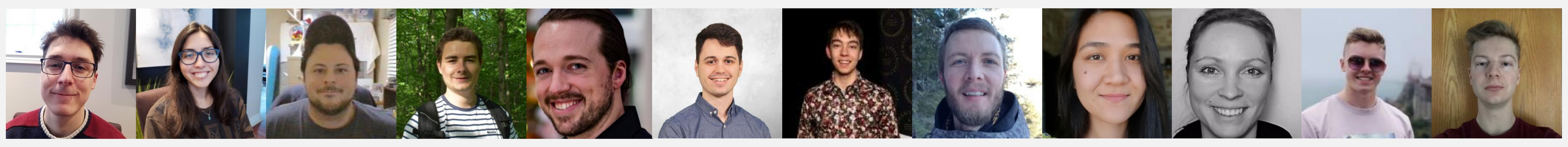
WEASEL

Winter Electric Autonomous Snowplow Engineered at Laval



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Our Team

The VAUL is a mobile robotics club from Université Laval, Québec, Canada. Our team is made up of students from different fields, but mainly electrical, mechanical and software engineering. We seek to learn through challenging projects such as the Autonomous Snowplow Competition.

Vehicle Summary

Weight 500 pounds	Propulsion 4 independent motors	Dimensions 1.43 x 1 x 1.5 m
Power 100Ah 24V Deep-Discharge Batteries	Steering Skid-Steer Drive	Plowing capacity 30 kg (Dry asphalt) 12 kg (Wet Ice)

Computing Power

Dell 3070

This compact computer is the main brain of the robot. It is used to process the data from the sensors, plan the robot's trajectory and send commands to the motors. It packs 8 Cores at 3.0 GHz, 8 GB of RAM, runs the Robot Operating System (ROS) over Linux.

Xavier AGX

The Nvidia Xavier AGX is used for its capacity to process images from the cameras way faster than the PC. It is mainly used to detect objects in images using deep neural networks.

Control System

The low-level electronics control the displacement of the snowplow. Intelligent motor drivers control each wheel independently and regulate angular speed with feedback from optical encoders. Two linear actuators can move the blade up or down. E-Stops directly cut power fed into the motor drivers.

