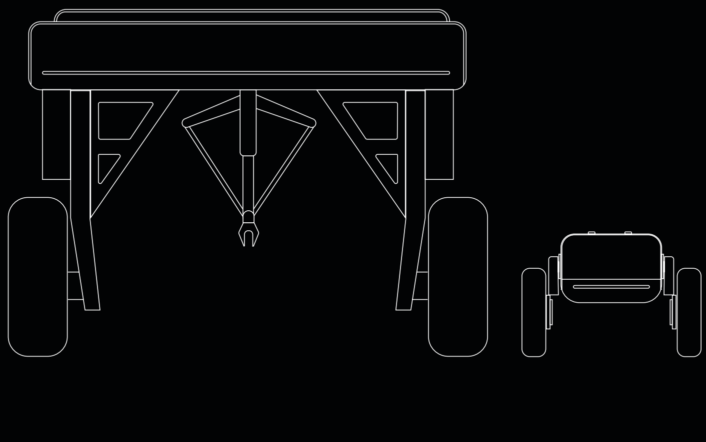
# **CURT** robots



# **CURT** robots

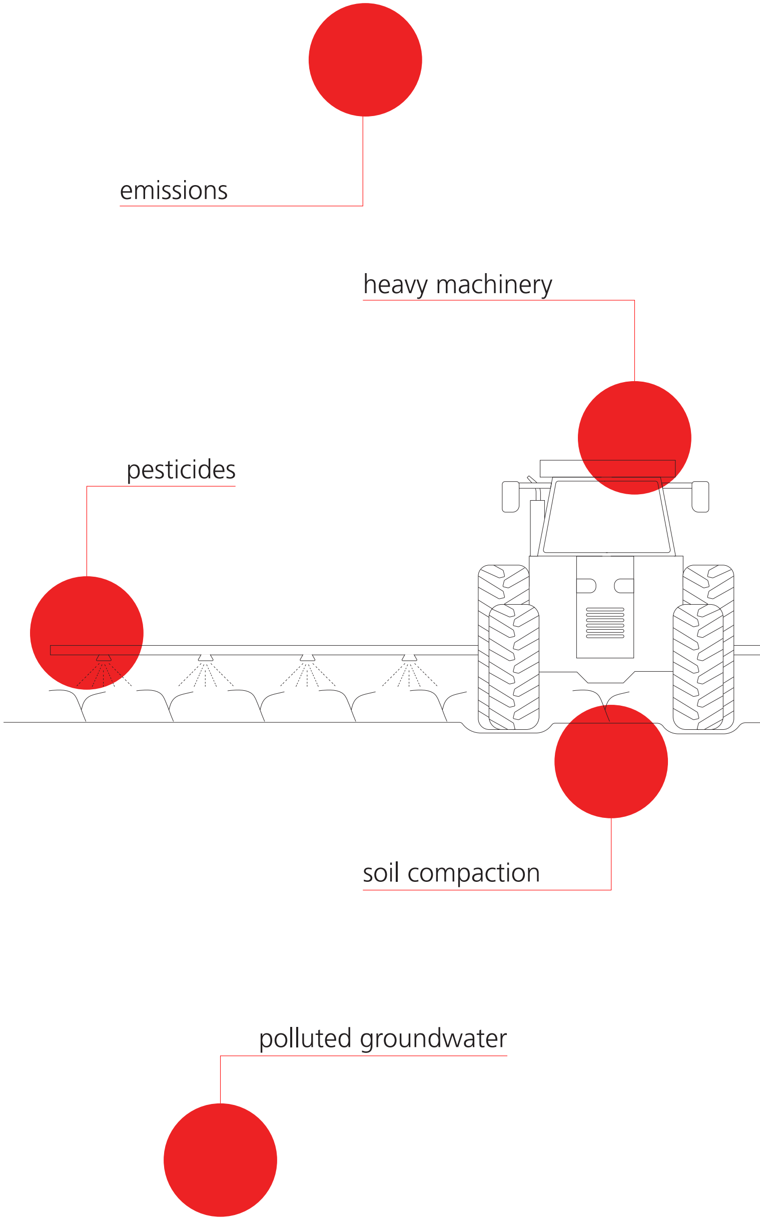
developed by the
Professional Service Robots –
Outdoor research group at
Fraunhofer IPA

