

ELROB 2018 - Team Patria participating in Convoy Scenario

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Abstract

The team Patria consists of three project partners with different focus in research and development. The Patria AMV vehicles used in the scenario are both R&D platforms, which have been developed in a cooperation of Patria and Diehl Defence. The platforms are used by the team in the convoy competition at the ELROB 2018. While one of the vehicles (called AMV 2) is equipped with a Drive-by-Wire system developed by Patria and with a sensor package to track a leading vehicle the other AMV (AMV 1) is a vehicle with standard configuration. Only a LTB (Leader Tracking Box) developed by Diehl Defence is installed on this vehicle. The LTB consists of a GPS/IMU system and radio. Therefore, the LTB is able to determine its position and to send it to the following AMV 2 vehicle. The AMV 2 additionally has a Continental automotive RADAR which is used for tracking. Both, sensor data from the RADAR, and the LTB position estimation, are fused to achieve a robust and accurate tracking of the leading vehicle.

I. Introduction

In the team Patria three project partners are joint. Two partners are Diehl Defence in cooperation with Hentschel System GmbH, who successfully integrated the PLATON convoy capability into the Patria AMV vehicle. The third partner Patria provides the AMV platform

equipped with an own-developed Drive-by-Wire system. The individual partners have different experiences gathered during the last decade. Diehl Defence GmbH & Co. KG and Hentschel System GmbH have participated in the ELROB 2006, 2008 and 2016. Patria has no experience with ELROB so far.

II. Robotic Platforms

The development of Patria AMV Demonstrator (AMV 2) started in 2017 when Patria began to implement the Drive-by-Wire system (DbW). In parallel Diehl Defence and Hentschel System GmbH adapted the convoy functionalities of the PLATON system so that they are suitable for the environmental conditions in Finland (low temperature, snow). For this, the convoy algorithm which was based on LiDAR and GPS was modified in a way that radar data was used instead of LiDAR.

Beginning of 2018 the implementation of the DbW and the modification of the convoy algorithm was complete and Diehl Defence started the integration on the platform. This was done during a one week integration campaign which already included first test driving. Robustness and accuracy were improved in 2018 during two more test campaigns in Finland.

PLATON developed by Diehl Defence is a conversion kit which includes several functionalities for unmanned driving. It is also used in the platforms TULF, StrAsRob, MILREM THEMIS, HyMUP and Mustang. To support the open architecture, the middleware ROS is used for the data exchange between all software components.

The Patria AMV (Armored Modular Vehicle) platform itself is an 8×8 multi-role military vehicle. The main feature of the AMV is its modular design, which allows the incorporation of different turrets, weapons, sensors, or communications systems on the same carriage. The velocity in manual operation mode is limited to 100 km/h. All robotic modifications and extensions have been performed in a manner that the vehicle can operate in manual operation

mode without any specific limitation on public roads. The vehicle as an unmanned platform has been developed in an industrial cooperation between Patria and Diehl Defence.



Figure 1: Patria AMV (AMV 2)

A. Sensors

For the self-localization the following sensor set is integrated into the AMV 1: a XSens MTi-G as inertial measurement unit and GPS based sensor system combined with a KVH DSP-3000 optical gyro. The AMV 2 is equipped with an inertial navigation system by Oxford Technical Solutions. With this sensor setup both vehicles allow a robust ego-motion estimation, which compensates even short losses of satellite link.

As active sensors for the tracking of the leading vehicle, the AMV 2 has a commercial distance radar. For documentation and to improve the situational awareness of the UGV operator (driver of the leading vehicle AMV 1) a front and rear camera are installed on the AMV 2. The picture of the rear camera is send via radio to the control station of the UGV operator.

B. Hardware Architecture

The AMV 2 has 2 conduction-cooled quadcore CPUs, each with 4 GB of memory and two 1 GBit Ethernet interfaces. As operating system Ubuntu 14.04 LTS 64 bit is used and the communication between the CPU boards is realized using ROS.

