ELROB 2018 - Team Diehl THeMIS participating in Mule Scenario

Jürgen Köberle, Stefan Bullmer, Jens Henzler, Björn Steurer, Dr. Alexander Wolf, Steffen Ruedel, Fabian Meilinger, Christian Seidl, David Skuddis
Diehl Defence GmbH & Co. KG, Überlingen, Germany

Dr. Matthias Hentschel
Hentschel System GmbH, Hannover, Germany

Abstract

The team Diehl THeMIS Vehicle is the tracked THeMIS platform developed and produced by Milrem Robotics (EST). Milrem has participated with the THeMIS in several competitions in the last couples of years like SMET (US) and Last Mile (UK).

For the mule scenario the THeMIS will use a local terrain based grid map generated based on two LiDAR systems in combination with a waypoint navigation algorithm that has been developed and optimized continuously in the last five years. Both, map and navigation algorithm has been developed by Diehl Defence and Hentschel System.

I.   Introduction

In the team Diehl Defence THeMIS   Diehl Defence and Hentschel System joined to equip the THeMIS UGV developed and produced by Milem Robotics (EST) with unmanned capabilities. Both players participated in several ELROB competitions before while the THeMIS platform is presented on an ELROB for the first time.

II.   Robotic Platforms

The Milrem THeMIS shown in Figure 1 is a Diesel-electric hybrid vehcile with rubber tracks a modular design. It is developed and produced by the estonian company Milrem Robotics.

Figure 1: Milrem THeMIS

The specifications of the platform are

- Payload: 750 kg
- Weight: 1450 kg
- Length: 240 cm
- Width: 215 cm
- Height: 111 cm
- Max speed: 22,4 km/h
- Operating time: 12 hours

The THeMIS is based on a modular concept as one can see in Figure 2 where the mechanical architecture is shown. All components are located within the tracks. Between the track-modules there is a empty center platform for wide variety of payloads. During the development the use of as many COTS components as possible was a key criterion. An Open system architecture with ROS node simplifies the integration of unmanned capabilities.
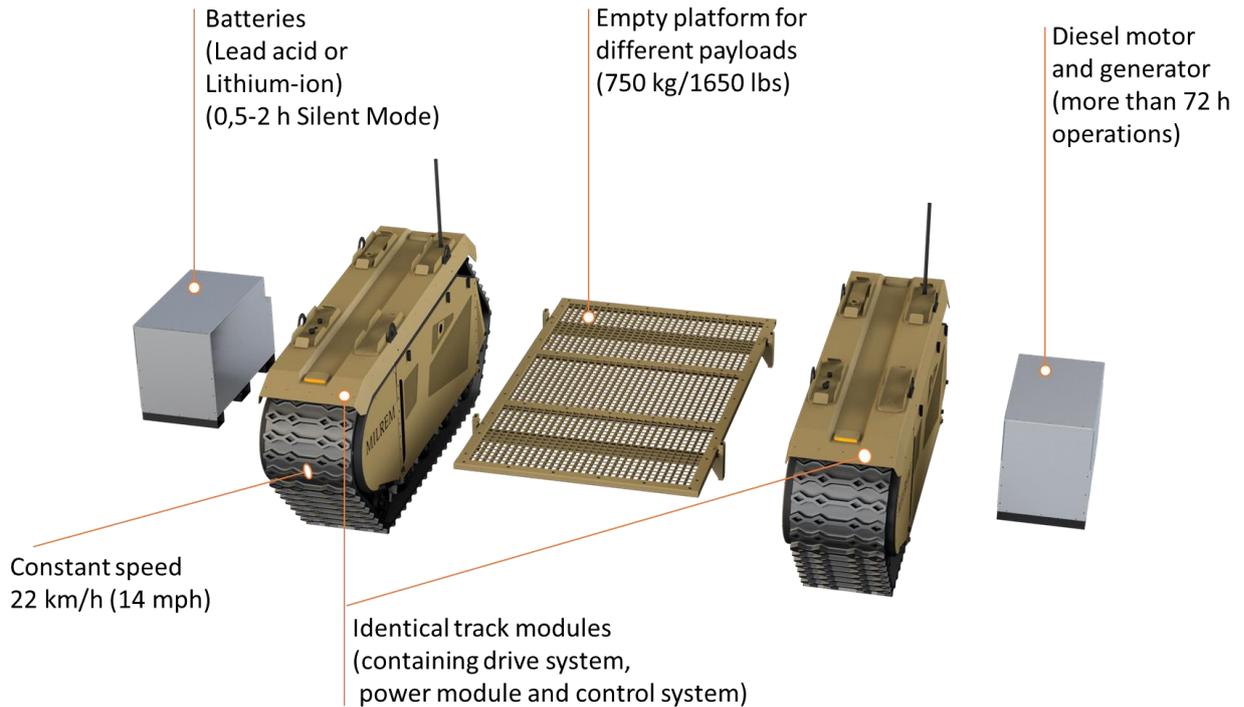
Batteries
(Lead acid or
Lithium-ion)
(0,5-2 h Silent Mode)