Fraunhofer IPA

**an overview**

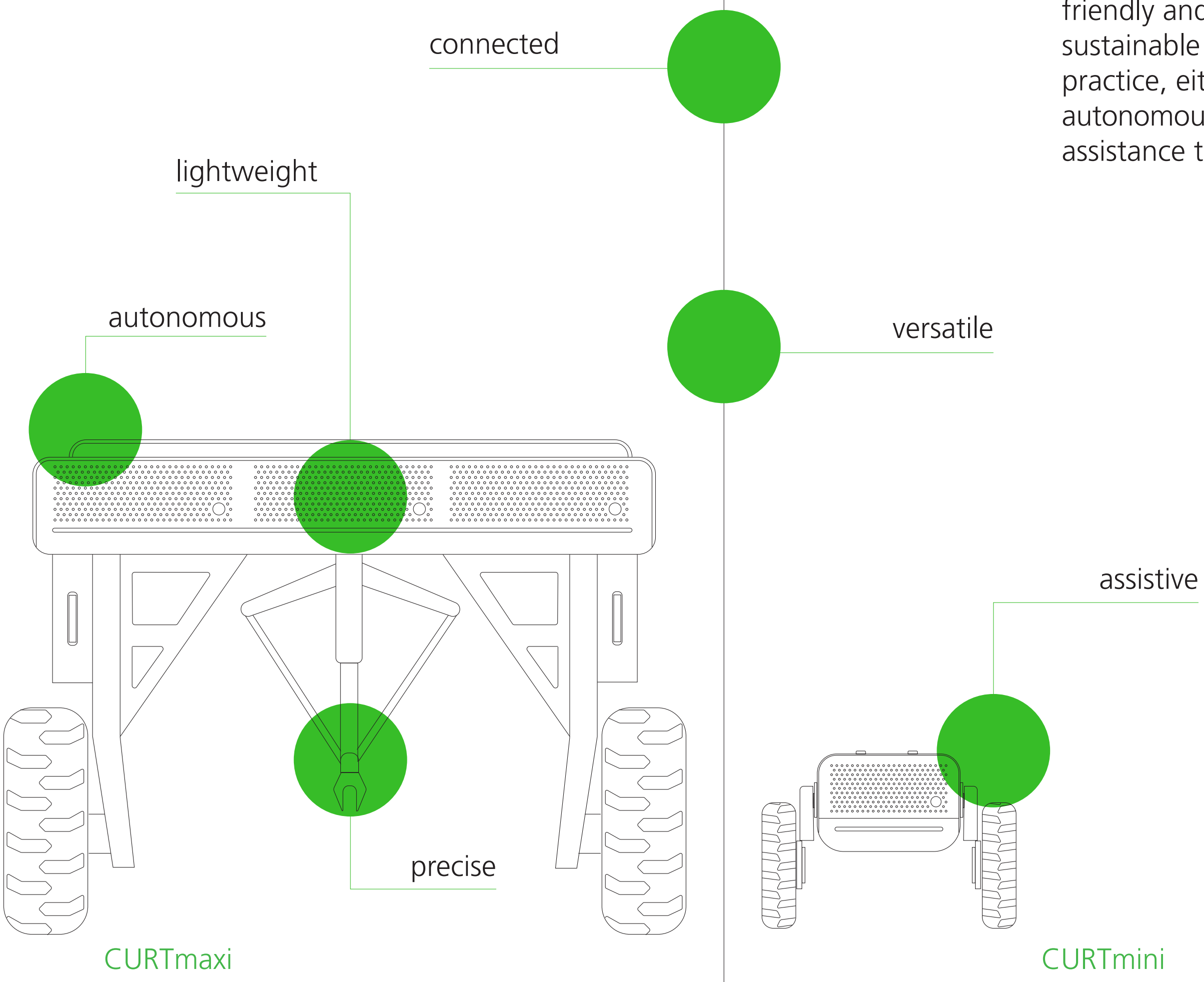
"A third of the agricultural workforce is seasonal, which poses a planning risk for farms due to fluctuations."
(BMEL, 2023)

Agriculture is under enormous pressure. On one hand, environmental problems, such as groundwater pollution and massive insect mortality, must be increasingly taken into account in the way food is produced; on the other hand, economic efficiency and productivity must not suffer as a result, and at the same time the high level of productivity must be maintained or even increased. Automation offers an opportunity to rethink certain work processes and to question conventional methods.
The use of pesticides can be greatly reduced through selective application, and autnomous robots can assist manual labor.