C. Software Architecture

The Patria uses a software architecture which is similar to that of the R&D vehicles TULF and StrAsRob, as both use the PLATON Kit developed by Diehl Defence. 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. 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. Convoying / Movements Scenario

This section describes how the Patria AMV 2 will be able to follow the Patria AMV 1 in the convoying / movement scenario of the ELROB 2018. Therefore AMV 1 will be manually driven as lead vehicle while the AMV 2 is used as autonomous vehicle. Due to safety issues, a safety driver will be onboard the AMV 2 permanently to allow quick and secure reactions in case of an emergency. The plan is that AMV 2 is following autonomously AMV 1 during the complete trial. In the beginning of the scenario, the mission planning for the convoy task will be performed either in AMV 1 or AMV 2 vehicle with automated data exchange to the other vehicle.

A. Mission planning

The operator control station (OCS) for the convoying scenario is depicted in Fig. 2. It is mainly divided into three sections:

The command pane on the right side: This pane allows for pulling mission data from the WebDAV server prior to mission start, pushing logged vehicle data back to the server after mission end and switching between manual operation, remote piloting and automatic leader following. It further offers possibilities to reset the leader follow algorithm or to restart specific modules on the vehicle in case errors occur. Moreover, it is possible to command the vehicle to a closer follow distance for difficult situations.

The text output on the lower left side: This pane provides a textual output of useful information for the operator. Particularly, error messages and warnings will be displayed here.

The monitoring pane on the upper left side: This pane provides graphical display of important information like own vehicle state, distance to leader vehicle etc.

