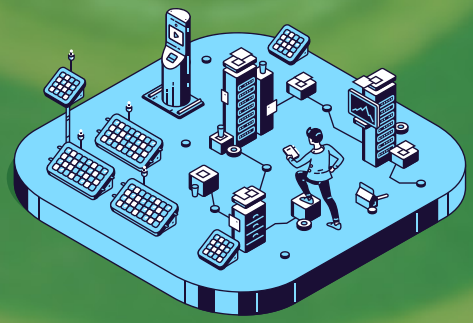
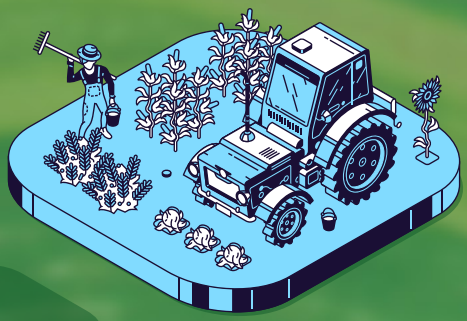
FLEXIGROBOTS

Contents



- Flexigrobots-h2020.eu
- FlexiGroBots
- Flexigrobots
- YouTube



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017111.

Project Updates

Requirements, architecture and standardisation

WP2 focuses on analyzing various aspects related to the design of the FlexiGroBots platform. The goals are:

- To know the opinion and expectations of the **potential stakeholders**.
- To specify **the platform requirements** and describe its architecture.
- To ensure the correct application of available standards for **agricultural safety, agricultural machinery and autonomous machinery**.
- To incorporate **ethical, legal and socio-economic (ELSE) responsibilities**.
- To ensure the development and implementation of **the three pilots**.

The work done during the last months can be summarized as follows:

- **The initial analysis of the stakeholders' requirements has been refined and extended** according to the progress of the implementation of the FlexiGroBots platform in WP3 and the four project pilots in WP4, WP5 and WP6. It includes the revision of the content of deliverable 2.2 regarding the characterisation of the jobs, pains and gains for FlexiGroBots target actors and the update of the functional and non-functional requirements to will guide the development of the project prototypes.
- **A new and more detailed version of FlexiGroBots reference architecture is being prepared** based on the previous one delivered in December 2021 with the aim to reflect the progress done in the last six months of the project. It includes the additions introduced after the assessment of the ELSE factors (i.e., anonymisation service, traceability of ML workflows) and an accurate specification of the functionalities to be delivered by each component and the interactions between them.
- To ensure collaboration, convergence and synergies between the four project's pilots, **the features offered by the FlexiGroBots platform have been discussed and reshaped**.

This process has been related mainly to the Mission Control Centre, requiring the participation of all the robotics systems providers of the project.

> *"The FlexiGroBots project has to, among its objectives, pay special attention to Portability, Interoperability and the use of Standards."*
>
> **Dr. Angela Ribeiro, Principal Scientist at CSIC, Leader of the ground robotics in Pilot 1**
>
> **Read "Standardisation activities" to know more.**

- **A first approach to the portability, interoperability and standard concepts was done** concluding that the use of standards is the best way to achieve both portability and interoperability in the different elements that are developed by and make up the FlexiGroBots project.
- In order to tackle the task of organizing and rationalizing the use of standards in a large-scale project as FlexiGroBots, **a partners questionnaire**

has been gathering information regarding the standards that the different working groups are using or plan to use throughout the project. After defining a number of general areas, the different standards proposed by the partners have been grouped accordingly.

- The original list of proposed standards has been shortened to those that are either very specific to the project or are used by more than one workgroup. Based on this selection the **deliverable 2.4** is been preparing to describe the different standards in use in FlexiGroBots.

- **As part of the preparation of D2.6. Interviews related to data protection were conducted with each pilot and the platform and recommendations were developed**. A thorough review of relevant legal frameworks was conducted. Interviews with farmers have been conducted. FlexiGroBots is now represented in TechEthos cluster in discussions on ethics and new technologies. A template for model cards and datasheets was developed the enable standardised and transparent reporting of the AI model and dataset outputs produced by FlexiGroBots. Lastly, discussions with the AI4Europe platforms has been entered to include more transparent reporting standards in the AI4Europe AI asset upload template, which can be used by FlexiGroBots, but also other projects.