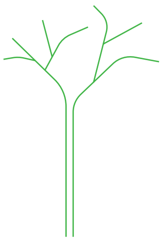
# project **CURT**

Small, more precise and autonomous field machines can be part of the solution to the problems described. CURT is such a system consisting of individual small robots. CURT robots aim to put ecological, environmentally friendly and economically sustainable agriculture into practice, either as a fully autonomous machine or as an assistance to human labour.

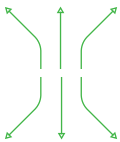


# possible **applications** for project CURT

**agriculture |** The first CURT prototypes were developed for use in agriculture. Because CURT is an electrified robot and therefore has limited power capacity compared to conventional internal combustion engines, it is mainly aimed at work that can be carried out in an energy-efficient manner. These include seeding, crop protection, fertilization, harvest monitoring and partial harvesting operations.



**forestry |** Possible applications in forestry include monitoring stands, planting trees and providing emergency assistance in the event of natural disasters such as forest fires or severe storms.

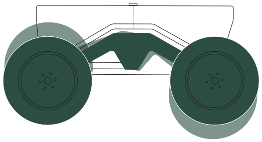


**outdoor logistics |** CURT robots can perform logistics tasks in outdoor industrial applications as well as in other fields such as construction, agriculture or delivery. Here, the focus of CURT is primarily on the reliable transport of goods.

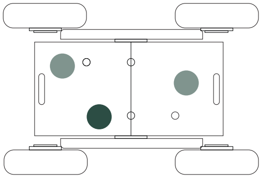
# robust. flexible.
# **testing platform.**

**agriculture | outdoor logistics | forestry | rescue missions**

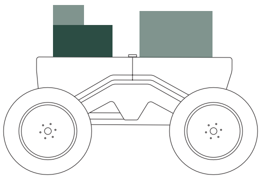
The autonomous small robot CURTmini is a robust and flexible outdoor robot platform for all outdoor environments. It can be equipped with sensors for any application. Prototyping and testing of new algorithms for autonomous navigation or perception can be implemented quickly and easily.



**Rocker kinematics** help CURTmini maintain ground contact on rough terrain while achieving good balance.



The **sensor platform** can be equipped with sensors for any application in different positions and used for testing new components or algorithms.



CURTmini offers the possibility for **further applications**, including outdoor logistics tasks and follow-me assistance for workers in the field.

lightweight.
autonomous.
**crop protection.**

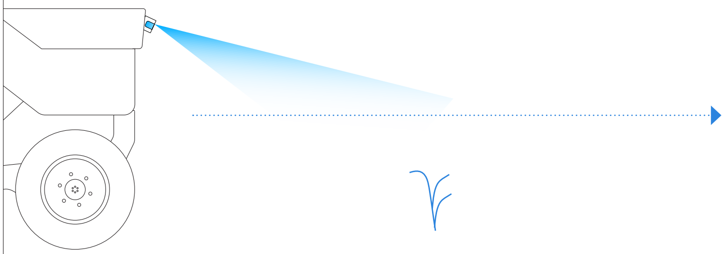
**crop protection | fertilization | irrigation**

The CURTmaxi is the largest representative of the CURT robots. It is used to test prototype developments for productive use, for example, to be able to carry out economic feasibility studies. It is designed for crossing two rows of fields, for example potatoes. The track width can be configured for all common field row distances. It is equipped with sensors for environment perception for navigation and with actuators for the implementation of certain applications, such as selective weed control.