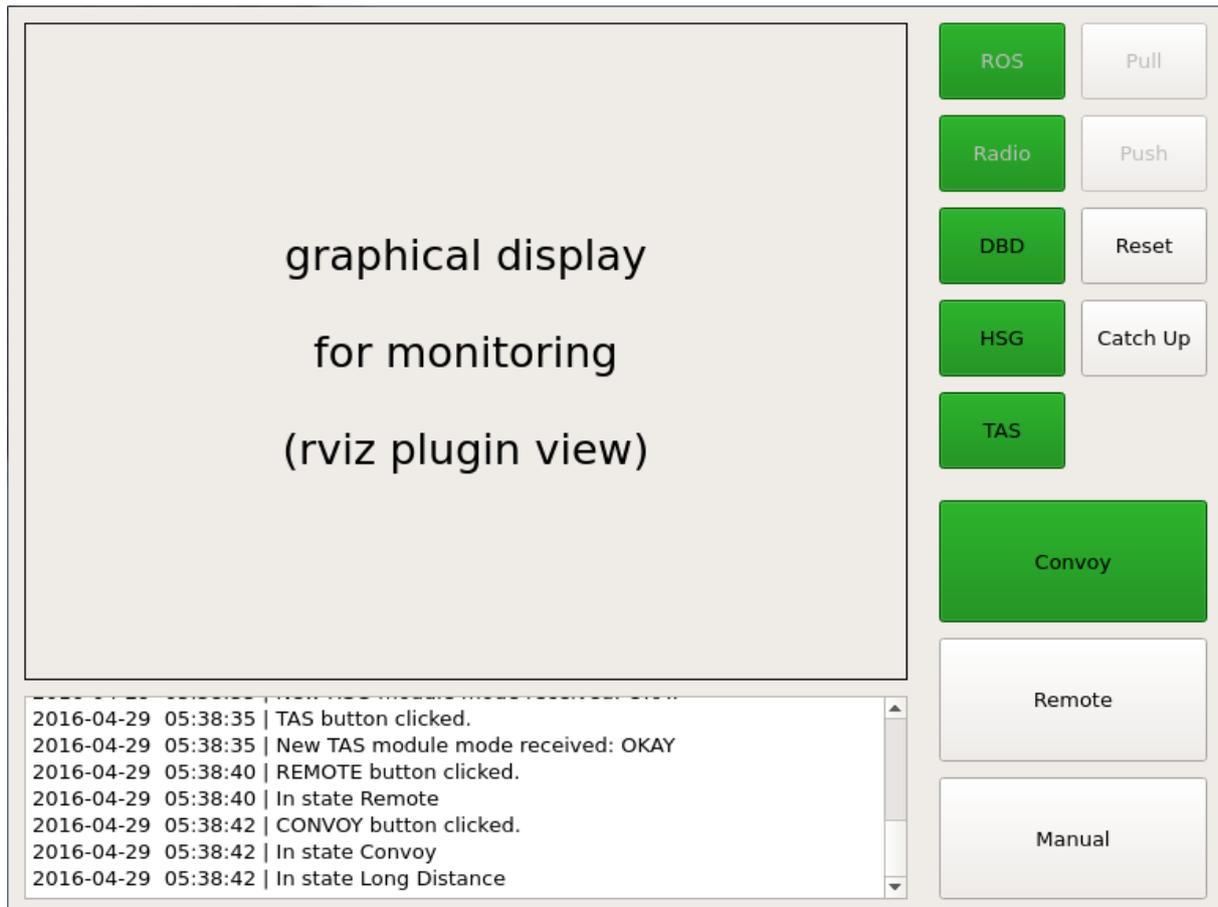


Fig. 2: Operator Control Station for Convoying Scenario

At startup, the OCS is in STANDBY as shown in Fig. 3. Only the pull button is enabled. By clicking the pull button, a mission startup procedure is initiated (see Fig. 4). First, the mission data are fetched from the WebDAV server. Then these data are internally processed in order to provide an automatically planned mission to the operator and the driver of the leader vehicle. The planned mission is displayed on a map in the graphical display. Finally the Logging is started and the OCS switches to READY state. Now all mission operations are possible.