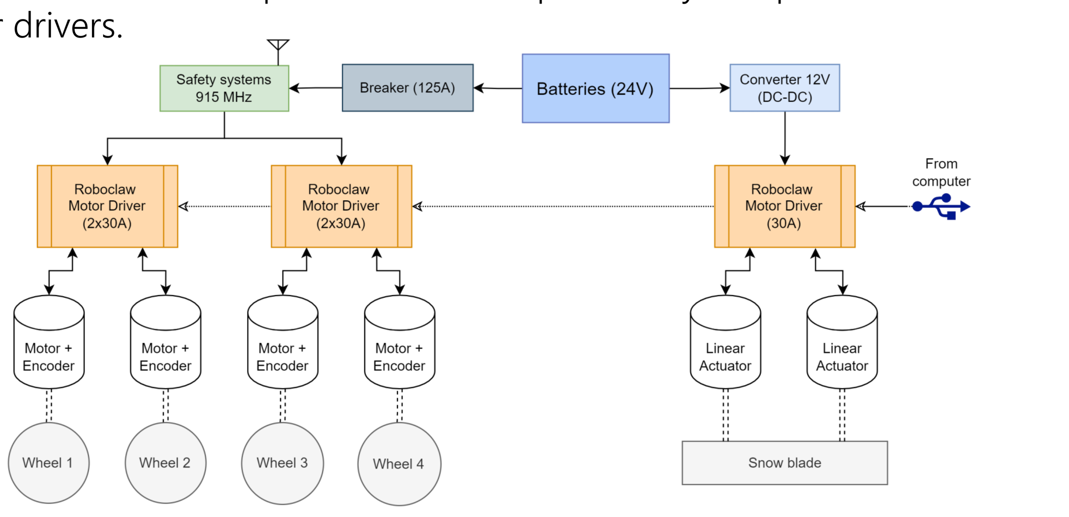


Figure 4 : Block diagram of the low-level control

Sensors and Software

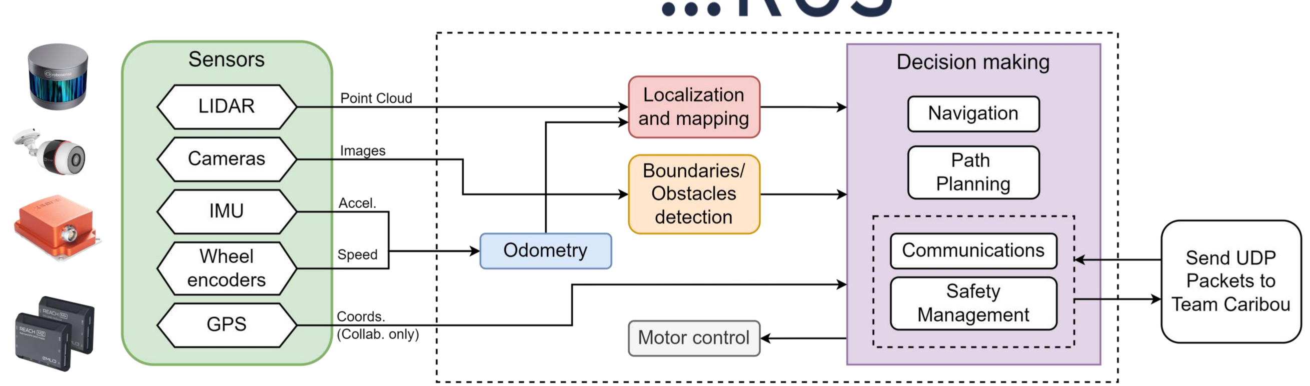


Figure 1 : Diagram showing the interactions between the sensors and the navigation stack.

The snowplow is equipped with cutting edge sensors to perceive its environment. A 16 beams LIDAR is used to map the world surrounding the robot and localize in it. Three cameras installed on the robot detect obstacles through deep learning. An inertial measurements unit (IMU) combined with data from the wheel encoders provide a good prior for the robot position. Two GPS are used in the collaborative challenge to share our coordinates with Team Caribou. Through Robot Operating System (ROS), parallel nodes exchange the sensors' data to make informed decision towards navigating the field and plowing the snow. For the collaborative challenge, information is exchanged through UDP packets with the other snowplow.

Safety System

To ensure everyone's safety, a physical E-Stop is easily accessible on top of the robot in case of emergency. A second wireless E-Stop can also be activated remotely by a visual observer which stops all movements.

The remote E-Stop relies minimally on software. Redundancy is planned to be added on the receiver side to alleviate the risks of a software issue.