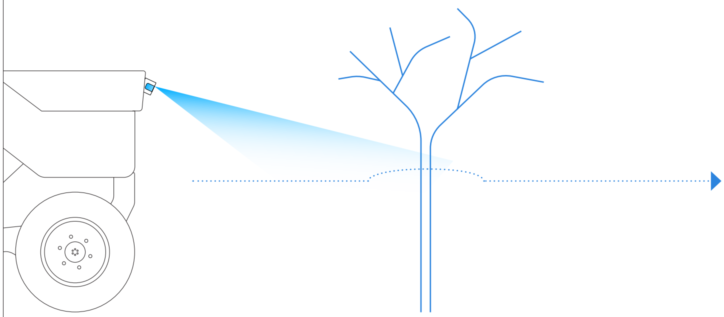
# autonomous **navigation**

## robot independent | environment adaptive

Autonomous navigation can be adapted depending on the application and is specifically designed for rough terrain, on paths with potholes, puddles and obstacles. In the case of obstacles, it is particularly important in outdoor applications to distinguish between obstacles that can be traversed (e.g. flexible obstacles such as grasses) and those that cannot (e.g. big rigid obstacles). To ensure a high degree of flexibility in different environments, CURT has versatile localization approaches to (fully) replace GNSS or wheel odometry if necessary. In order to ensure a high degree of flexibility in use, CURT can do without GNSS, for localization. In order to achieve a fully autonomous navigation, the interaction of several individual technologies is necessary. These technologies are localization, path planning (global and local), mapping and environment perception.