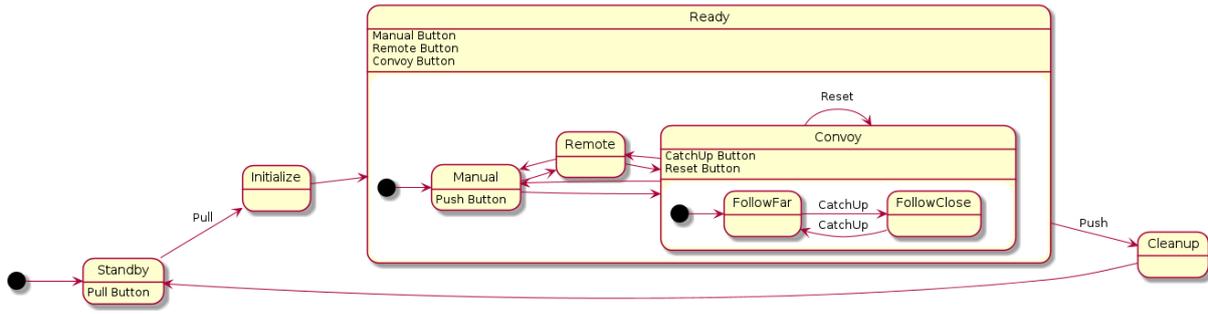


Fig. 3: Operational states in Convoying Scenario

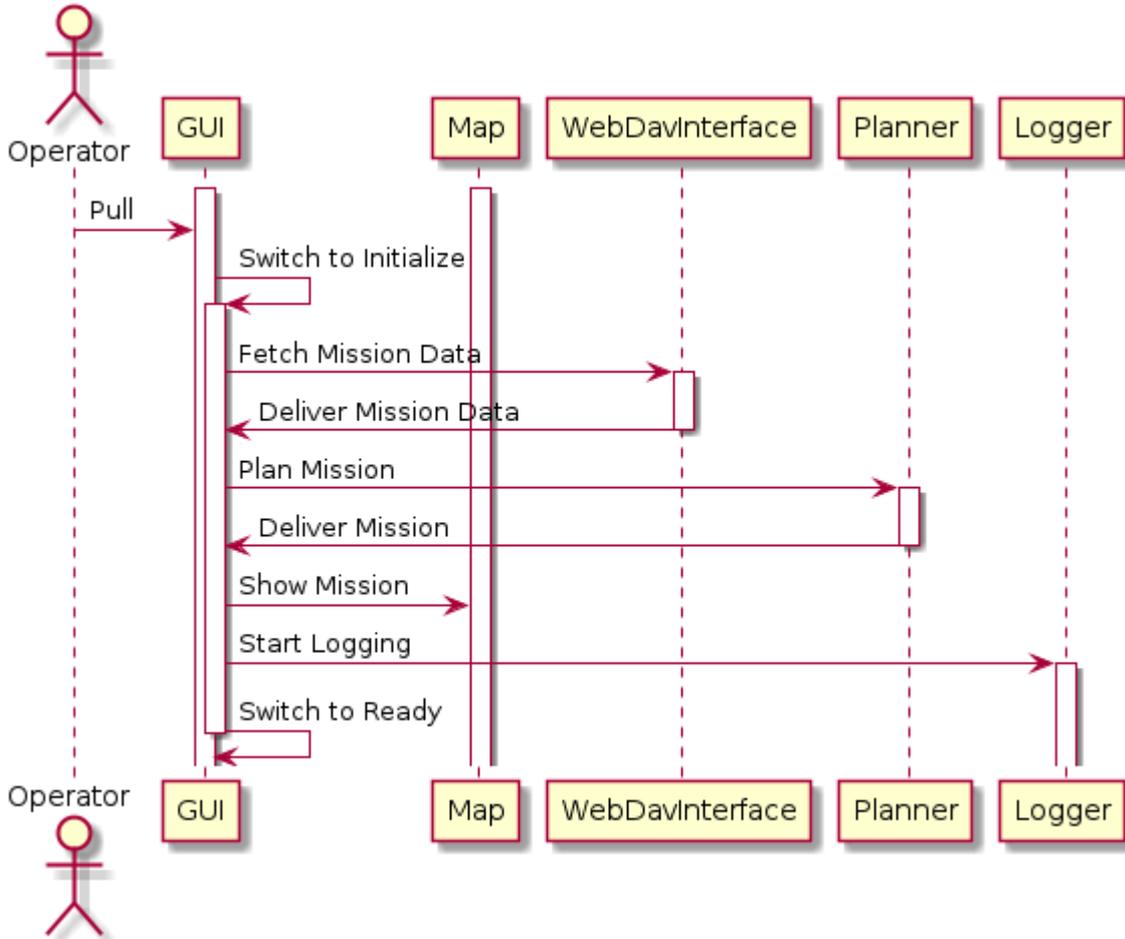


Fig. 4: Pull sequence

At the end of the mission, the operator must switch back to manual operation. Only in this state, the OCS allows for data collection and delivery on the WebDAV server. This is done by clicking the push button (see Fig. 5). The OCS then stops logging, fetches the log data from

the vehicle and pushes vehicle and OCS log data to the WebDAV server before switching to STANDBY.