- Finally, the results of the work done in WP2 during the last months will be delivered with **three new deliverables in June 2022: D2.3, D2.4 and D2.6**.

Platform development

The aim is to develop the **FlexiGroBots common platform and the building blocks** that support its implementation.

The main elements on which the platform will be based are an **Artificial Intelligence (AI) platform** and **IDSA-compliant agricultural data space**.

The platform will satisfy the stakeholders' requirements and it will enable the **reference architecture for mission control systems for heterogeneous robots' fleets**.

After the release of the first version of the **FlexiGroBots platform** in December of 2021 with deliverable D3.1, during the last months, **the project partners have been focused on the development of new functionalities for the different components**. The results obtained can be mostly observed in the project GitHub repository where multiple open repositories are available.

The Artificial Intelligence subsystem is being built leveraging one of the most promising and cutting edge open-source technologies available at the moment: Kubeflow. A dedicated instance has been deployed and is available at kubeflow.flexigrobots-h2020.eu. The underlying Kubernetes infrastructure incorporates several virtual machines and a GPU for accelerating models training. Several example workflows are being defined

for the project's models.

FlexiGroBots agricultural Minimum Viable Data Space (MVDS) is being developed leveraging International Data Spaces Association (IDSA) and open-source building blocks. Kubernetes manifests for the common components (i.e., DAPS and metadata broker) that have been created, producing a deployment that is available for the integration of specific connectors that will allow sharing data in a safe and sovereign way.

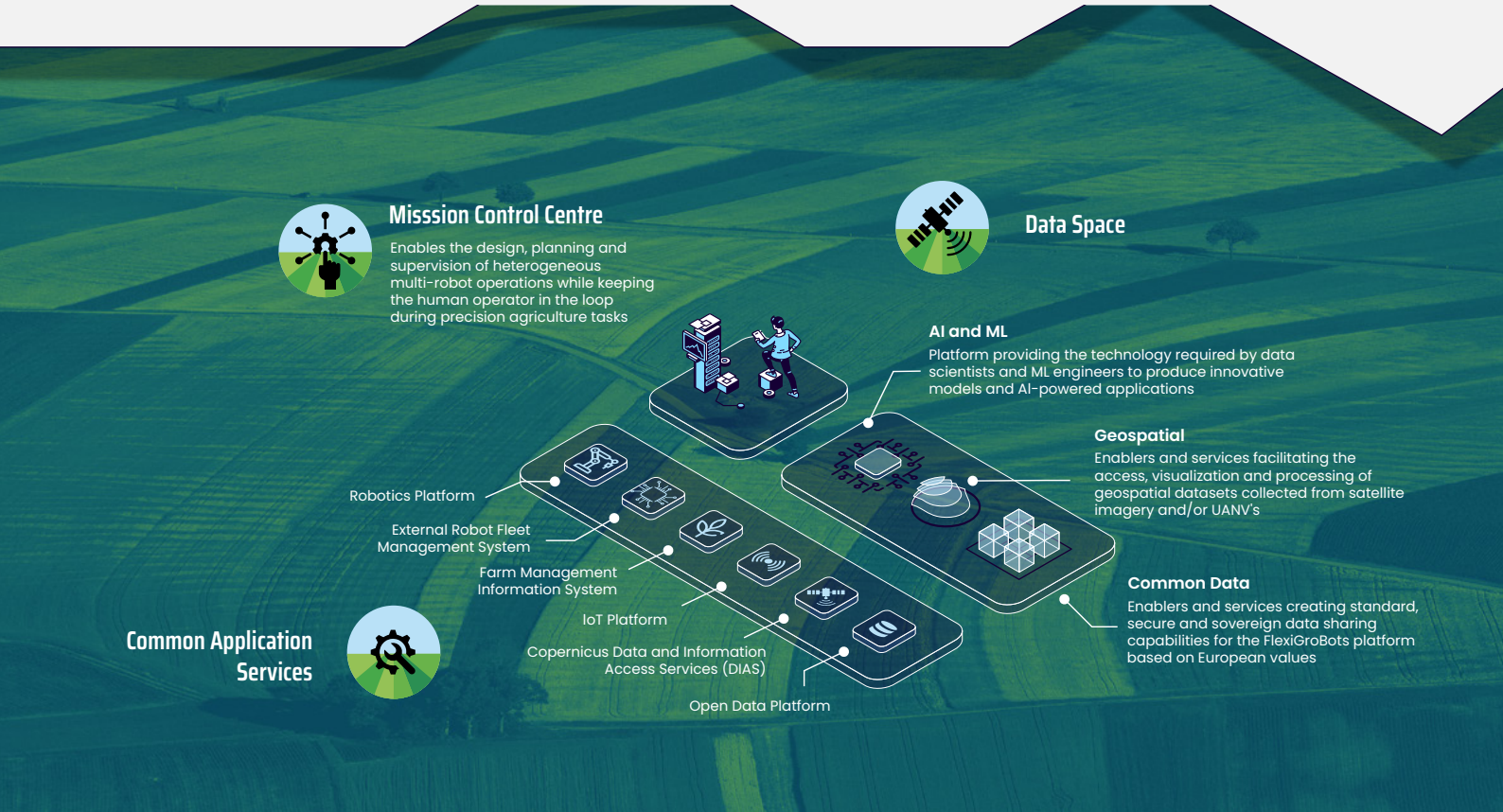
For geospatial enablers and services, an open data cube instance has been deployed in the Spanish pilot. Registration of Sentinel 2 Earth Observation products definition and indexing of data has been achieved, including an instance of the ODC explorer to facilitate data visualisation. Botrytis detected areas are also provided as a Web Feature Service (WFS).