small obstacles can be crossed

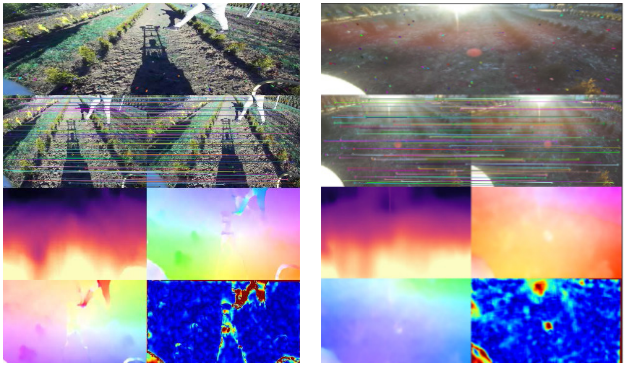


larger obstacles are bypassed

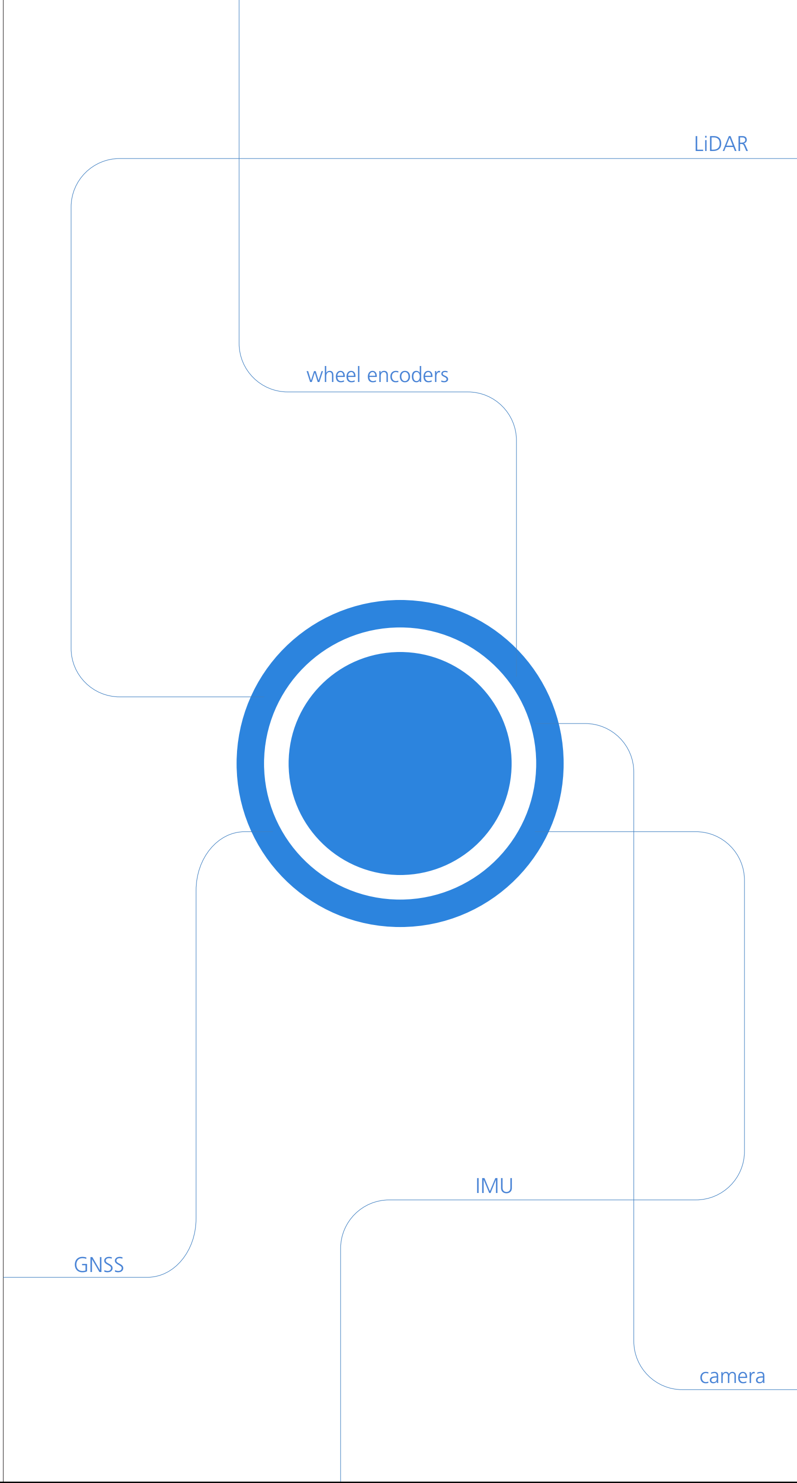
# localization

## GNSS-independent |
## dynamic in- & outdoor environments

In CURT, localization is based on multiple sensor data and their subsequent processing. Wheel encoders, cameras, lidars, IMU and GNSS can be combined as sensors by fusing the generated data. Individual sensors can be compensated, depending on the application. For example, CURT's precise visual odometry can eliminate the need for wheel encoders or CURT's row detection and tracking algorithms can replace the GNSS systems if they cannot provide sufficient quality input temporarily or even permanently.



Visual odometry: Dynamic obstacles (left) and overexposed image (right). Actual image data and feature matching (both top). Depth image map, forward optical flow, backward optical flow and flow consistency (both bottom)



# path planning

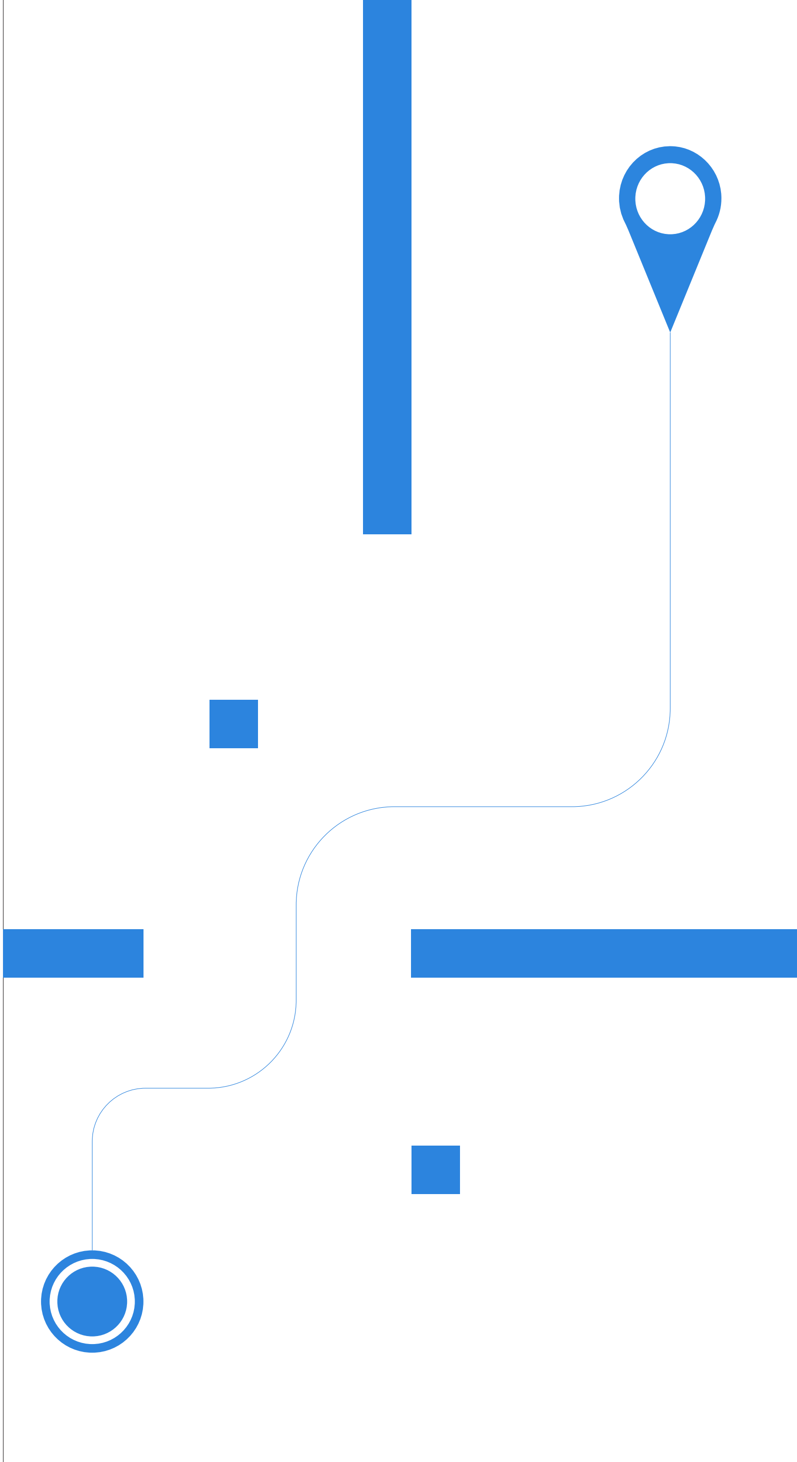
**for all kinematics | optimal traversability | obstacle avoidance**

