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First Release of Farming and Logistic Robot Prototypes – *DRAFT*

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Executive Summary

This report describes the content of a video documenting the first release of the two robotic prototypes and presenting their basic autonomous functionalities (navigation, data acquisition and transmission), their respective BEM designs. This video, which serves as a proof of the functioning prototypes, can be found at the following link:

[Deliverable_3_2.mp4]

Please note that this document and the included video is to be considered as a draft since the dual arm and end-effectors components have not been included yet because of unexpected delays encountered by Beneficiary n.8 PAL Robotics in their realization. The reason behind this delay is mainly due to both the global shortage of the manufacturing of electronic components and the longer delivery time for the machined parts again caused by the shortage affecting the raw materials.

At the time of submission of this document, according to the information provided by the Beneficiary PAL Robotics, these components will be released and made available to the Consortium within May 2022. Therefore, the final version of this deliverable will be prepared and submitted right after this date. Should further delays (which are not foreseeable at this time) occur, we will promptly inform the Project Officer to agree upon additional contingency measures to be implemented.

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Abbreviations and Acronyms

BEM	Box-Exchange Mechanism
CAN	Controller Area Network
GNSS	Global Navigation Satellite System
IMU	Inertial Measurement Unit
LIDAR	LIght Detection And Ranging
ROS	Robot Operating System
WP	Work Package

1. Introduction

This deliverable describes the first release of the two robotic prototypes. The video serves as a proof of the functioning prototypes presenting that they are complete, work properly, and can perform the basic autonomous functionality (navigation, data acquisition and transmission). The robotic prototypes are also presented to include a first version of the BEM design, as well as the first versions of farming robot's agronomic dual arm and end-effectors. Due to the continuous development of both prototypes this deliverable is expected to be periodically updated during the project. The video format allows for an easier dissemination of the robotic systems' development in the project. The video is expected to be used in conferences, workshops, as well as, to communicate our research activities through the dissemination channels of CANOPIES.

2. Video overview

This video deliverable was developed to communicate the capabilities of the robotic prototypes, that are verified to operate under relevant environments and navigate autonomously. In detail, the robotic prototypes are shown to cover the following requirements:

Data acquisition: In the beginning of the video the robot is shown in a data acquisition experiment that took place in the fields of Aprilia, Italy in July 2021. In those experiments, the first phase of robot integration was complete, i.e., all sensors were mounted, powered and they have been integrated through ROS. The video shows the robot moving in the field through teleoperation while being able to collect data from the IMU, GNNS, LIDARs and motor odometry which assisted the research development of the project.

Integration of a platform that is ready for the field: the video also shows the latest stages of hardware integration which was developed by taking into consideration the information gathered from the integration phase and the field testing. In this version the robotic prototypes have secure mounting solutions for all sensor and compute units as well as a casing with resistance to dust and some resistance to water.

Mapping and localization: having a constant understanding of their position in space is crucial for the autonomous navigation capabilities of the robotic prototypes. To that end, we have modified and implemented the Fast-Lio SLAM algorithm[1]. The algorithm is using IMU and LIDAR to achieve the localization. In the video the robot is shown to achieve good localization results in the maps representing the two Acceptance Test cases. The use of this SLAM algorithm acts as a baseline solution that will allow the research activities to proceed while we focus on the development of our own SLAM solutions.

Execution of navigation goals: the robot prototypes are able to receive navigation goals, plan a path, as well as convey the required commands to the robot's hardware in order to achieve the desired movement. We have integrated a ROS based navigation which combines the localization and mapping capabilities with move_base[2] a very well-established framework for navigation. This framework allows testing between a variety of available planners, with the capability of path replanning and obstacle avoidance. We also integrated a ROS-based CAN communication layer to the platform's motor controllers, thus allowing us to control the platform's motors. For our acceptance tests it is shown the current setup is navigating autonomously in lab conditions, i.e., parking lot at DTI, and in a relevant environment, i.e., forest path close to DTI. The use of this

[1] Wei Xu and Fu Zhang, FAST-LIO: A Fast, Robust LiDAR-inertial Odometry Package by Tightly-Coupled Iterated Kalman Filter, 2021, https://arxiv.org/abs/2010.08196

[2] ROS move_base, http://wiki.ros.org/move_base

move_base architecture acts as a baseline solution that will allow the research activities to proceed while we focus on the development of our own navigation solution.

First dual arm and end-effector prototypes: as part of this deliverable, we have to present the capabilities of the dual arm and end-effector system developed for the farming robot. However, due to global shortage in electronics the prototype assembly has been significantly delayed. For that reason, the deliverable will be updated and resubmitted once the hardware is assembled and assessed, which is expected to happen by the end of May, 2022.

Integration of the Box-Exchange-Mechanism (BEM) prototype: both robotic prototypes include a BEM in their design. According to the most updated specifications of the BEM, we had to design a unit that would cover the needs of both robotic prototypes in order to reduce the complexity of integration and operation. In the video we present the first BEM prototype, which can carry and exchange boxes up to 10kgs. The prototype presented has a single box configuration, allowing us to study several design parameters before moving to a double box configuration. Moreover, the prototype is operated using ROS-serial, which makes it easy to integrate with our research activities in mobile robot coordination.