Empty platform for
different payloads
(750 kg/1650 lbs)

Diesel motor
and generator
(more than 72 h
operations)

Constant speed
22 km/h (14 mph)

Identical track modules
(containing drive system,
power module and control system)

Figure 2: THeMIS mechanical architecture

A. Sensors

For the ELROB trials the THeMIS is equipped with an inertial navigation system by Oxford Technical Solutions. With this sensor setup a robust ego-motion estimation, which compensates even short losses of satellite link.

As active sensors for the environment detection the THeMIS has two Velodynes VLP 16 placed on the track modules. Additionally a camera is placed on the vehicle. This is used for OPI detection and for documentation.

Furthermore a PLATON Kit (ruggedized PC + Algorithms) and a radio system is placed on the center plate of the platform.
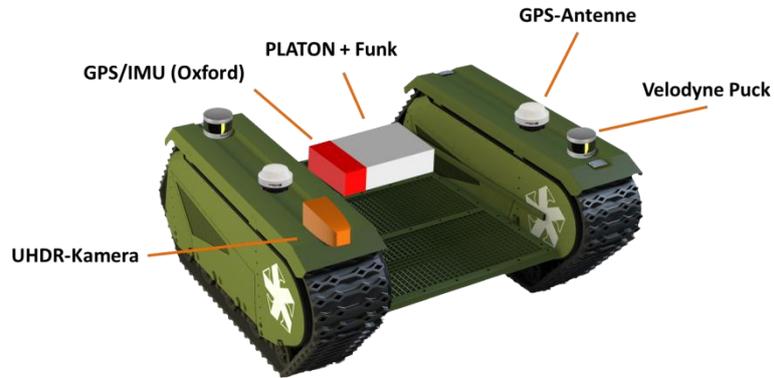
Figure 3: Sensor Setup

B. Hardware Architecture

For the processing hardware standard equipment can be used. The following hardware is used:

CPU:

Intel Core i7-3612QE, Quad Core, 2.1 GHz, 6 MB Cache, 35 W

Memory:

- System RAM
  - Soldered DDR3, ECC support
  - 8GB
- Boot Flash
  - 64 Mbits

Graphics;

- Integrated in QM77 chipset
- 650 MHz graphics base frequency

- 1.2 GHz graphics maximum dynamic frequency
- Simultaneous connection of two monitors