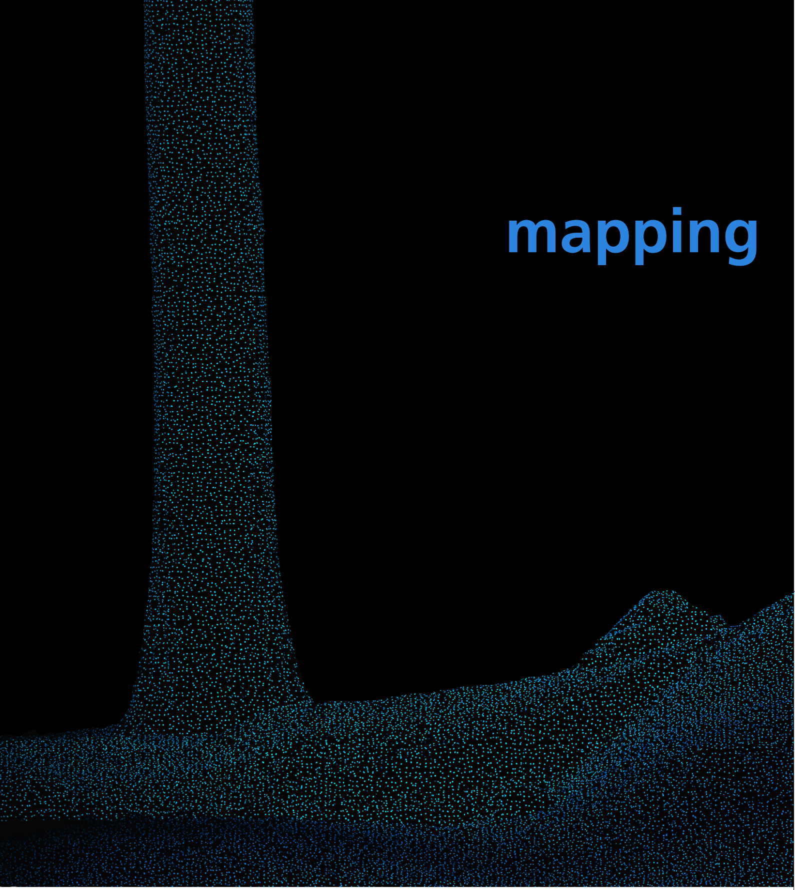
Path planning is divided into local (dynamic in the immediate environment, reactive to new, temporary events) and global planning (static from start to destination, through a priori information).