The first prototypes are available for several services: SLAM, actions recognition, people detection, etc.

Datasets are being collected and annotated to fine-tune existing models or to develop new ones in collaboration with the pilots.

A simulation environment has been developed for the Mission Control Centre. A new extension of QGroundControl has been developed to allow the integration of MQTT communication channels between robots, IoT platforms and the MCC.

Check the updated FlexiGroBots website regarding the PLATFORM



Pilot 1: Grapevines

Pilot 1 has the global objective of **automating and improving the management tasks** that are carried out in a vineyard during the season. The objectives are:

- **Early detection of Botrytis** using the data collected by a fleet of Unmanned Air Vehicles (UAV or drones) and by a close inspection by Unmanned Ground Vehicles (UGV).
- **Phytosanitary treatments** of affected grapes using UGV.
- **Transport of the grapes**, which will be carried out by UGV.

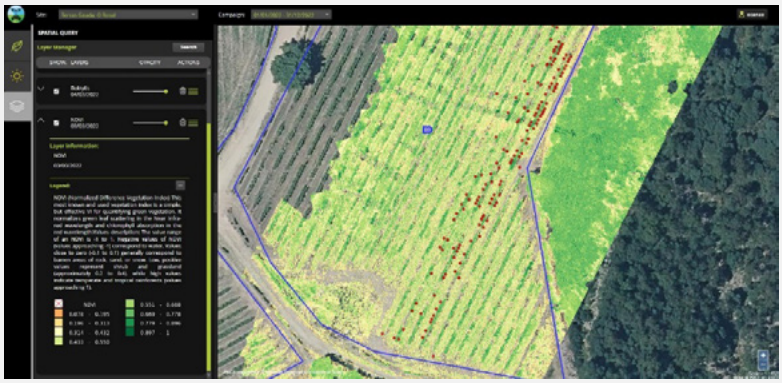
The **second version of the DSS platform** of Pilot 1 has been implemented and integrated with the Open Data Cube and the **OGC web services** to obtain and visualize the layers resulting from the processing of geospatial data.

In addition, it has been integrated with a **GeoServer** to visualize geographic information on the platform, such as NDVI and the location of crop areas where Botrytis has been detected.

From the platform we can find a **map**, in which it will be possible to interact with the layers obtained, either showing or hiding them, and even moving the order in which they are shown. In some cases where the layers are updated from time to time, it will be possible to see how they have evolved as the days have passed until the last data collected.