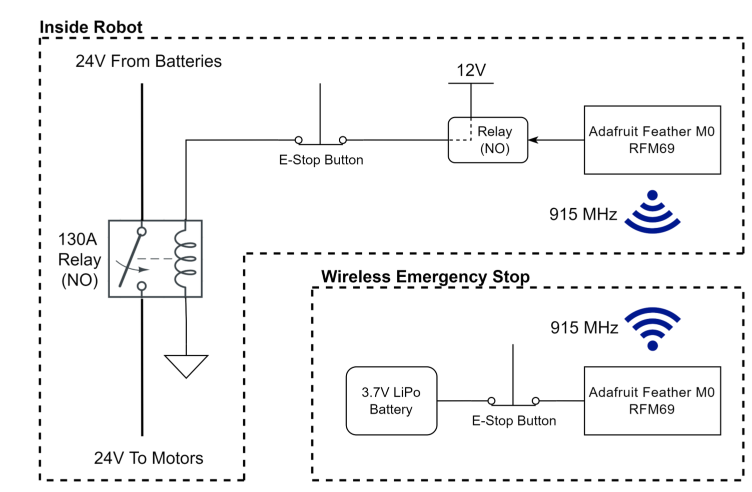
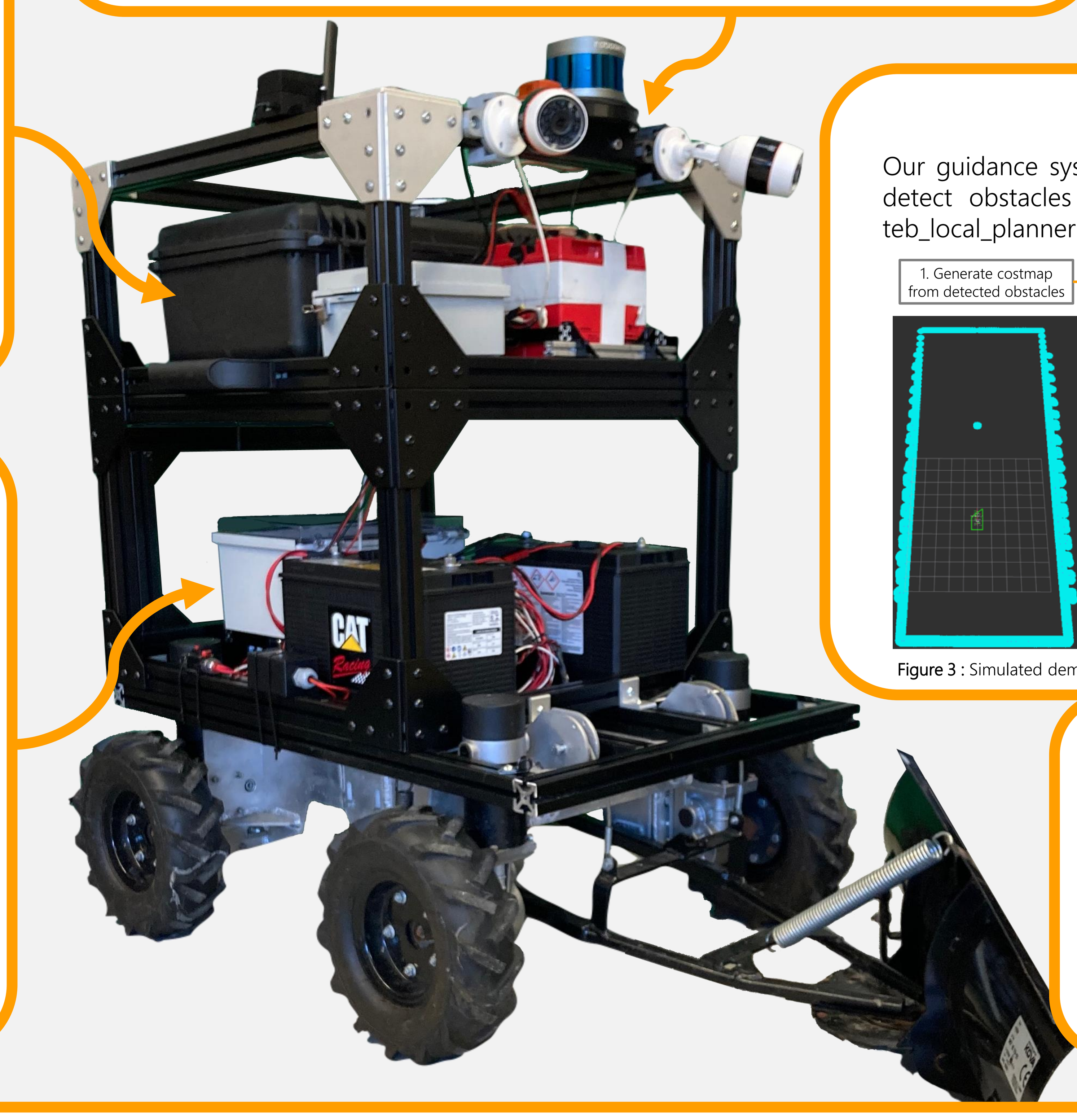


Figure 2 : Schematics view of the safety systems.