Interfaces

- Video
    - One VGA connector
    - DisplayPort/HDMI
    - HD Audio
- USB
    - USB 2.0 (480 Mbit/s)
- Ethernet
    - RJ45 connectors, 1000BASE-T (1 Gbit/s), or
    - 9-pin D-Sub connector, two 100BASE-T (100 Mbit/s), or
- PCI Express
    - 1 links (500 MB/s per link), PCIe 2.x (5 Gbit/s per lane)
- SATA
    - Two channels, SATA Revision 3.x (6 Gbit/s), RAID level 0/1/5/10 support
- Compatible with PICMG 2.30 CompactPCI PlusIO
    - 1PCI33/4PCIE5/2SATA3/2SATA6/4USB2/1ETH1G

Supervision & Control

- Board controller
- Watchdog timer
- Temperature measurement
- Real-time clock with supercapacitor or battery backup
- Intel Active Management Technology

Environmental Conditions

- Temperature range (operation)
    - -40°C to +85°C (model 02F022P00)
    - Airflow 1.5 m/s
    - Temperature range (storage): -40°C to +85°C
- Cooling concept
    - Conduction-cooled
- Relative humidity (operation): max. 95% non-condensing
- Relative humidity (storage): max. 95% non-condensing
- Altitude: -300 m to +2000 m
- Shock: 50 m/s², 30 ms
- Vibration (Function): 1 m/s², 5 Hz to 150 Hz
- Vibration (Lifetime): 7.9 m/s², 5 Hz to 150 H

The above described hardware configurations is an excellent and robust baseline for the use within a UGV AI-Kit.

C. Software Architecture

The R&D vehicles THeMIS and TULF are using a similar software architecture. In both systems, the software is split into dozens of individual small programs with dedicated tasks. All this small programs are communicating using ROS with each other. Some of them are reading sensor data (one individual program or one individual instance of a program for each sensor) others are processing the data for object tracking or generation of local maps. Finally, the movement commands are generated by a sequence of path planning, high-level platform controller and platform interface software modules before executed by the platform itself. This structure allows it to individually scale the developed software to the available CPU power and to shift whenever during R&D tests required one software component from on CPU board to another.

III. Mule / Transport Scenario

The mule scenario will be performed with the THeMIS. Due to the small size of the vehicle no safety driver will be onboard. The engineer, who will walk in front of the vehicle will have a remote emergency system. Therefore he will also accompanying the platform during the complete MULE mission.

