (See chapter 1 «drive train»)

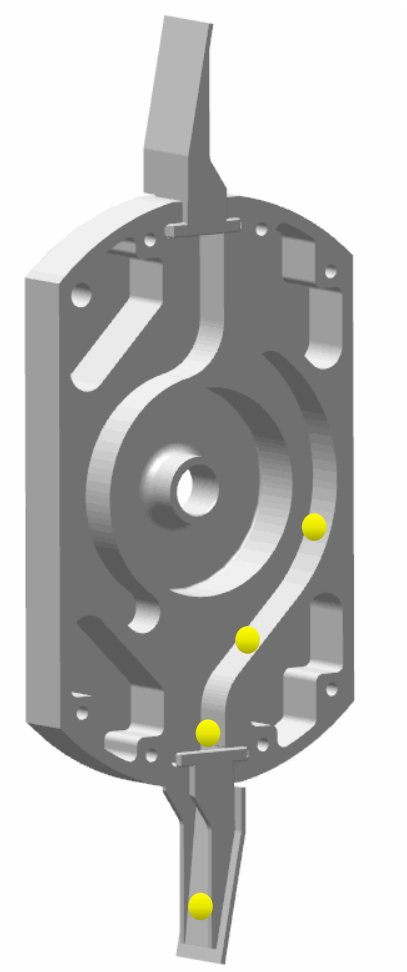
Functional Description:

1) Flap mechanism

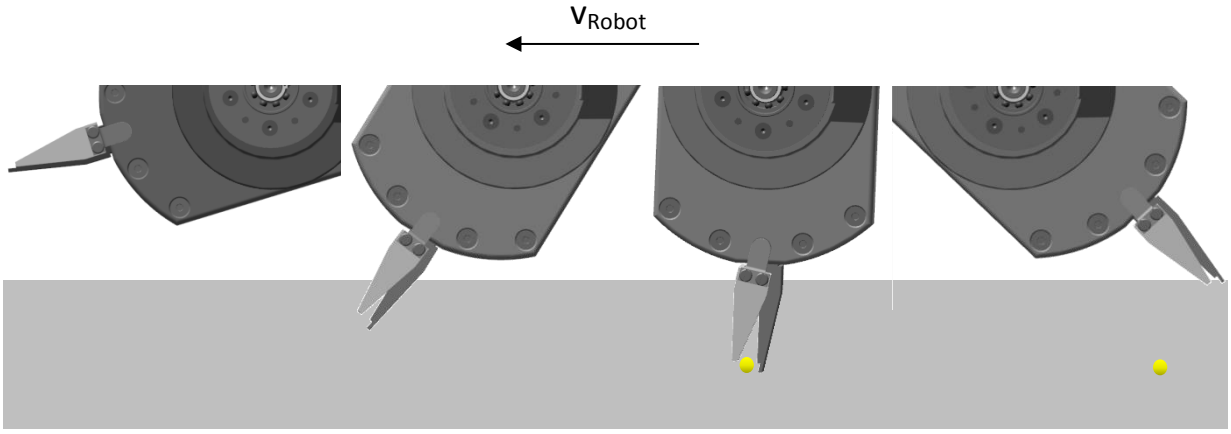


2) Feeding system

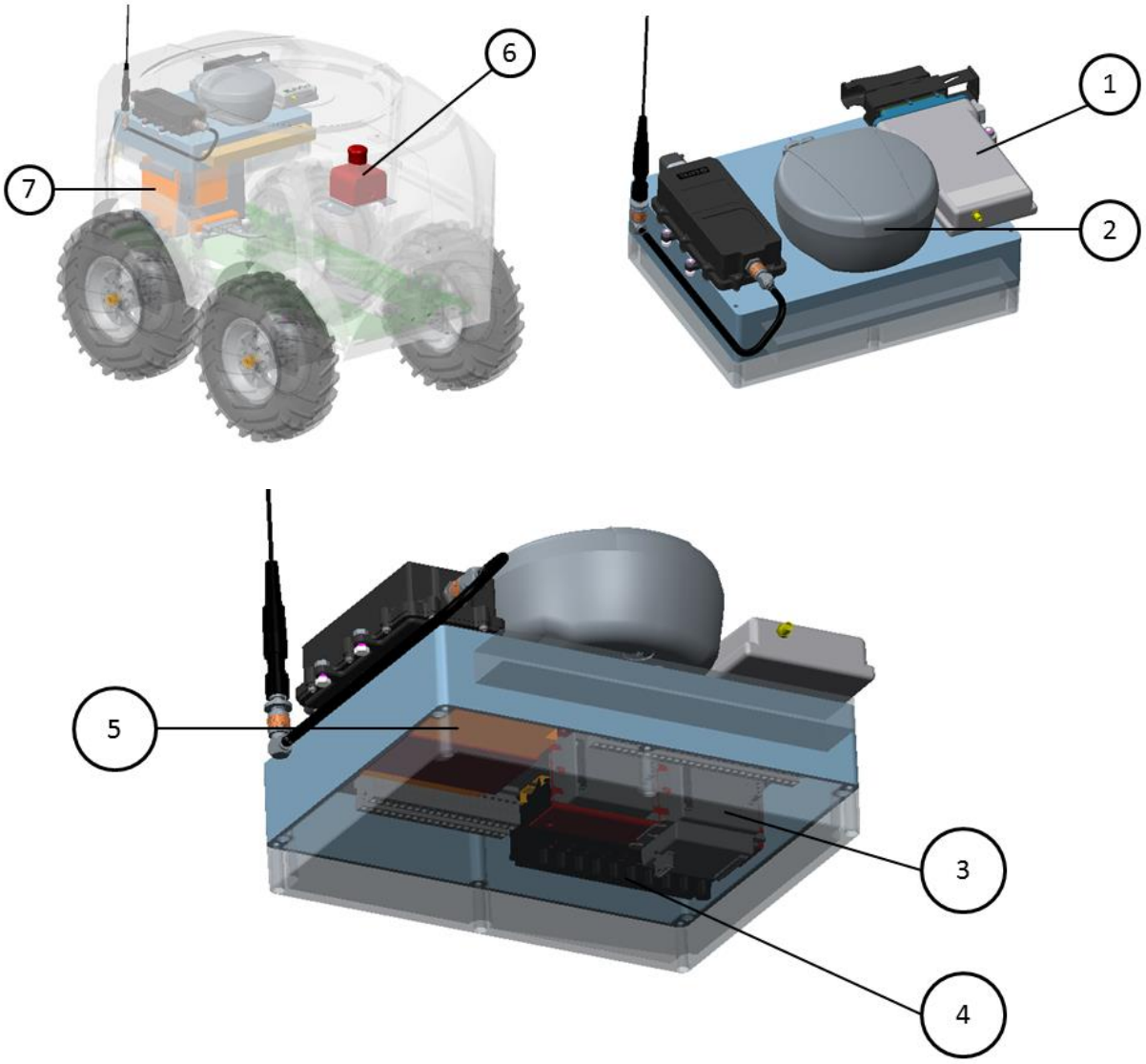




3) Seeding process



1.4 Electronic System



Position	Description	Details
1	Robot ECU	STW VD03 (IMU, 2x CAN-BUS (250 kBaud/s), GSM Modem)
2	GPS antenna	Smart antenna (Novatel SMART6-L with RTK)
3	Motor controller	miControl B60, max. current: 15 A (5x)
4	Fuse Box	
5	Wifi-CAN Gateway	Gateway for OptiVisor – Robot Communication (PEAK Systems)
6	Emergency stop	
7	Battery	Lithium iron phosphate battery, 240 Wh, 24 V

2 Software

Figure 1 shows the communication structure with CAN-BUS as the basic layer. The communication with OptiVisor is established through a WiFi-CAN Gateway. The central ECU (Electronic Control Unit) is the "VD03" (see **Figure 1**), which manages the communication between all entities.