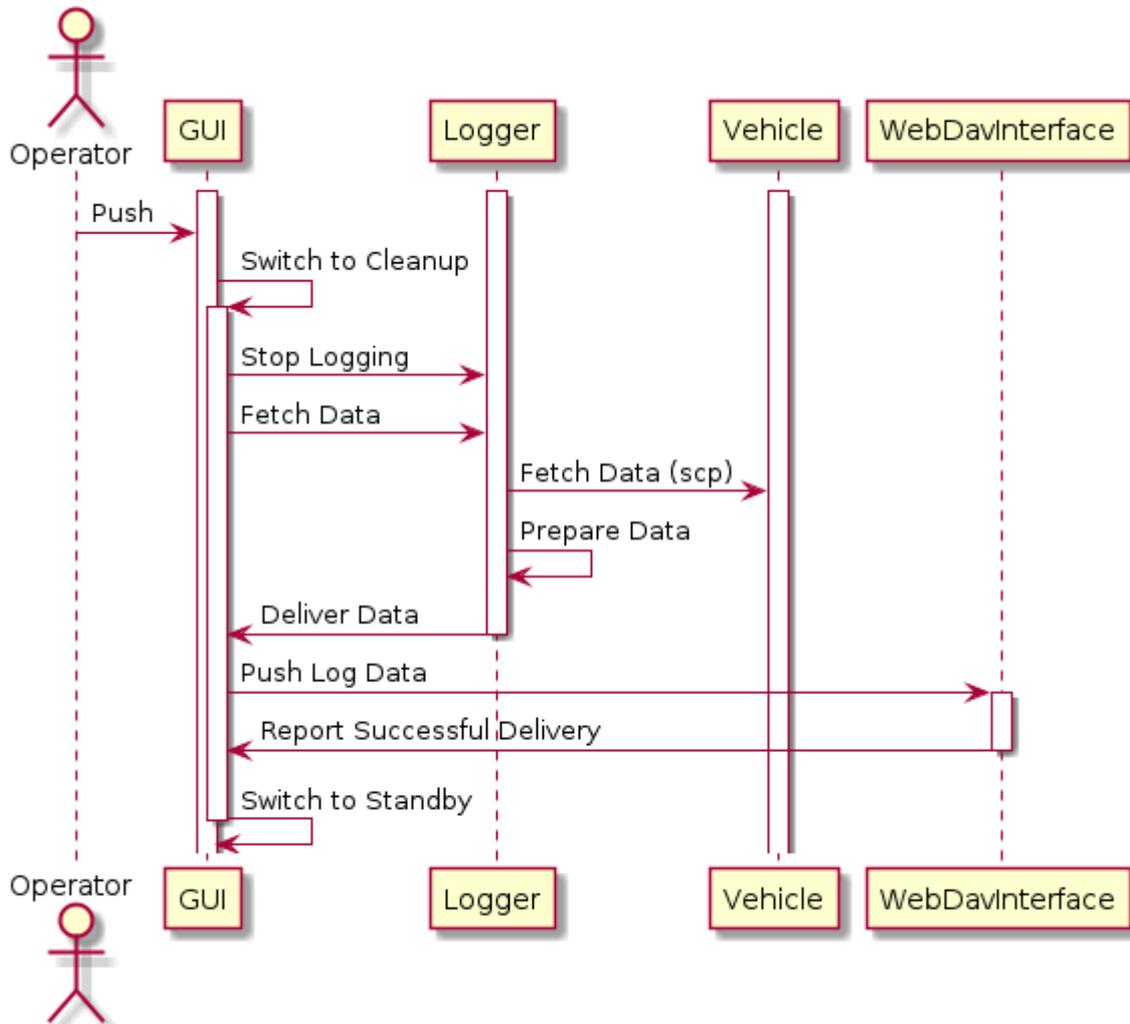


Fig. 5: Push sequence

B. Vehicle Tracking

In order to achieve robust vehicle tracking with high accuracy we have implemented a module which fuses the measurement data of all sensors and tracking modules at object-level. It thus estimates the position, orientation and velocity of the leading vehicle based on a kinematic single-track model as a motion model.

Another important input data for the filter is the absolute global position of the leading vehicle determined by GPS and received by car-to-car communication. The problem here is that measurement is often disturbed by a significant GPS offset of several meters.

In order to be able to use the information it is vital to estimate the GPS offset online using the mentioned inertial sensors. As soon as the GPS offset is estimated good enough, the corrected position measurement can be used during phases with poor or completely missing local measurements. The resulting output of the fusion module is an estimate for the position, orientation and velocity of the leading vehicle which can afterwards be used for path planning and vehicle control.

C. Leader Following

In this operational sequence there are two interdependent activities. One is the path planner, which is responsible for generating a trajectory between the leading and the following vehicle. Therefore it uses the UTM-positions of both vehicles from the data fusion algorithm and hence it plans an optimal chain of (aiming) points.

The second function within the modus is the controller or rather an interaction of different controller. After all the challenge to follow a vehicle can be divided into three different tasks. One is to keep a defined distance to the leading vehicle. The second condition is the desired velocity of the following vehicle with respect to the leading one. And finally the third task is to stay on the planned path.

IV. Summary

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