Navigation Approach

Our guidance system takes advantage of the LIDAR generated map to detect obstacles and plan the robot's trajectory. The ROS package teb_local_planner is use to control the snowplow

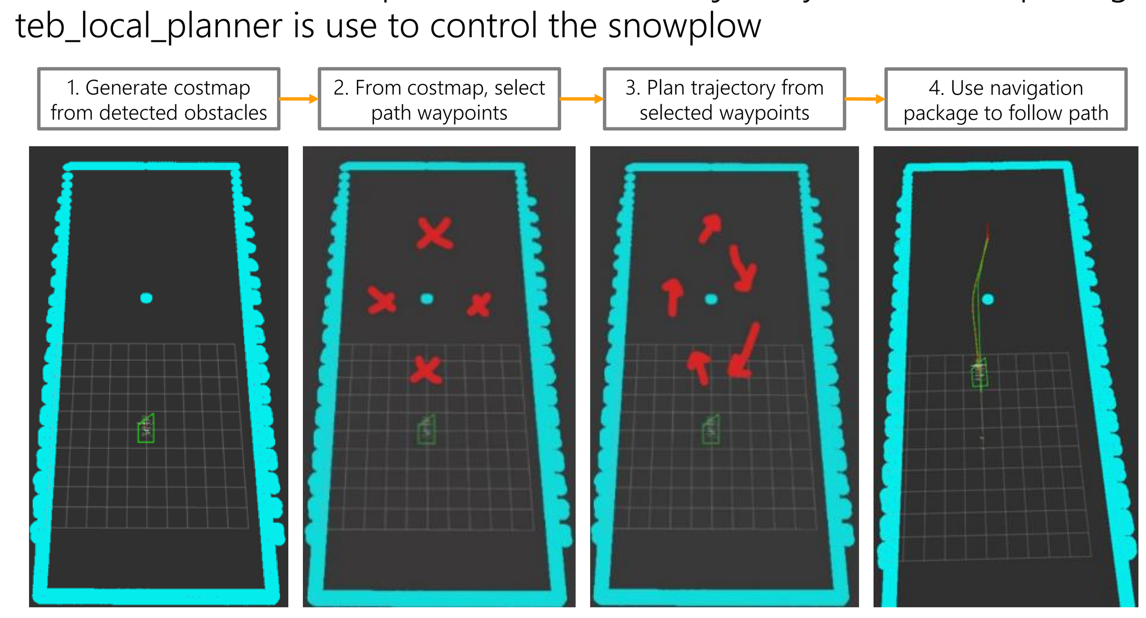


Figure 3 : Simulated demonstration of the robot planning its trajectory around a detected obstacle (middle).

Single-I Strategy

Our strategy is to plow in a straight line a full stripe of snow. The snowplow's odometry can detect that the robot is stuck and can't push any more snow. In this case, it triggers a special maneuver to push the excess of snow aside. If the maneuver was successful, plowing can resume as before. If it gets stuck too often the width of the stripe of snow plow is diminished.

Special maneuver :

Collaborative Triple-I Strategy

For the collaborative part of the competition, WEASEL teams up with Caribou Plow to accelerate snow removal from a bigger parking lot. To avoid collisions, both snowplows have a separate part to clean up.