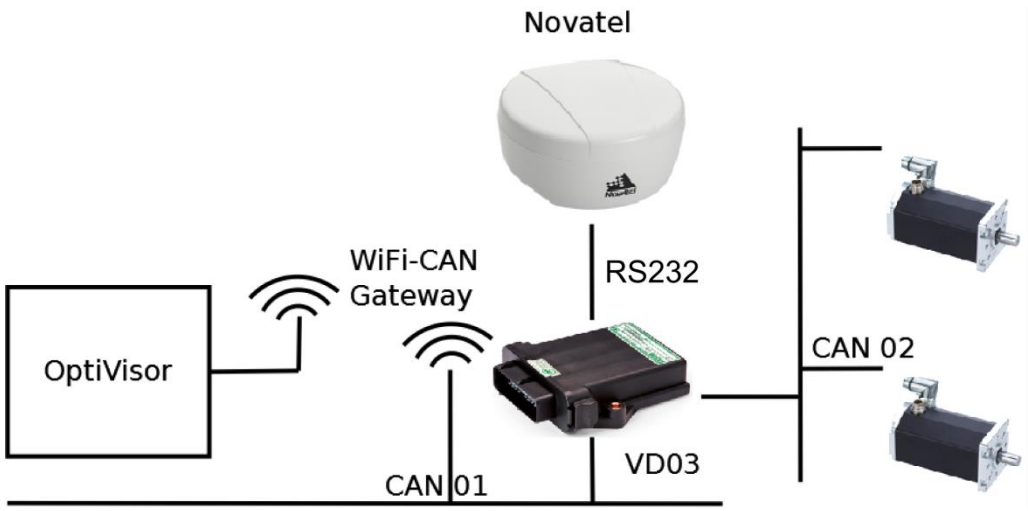


Figure 1: MARS Communication Structure.

The software embedded in the VD03 is based on real-time POSIX threads running on a Linux-based OS. It consists of three main abstract layers (**Figure 2**):

1) Motor Driver (CAN 02)
2) OptiVisor <-> Robot Communication (CAN 01 / WiFi)
3) Guidance Algorithm

The first layer "Motor Driver" is in charge of the motors and of the steering system. It is implemented on top of a CAN-BUS communication protocol (CANOpen). The second layer "OptiVisor - Robot" manages the communications between these two parts of MARS. Finally, the "Guidance" layer is in charge of getting the position from the receiver as well as of calculating the control signal for path-tracking. All layers can communicate to each other either through CAN-BUS or through internal shared resources. In contrast to the shared resources, data on the CAN-BUS is available to the external world.