In global planning, a complete and contiuous path from start to goal is sought for a given robot, using all the information available in advance.

In local planning, the immediate environmental information is used to adaptively respond to all possible deviations from the a priori knowledge. For instance, there may be unknown temporary obstacles in advance, such as large puddles after heavy rain on the planned route, or people and animals, as well as newly emerging vegetation.

CURT therefore works with all available information and can find possible routes reliably and independently.

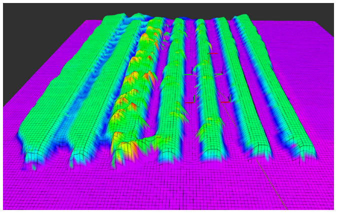




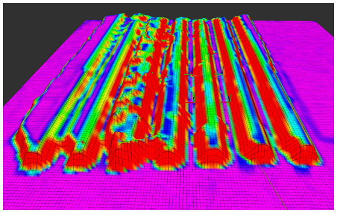
# mapping

Maps are used to utilise and store the processed data for CURT's locomotion and interaction. Depending on the application and the sensors used, the maps need to contain varying types of information about CURT's environment.

Elevation maps from 3D point cloud data provide the basis for so-called traversability maps. The traversability information is calculated based on the slope, steps (geometric) and surface type and condition (semantic) detected by LiDAR and camera data.



Generating an elevation map from LiDAR data



Generating a traversability map as a basis for intelligent path planning

testing.
evaluating.
**rapid prototyping.**

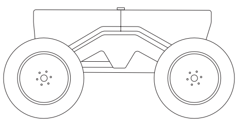
**arable farming | tree nurseries | special crops**

All CURT robots are prototypes that can be adapted and used depending on the application. CURTmvp, minimum viable product, was built as a fast prototype with minimal sensors and actuators to enable rapid testing of new technologies and application scenarios for which CURTmaxi could be used. CURTmini was prototyped primarily for logistic tasks, data acquisitions and navigation tests in rough terrain. Based on these platforms and with the experience of these prototypes, new applications can be developed and tested for feasibility in the shortest possible time.


mvp and prototypes for CURTmaxi (left) and CURTmini (right)

# CURT**mini**

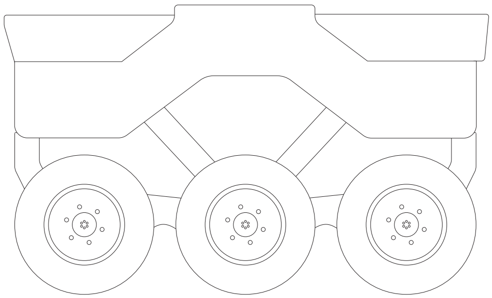
| size and weight | |
|---|---|
| dimensions L*W*H | 780*540*360 mm |
| wheel base L*W | 520*460 mm |
| mounting area top L*W | 234*230 mm |
| mounting area front W*H | 220*104 mm |
| mounting area back W*H | 220*72 mm |
| weight | 35 kg |
| ground clearance | 155 mm |
| **performance** | |
| payload | +30 kg |
| max speed | 2 m/s |
| drive torque | 150 Nm per wheel |
| **power system** | |
| battery type | LiPo |
| capacity | 30 000 mAh |
| runtime | 4 h |
| **software** | |
| middleware | ROS1, ROS2, Docker |
| simulation | Gazebo model and RViz visualization |
| autonomy packages | autonomous navigation on fields, follow-me capabilities |



# CURT**maxi**

| size and weight | |
|---|---|
| dimensions L*W*H | 2100*1700*1300 mm |
| wheel base L*W | 1400*1500 mm |
| mounting area top L*W | 600*1400 mm |
| mounting area front W*H | 1400*150 mm |
| mounting area back W*H | 1400*150 mm |
| weight | 300 kg |
| ground clearance | 1000 mm |
| **performance** | |
| payload | +200 kg |
| max speed | tbd* |
| drive torque | tbd* |
| **power system** | |
| battery type | tbd* |
| capacity | tbd* |
| runtime | tbd* |
| **software** | |
| firmware | ROS1, ROS2, Docker |
| simulation | Gazebo model and RViz visualization |
| autonomy packages | autonomous navigation on fields |

*customised adaptation possible



**contact**

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