Click HERE and read: D4.1 Pilot 1 objectives, requirements and design D4.1 – Pilot 1 objectives, requirements and design

Regarding the **Use Case 1**, the Botrytis fungus early detection trial to treat it in time and stop its progress, during the 2021 field trials, there was a little incidence of attacks of this disease. Thus, for this growing season, we have decided to directly **inoculate the fungus** in grape bunches to be more certain that the disease is present. To further ensure the presence of the fungus in the 2022 trials, another plot of the same grape variety has been selected, located in an area with better orographic and climatic conditions to be attacked.



Regarding the **Harvesting Assistance**, in 2022 we are going to carry out similar trials to those of 2021, on the same plot but with different Ground Robots to assist the

human grape pickers.

In addition, we will do a new trial of great interest for the sector, which will be a comparison.

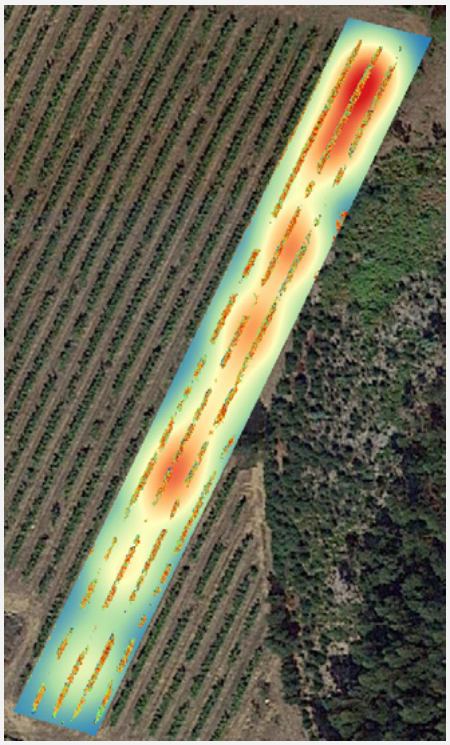
Regarding **Ground Robots** we can summarize our main work carried out in last months as follows:

- The definitive prototype of the harvesting assistance robot is now available. The **RGB-D camera, UWB sensors** and a **scale** have been integrated into an RB-Vogui platform by Robotnik. A metal structure has been designed and built to house these devices. A robust system for anchoring the box where the fruit is to be deposited has also been integrated. Software has been developed and integrated into the platform to detect the operator and generate orders for the robot to follow he or she keeping a constant distance.

Check the Non-scientific article "USE OF DRONES AND LAND ROBOTS TO DETECT DISEASES AND WEEDS IN THE CROP"

- All the elements to act on the brake, acceleration and steering have already been integrated in the Botrytis detection and treatment robot. All the actuators are integrated in an **ISOBUS**.
- Finally, **different CNN models** have been trained and tested to detect late Botrytis. Preliminary results will allow us to better design the experimentation to be carried out in the field at the beginning of August.

Regarding the **aerial part** of pilot 1, months 12-17 have mainly been focused on developing the algorithm to **detect the risk of Botrytis**, assessing a wide range of variables using only multispectral imagery. A lot of progress has been achieved towards the **automatization of the orthomosaic generation**. Extracting the Canopy Height Model (CHM) of the grapevines is now also automated, which allows isolating the vineyard vegetation from the vegetation cover and knowing the height of the vine at each part of the field. Moreover, a DJI M300 has been acquired and the required field tests are being performed successfully.



Pilot 2: Rapeseeds

The Rapeseed pilot focuses on **piloting solutions in pest management, weeding and harvesting of silage**.

The rapeseed pilot is preparing to the field tests for the second summer. We shall conduct more data collection flights using several drones and cameras. The aim is to enhance the data sets for pest detection, weed detection and situation awareness. The second aim is to conduct unit tests for the autonomous robots at the fields. This will include Luke's autonomous tractor tests with windrower implement, field test of both Probot's weeding robot platform and VTT's weeding tool, and test missions with multiple imaging drones and the Luke's spraying drone.