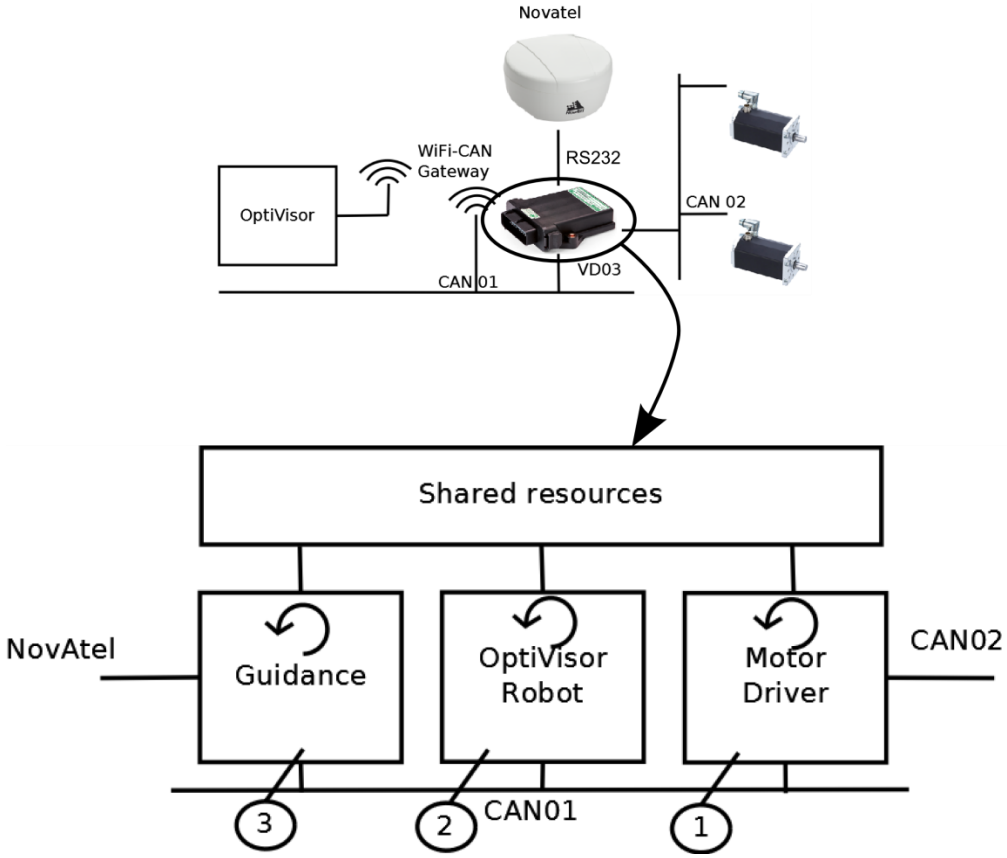


Figure 2: Main software layers implemented on VD03.

2.1 Motor Driver

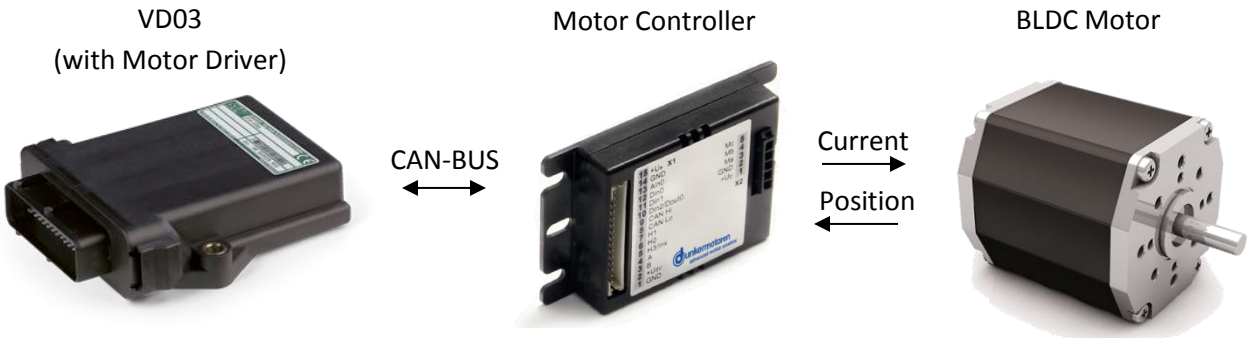


Figure 3: Physical communication layer.

Figure 3 shows the physical communication layer between Robot ECU (VD03), Motor Controller (MC) and motor. Each MC is connected to one motor and has a unique address. The MC matches the actual motor speed with the received set point speed from the Motor Driver (MD). It also transmits the actual phase current, voltage, temperature of the power electronics, speed and position to the MD via CAN-BUS. This enables a precise control of the driving, turning and seeding speed of the robot.

The communication between the MD and MC is done by SDO and PDO messages (CANOpen Protocol). All actual motor values are transmitted periodically to the MD via PDO messages while the MD mainly sends SDO messages for activation, speed control or deactivation of the connected drives. **Figure 4** shows the MD interface which can be used by other tasks within the VD03.

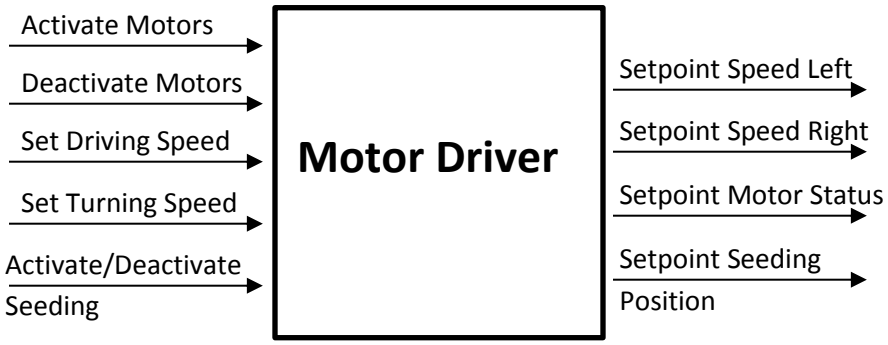


Figure 4: Motor Driver interface.