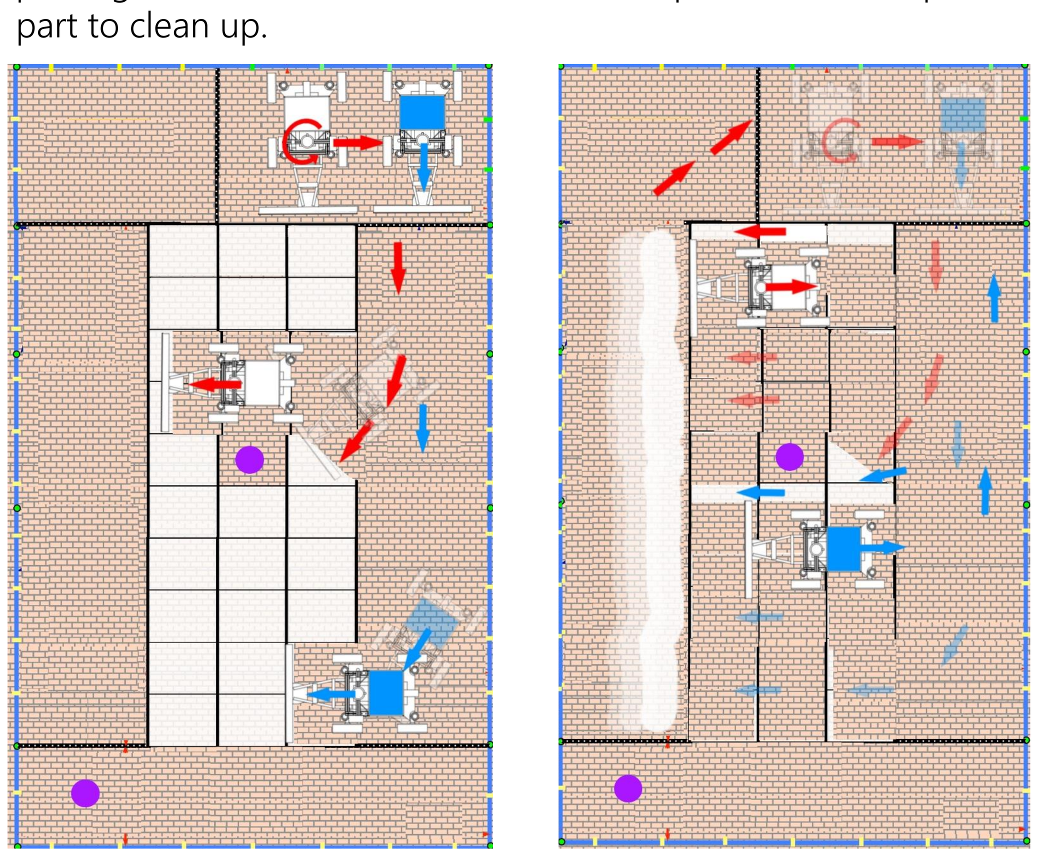


Figure 5 : Plowing strategy for the Triple-I Collaborative competition.

Collaborative Communication

Our two systems are linked by ROS bridge. UDP packets of vital information are shared bilaterally. A heartbeat boolean is use to know the status of the other robot. Coordinates of path planning, localization and obstacles detected are shared to the other team. Robot 1 has the wireless router set as a DHCP server and manages the the trafic.