During the **first half of 2022** we have done both the robots' developments and the overall pilot system development. The main highlights are following:

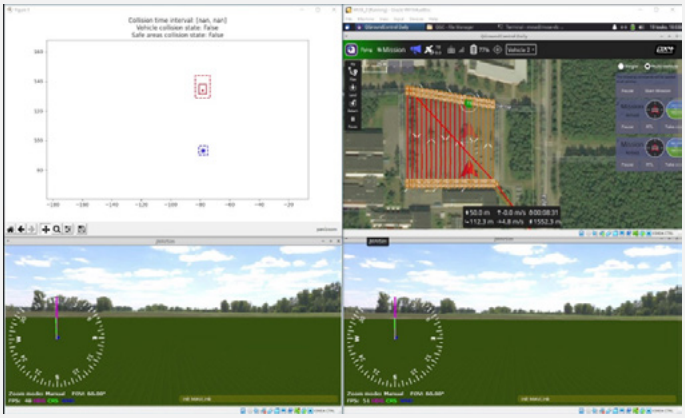
- **The autonomous tractor missions can now be simulated and visualised using a tractor simulator**. The tractor's autonomous driving capabilities have been improved with new sensors.
- **In UAV's we have improved to autonomous mission capabilities** based on using QGroundControl (QGC) open-source tool as a basis of robot fleet monitoring and control environment. We have created a MQTT interface to QGC capable of sharing the telemetry data from robots to QGC and FIWARE platform. QGC can now be used for the visualisation of the status or the heterogeneous multi-robot fleet working at the field. These results will be integrated to MCC Multi-robot control centre to be done in WP3.

Click HERE and read: D5.1 Pilot 2 Rapeseeds: objectives, requirements and design

- **With weeding robots, the prototype of the field robot platform has been developed and it is now ready for the first field tests**. With weeding tool, the weeding operation forces, tool movements, and weed posture detection have been under development. Part of the work has been the growing of grass and weeds in laboratory environment so that tests can conducted also when outdoor conditions do not allow it.
- **The implementation of the embryonic agriculture data space has made major progress**. We currently have a working data space with IDSA metadata broker, DAPS (a component providing certificates that validate the trustworthiness of participants), and couple of data connectors. VTT has been working on generic data space interface to back-end systems and Mtech has added a data space connector to its farm management system for exchanging drone imagery data in the first step. The plan is to extend this data

space as a common data space for the whole project in WP3.

The spring in northern Europe has been cold and late, but now we are ready to start the field activities. The tests will be conducted in our pilot site in Ruukki, Finland and in other Luke's test farms in Jokioinen and Mikkeli. Autonomous drone flight tests will also be done in Arctic Drone Lab test flight area in Oulu.



Pilot 3: Blueberries

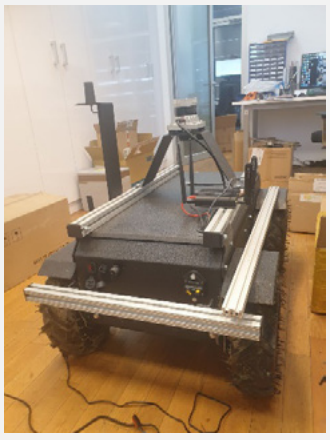
The goal is to demonstrate novel robotic solutions for blueberry farming in real (farm) operational environments, supported by **advanced remote sensing, deep learning and decision-support techniques**.

Pilot 3 is structured according to **3 goals** and areas of foreseen **technological development and innovation**:

- **Detection**: Integration of monitoring solutions.
- **Assessment**: Actionable insights for decision making and optimization.
- **Action**: Autonomous robot for operations in blueberry farms.

Spring brought new leaves to blueberry orchards and with them came the whole arsenal of digital technologies. Our **new robot Gari** (which is actually the slang for a person from his hometown of Novi Sad) took the first ride through the fields. We tested different setups for soil analysis and the performance of the robot, especially in terms of stability, **proved to be excellent**.

The ground robot got aerial support from both **Serbian and Lithuanian UAVs**, which were used to scan the fields in a large number of spectral bands. These **images** seved as the training set for the **AI algorithms** that will be used for **weed and disease detection and assessment of the health status of crops**. We are looking forward to the next 6 months and good blueberry yields for our favourite cheesecakes!