The Motor Driver also helps to avoid unnecessary power loss while standing still by automatically deactivating the front drives.

2.2 OptiVisor to Robot Communication

The OptiVisor task is in charge of the communication between OptiVisor and Robot and the communication flow is shown in **Figure 4**.

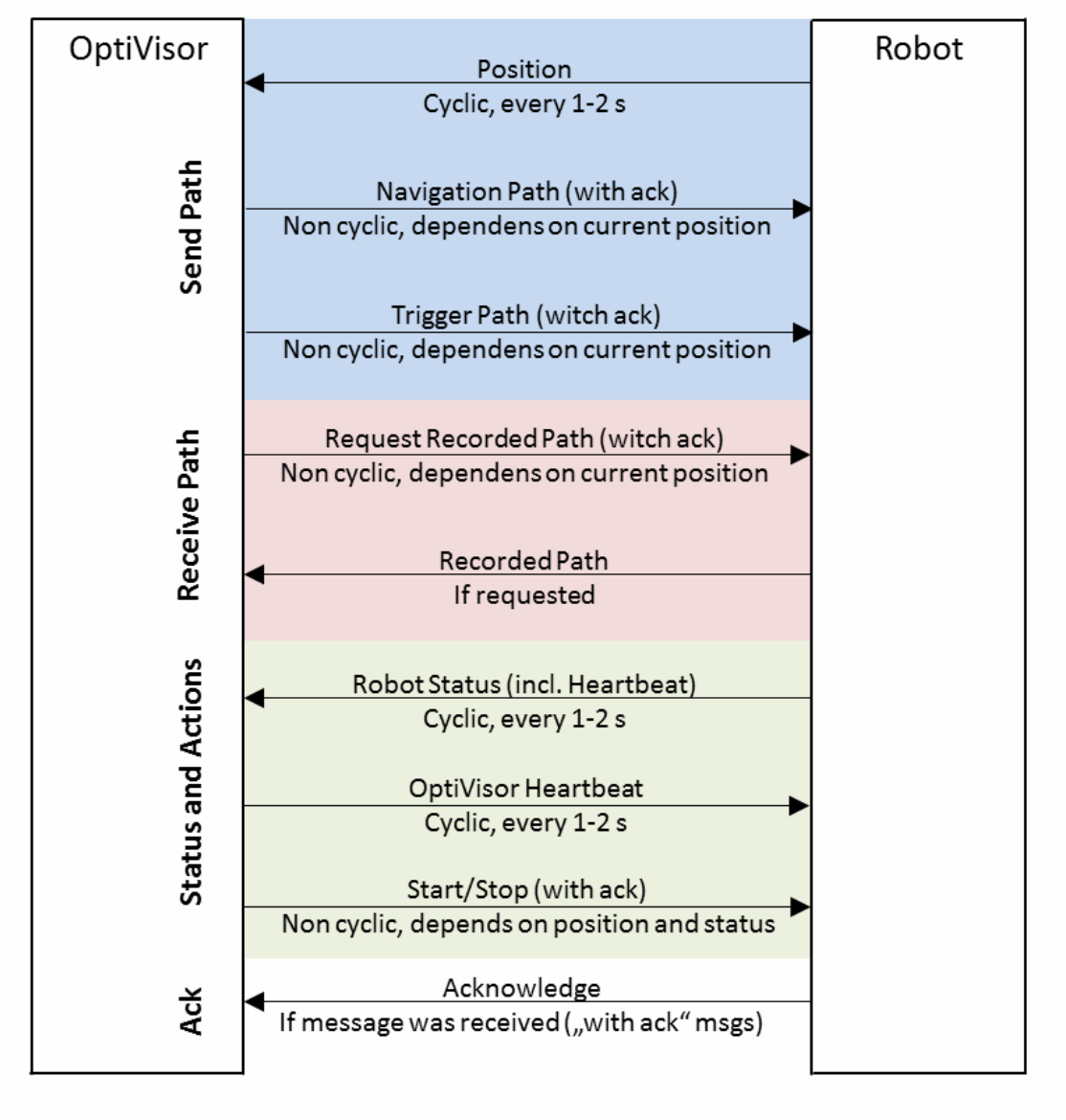


Figure 4: OptiVisor-Robot communication.