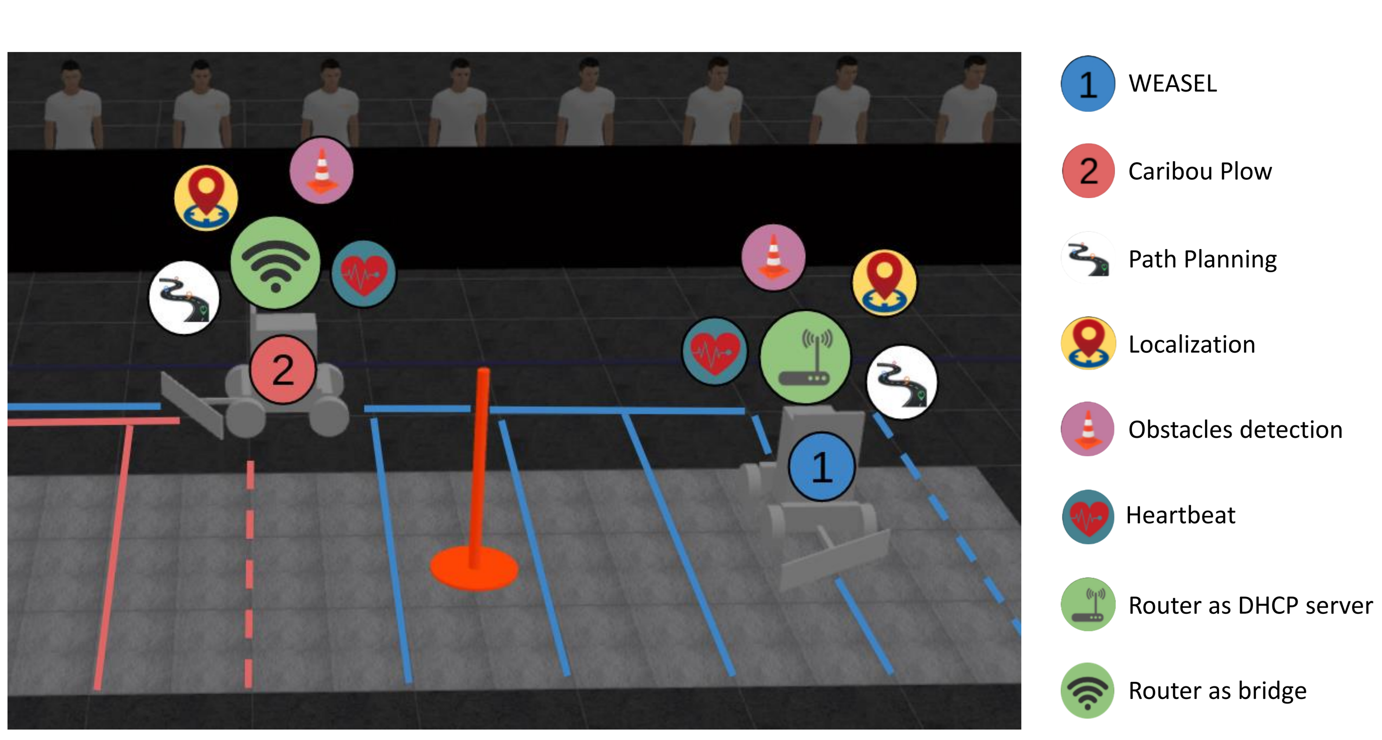


Figure 6 : Illustration of the information transmitted between the collaborating snowplows.

Collaborative Safety

A robot would be notified by missing heartbeats if its partner failed for any reason. In this case, it can complete plowing its part and finish what was left out by its partner. A safe perimeter is also defined for each robot so that the other one stops before a collision occur.

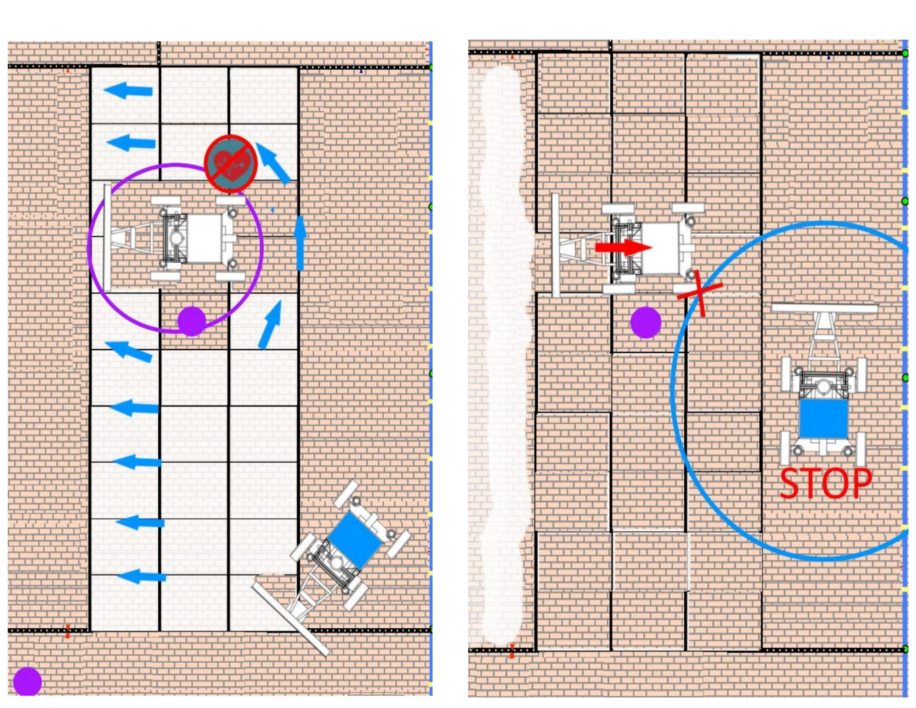


Figure 7 : Demonstration of hazardous situations during collaborative competition.

Special thanks to

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