Click HERE and read: D6.1 Pilot 3 objectives, requirements and design

Dissemination and Exploitation

Progress:

Regarding **Task 7.1 – Dissemination**, the last months have been quite productive since FlexiGroBots has cooperated in a great variety of events. FlexiGroBots has attended three conferences representing Pilots 1 and 3, one online webinar speaking for Pilot 2 and an online workshop regarding perception and social acceptance of robotics. Moreover, a non-scientific publication has been published with the cooperation of two partners: WU and CSIC. The three partners have been very active in the social media, with a total of 13 posts combining Twitter, LinkedIn, Facebook and web posts. Finally, a project event is being organized during the ROBOT2022 conference by the end of the year, in Spain, where the attendance and the participation with papers of all partners is very welcome.

When it comes to **Task 7.2 – Communication**, during the first five months of 2022, the FlexiGroBots project pages on social media made significant progress. 110 new followers on LinkedIn page stand out, mostly from Spain, making a total of 319 followers and meeting the project's target of 300. Also, the FlexiGroBots Twitter profile has acquired 46 new followers and now has a total of 206, significantly closer to the target 300.

As for the **FlexiGroBots project website**, the section related to the FlexiGroBots Platform has been updated. Also, six new blog posts have been published and several new deliverables are expected in June, as well as the 2nd press release in July. Finally, partners from the FlexiGroBots consortium have participated in various events such as Transfiere: 11º European Meeting on Science, Technology and Innovation (CSIC); TechEthos Cluster (CEPS); HANNOVER MESSE 2022 (IDSA); First conference of the berry fruits agrobusiness sector (ZEL and BIOS), etc.

> *"This project will focus on DIHs and new business model offerings that will commercially enable the services and tools developed during the FlexiGroBots project and create value for the entire agri-food ecosystem."*
>
> **Giedrius Leskauskas, Head of Communications at AgriFood Lithuania DIH**
>
> **Read "Commercial Exploitation Roadmap" to know more.**

Within the first half of Y2 of the project **T7.3** is under full actuation, with both aspects of it – **business modelling and ecosystem building** – progressing in parallel.

More specifically, on the **business modelling part**, we have initiated the series of internal meetings with the partners involved in the implementation of the pilots and the development of the platform. The aim of these meetings is to explore and crystalize separate elements of the business model, i.e., exploitable elements, value propositions, distribution and service delivery models, etc. The first sessions of these series took place within April and currently we are working on the development of the first draft of the business models. Also, regarding the **ecosystem building process**, an initial mapping of the currently existing key partners, groups, networks, initiatives, etc. of the consortium is under development with the aim of preparing

a DIH-focused strategy with targeted approaches for each key stakeholder or stakeholder group.

During the first half of the second year of the FlexiGroBots project implementation, **T7.4**: **Technology transfer and demonstrator roll-out** was initiated. With an aim to enable technologies developed under the project to become accessible and usable by interested parties with the purpose of future commercial exploitation, Task 7.4 will facilitate developed technology transfer from the project consortium partners to relevant project result exploitation partners.

To enable smooth and successful pilot demonstration and solution promotion activities targeted at prospective end-customers (farmers), Task 7.4 is currently developing:

- Methodology for virtual pilot demonstration as a response to ongoing public health crises, limited capabilities to transport and demonstrate robotic solutions close to farmers, and
- Guidelines for pilot demonstration on-farm events that will include tools and methodologies for planning, organising and evaluating physical demonstration events

News & Events

Transfiere: 11º European Meeting on Science, Technology and Innovation

16-17/02/2022 | FYCMA TRADE FAIRS & CONGRESS CENTER OF MALAGA

CSIC participated in event with a **booth (E11)** where they featured new prototypes including **Robert** (Robot for collaborative manual harvesting) developed by **CAR-CSIC-UPM.**

CAPIGI Webinar | "When will spray drones lift off?"