2.3 Guidance

The Guidance task receives the state of the receiver and of the navigation system. It also communicates with the OptiVisor-Robot task to process the start/stop commands as well as the navigation path to be able to compute the steering control signal. If the navigation system is ready, a valid path has been received, and the OptiVisor has sent a “START” command, the corresponding control signal is sent to the Motor Driver task. The flowchart of the Guidance task is shown in **Figure 5**.

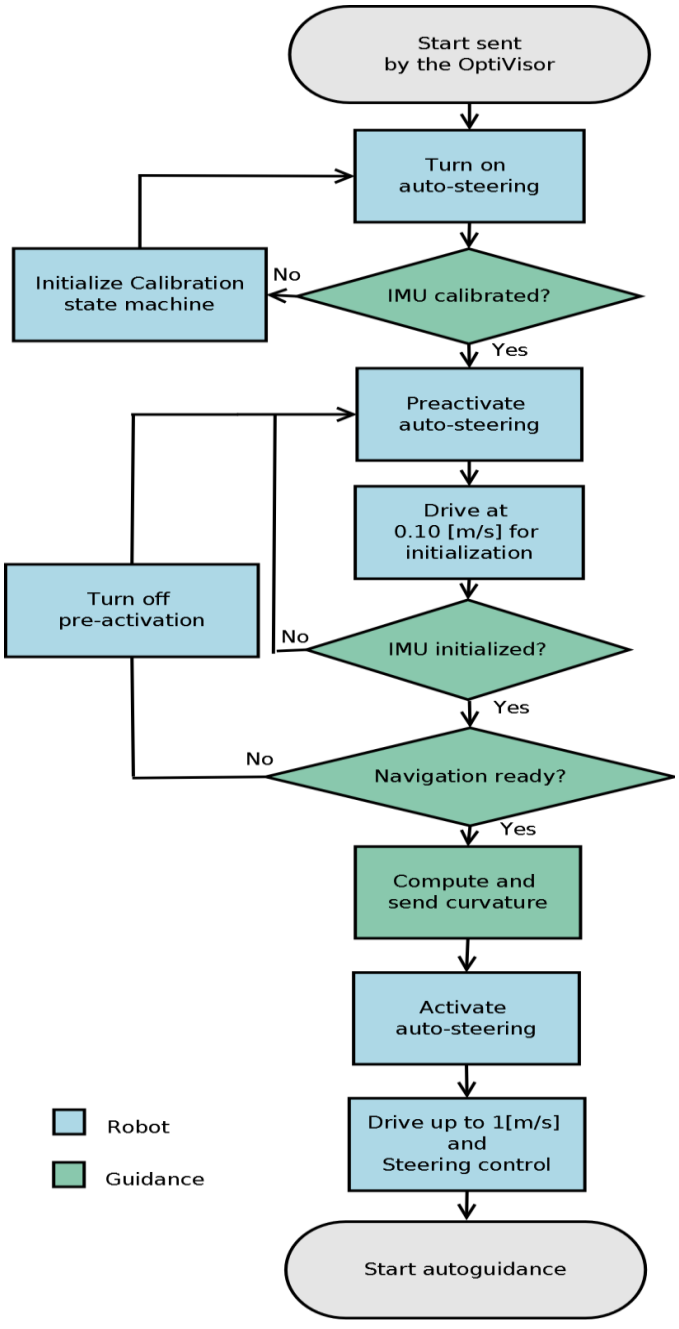


Figure 5: Auto-Steering flow chart.