A. *Mission planning*

The operator control station (OCS) for the mule scenario is depicted in Fig. 6.
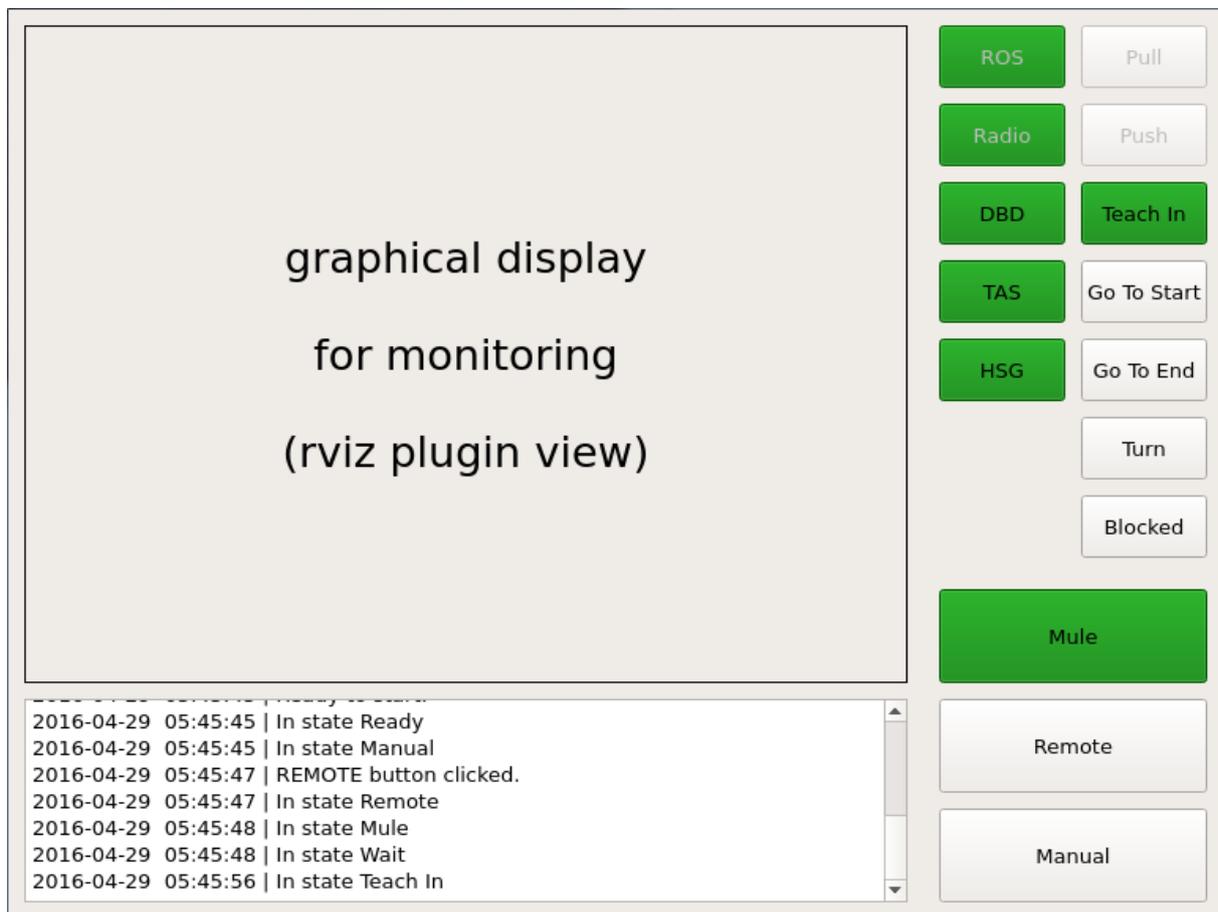

Figure 4 : Operator Control Station for Mule Scenario

The OCS is divided into three sections:

- The command pane on the right side

    The text output on the lower left side.

- The monitoring pane on the upper left side

The general behavior of the OCS is similar to the one in the convoying scenario with the difference that in mule mode the operator is able to switch between manual operation, remote piloting and automatic mule operation. The OCS further offers possibilities to mark the actual position as blocked for mule. In mule mode, the operator can separately command teach-in, mule operation in both directions and 180° turns to be able to handle difficult U-turn situations in close connection with the operator.

B. *Waypoint Navigation*

The UTM waypoints provided at mission start are used for waypoint navigation. With the provided waypoints, a global path planning is performed using a database which includes all available (and mapped) routes and tracks. From the set of available routes, the optimal (e.g. shortest) path is computed which leads from the current position of the THeMIS to the mission waypoint. The planned path is presented to the operator which may modify the path or set additional waypoints. The final planned path is executed by the waypoint following algorithm autonomously. This algorithm uses the planned path, the current position and orientation of the THEMIS and the environmental information of both Velodyne 3D LiDAR sensors as sensory input. From the input, the algorithm computes the optimal velocity and steering angle to maintain roughly the planned path and avoid any obstacle interference. While following, the planned path, a map of the environment is created which includes the static obstacles in the environment. This map is used by the waypoint following algorithm for vehicle control. Furthermore, this map is used for global path replanning, in case an obstacle is reactively unavoidable. When the vehicle reaches the mission waypoint, the vehicle is turned automatically to shuttle back to the first mission waypoint.

IV.   Summary

This paper gives first an overview of the vehicles used by the team Diehl THeMIS at the ELROB 2018 regarding the systems itself and its hardware and software architecture. In addition the operation modes for the ELROB scenario mule are described including information of the mission planning and some of the most important algorithms which are used to perform the desired tasks.