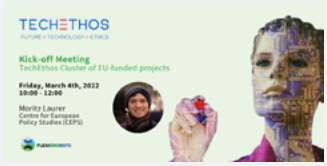
22/02/2022 | Virtual

At the CAPIGI webinar, **Jere Kaivosoja**, Senior Scientist at **LUKE**, participated as a speaker together with **Winfried Rijssenbeek**, Director Of Business Development at **Drone4Agro**. He explained how FlexiGroBots will use drones for this type of application.

European future in the sector of berry fruits

25/02/2022 | ARILJE CITY HALL

Partners from **ZEL** were organised this event to discuss the use of new digital technologies for boosting precision agriculture operations in berries crops. **Dr. Nebojsa Momirovic** and **M.Sc. Igor Vasiljevic** from **ZEL** gave lectures, as well as **Dr. Oskar Marko** from **BIOS**.



TechEthos Cluster of EU-funded projects | Kick-off Meeting

04/03/2022 | Virtual

FlexiGroBots project was represented by **Moritz Laurer** from the **CEPS**. His presentation was focused on sharing the main goals of the project, the expected results, and the ethical issues/challenges which are already being addressed.

First conference of the berry fruits agrobusiness sector

04/03/2022 | HOTEL JUGOSLAVIJA, BELGRADE

From the FlexiGroBots consortium, the lecturers were **MSc. Nevena Momirovic** and **Dr. Nebojsa Momirovic** from **ZEL**, as well as **Dr. Vladimir Crnojević** and **Dr. Oskar Marko** from **BIOS**. In addition to the lectures, an exhibition of products from successful manufacturers, as well as the organizers themselves, was organized.

Robotics4EU and AgriFood Lithuania DIH workshop: “Perceptions and social acceptance of robotics in AgriFood”

28/04/2022 | Virtual

Dr. Artur Bogucki from **CEPS** talked about perception as a factor in agricultural technology implementation. **Dr. Oskar Marko** from **BIOS** was spoke on the rapid digital transformation in agriculture, accelerated by the uptake of robotics in field operations.

First in-person TechEthos cluster meeting

23/05/2022 | Vienna, Austria

The cluster meeting fostered genuine conversations between participants on shaping a common voice and discussing how the cluster will position itself when working on ethical and legal challenges. The ethical challenges of the FlexiGroBots were presented by **Dr. Artur Bogucki** from **CEPS**.

Robotics4EU and AgriFood Lithuania DIH workshop: “Policy issues in agri-food robotics”

25/05/2022 | DURING LITHUANIAN ECONOMIC CONFERENCE “LIETUVOS DAVOSAS 2022“

The final workshop of the **Robotics4EU** initiative took place during the biggest Economic Conference in Lithuania - “Lietuvos Davosas 2022”. FlexiGroBots project was represented by **Dr. Artur Bogucki** from the **CEPS**, who was talking about **digital policy in precision agriculture**.

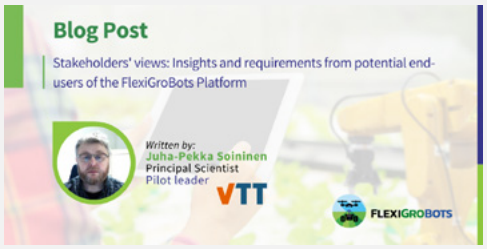
Hannover Messe 2022

30/05/ - 02/06/2022 | Hannover, Germany

The FlexiGroBots was presented at HM22 by the **IDSA** at **Hall 5, Booth A17**. **Arian Firouzbakhsh**, Senior Solution Architect at IDSA, was at the booth to answer questions about project. In addition, all project logos were printed on the new Data Space Brochure, which was also available there.

Project event

Blog Posts



Meet FlexiGroBots Partners

BioSense Institute (BIOS)

BioSense Institute is a research and development (R&D) institute for **information technologies (IT) in biosystems** and regional leader with over 30 H2020 projects. Thanks to the **ANTARES H2020 Teaming project**, BioSense is also on a sure path to become a European Center of Excellence for advanced technologies in sustainable agriculture and food security.

BioSense Institute entwines two of the most promising sectors in Serbia: **information and communication technology (ICT) and agriculture**. The Institute contains three research Centers - the Center for Information Technologies (CIT), Center for Sensing Technologies (CST) and Center for Biosystems (CBS). Such a structure allows for interdisciplinary research in areas of sensor design, robotics, remote sensing, big data and biosystems, with a common goal to increase food security and sustainability of agriculture in Europe.

Within FlexiGroBots project:

BioSense Institute is **the leader of WP6 and thus heads Pilot 3 - Blueberries** by employing a robotics platform and developing additional modules for it, in order to successfully perform field operations.

The Institute is also involved in **data analytics and image processing activities**, such as yield prediction, management zone delineation and weed detection. In this way, BioSense contributes to the FlexiGroBots project at every stage of robot involvement, from soil sampling and pre-sowing fertilizer application, through vegetation monitoring and all the way to harvest and preparation for the next season. Additionally, through T3.1, BioSense **heads artificial intelligence (AI) platform development** for FlexiGroBots.

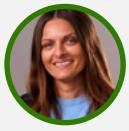
BioSense also participates in **Data and Ethics Management and GDPR** through T1.5, as well as **Pilots methodology, alignment and follow-up** through T2.5. Through these activities, BioSense strives to protect sensitive private data of users and field personel, in accordance with various EU-level intitiatives.

Finally, BioSense **leads project communication activities** in T7.2, while through T7.4 works on **facilitating transfer of developed technology** from the project consortium partners to relevant project result exploitation partners.

By intensively working on developing AI, robotics and sensor technologies, BioSense Institute strives to aid farmers and optimize production in order to bring about greener agriculture, increase profits, improve crop health and aleviate the ever rising costs of production.

Dr. Oskar Marko
Research Associate at CIT
Assistant Director for Innovation and Collaboration with Industry

Dr. Goran Kitić
Research Associate
Head of the Center for Sensing Technologies (CST)



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Dr. Damir Krklješ
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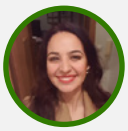
Csaba Petes
Junior Researcher at CST



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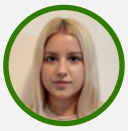

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VTT Technical Research Centre of Finland Ltd

VTT Technical Research Centre of Finland Ltd Is a state owned and controlled non-profit limited liability company established by law and operating under the ownership steering of the Finnish Ministry of Employment and the Economy.

VTT is an **RTO** whose activities are focused on three areas: Carbon neutral solutions, Sustainable products and materials, and Digital technologies. VTT is impact-driven and takes advantage from its wide multitechnological knowledge base to strengthen Finnish and European industrial competitiveness. **VTT can combine different technologies, produce information, upgrade technology knowledge, and create business intelligence and value added for its stakeholders**.

VTT has a staff of over 2000 persons and annual turnover about 150M€. VTT has gained vast experience from participation and coordination of numerous European projects including R&D Framework Programme projects and other thematic frameworks and programmes. VTT is ranked among the leading European RTOs.

Within FlexiGroBots:

VTT participating into **data sharing solutions**, **multi-robot control centre development** and to the **leading the Finnish pilot** dealing with silage harvesting, weeding, and pest management.

VTT is also **Finnish IDSA Hub**, and we are implementing the data space solution with core data space functionalities and components for the project.

For Finnish pilot the data space involves six interacting connectors sharing data between the parties involved in the pilot use cases.

In multi-robot coordination we are developing a **QGroundControl open source software based multi-robot mission supervisor and control solution** that supports loosely-coupled autonomous robots in their common mission. In the pilot this will be extended with situation awareness module providing an eagle-eye view to the field.

We are also developing a **weeding arm and tool solution for the weeding robot**. The focus is in the recognition of Rumex posture and robot controls for the removal of the plant. The tool will be integrated to the actual weeding robot.

Dr. Juha-Pekka Soininen

has a long experience in system architectures, IoT, and data spaces also in agricultural context

Kari Kolehmainen

is experienced with embedded systems and IoT platforms in agricultural setting as well as data spaces in industrial systems

Dr. Tapio Heikkilä

team leader for Intelligent Robotics at VTT with long experience in intelligent robotics, 3D computer vision, embedded systems, and SW and systems engineering in general

Dr. Eric Halbach

is specialist in mobile machinery and mobile robotics

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