



## Smart Anything Everywhere Initiative

### Area 3: Advanced micro-electronics components and Smart System Integration Project: H2020–No 761809



## Digital Innovation Hubs boosting European Microelectronics Industry

### *Deliverable 3.1*

## *DIATOMIC PUSH Experiments Coordination*

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#### **Abstract:**

This deliverable sets the framework with respect to PUSH Experiments in all implementation aspects of the DIATOMIC project. In this way, it will establish a solid and definitive architecture of the solution chosen for the project. Moreover, it defines the PUSH Testbeds, which are pilot sites where the DIATOMIC technology will be shown to users and will exploit partner's technological competencies and use them to ignite digital innovation thinking in non-tech SMEs, to push AME/SSI technologies. These experiments will be described in this document and will help future DIATOMIC Open Call participants to understand the technologies that they have at their disposal and will serve them as inspiration.

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## List of Abbreviations

|        |  |
|--------|--|
| DIH    | Digital Innovation Hub   |
| EU     | European Union   |
| HN     | Head Node  |
| PN     | Peripheral Node  |
| API    | Application Programming Interface  |
| AME    | Advanced Micro-Electronics   |
| SSI    | System Integration   |
| CC     | Competence Centres   |
| SME    | Small & Medium Enterprises   |
| CPPS   | Cyber-Physical Production System   |
| PCB    | Printed Circuit Board  |
| PLC    | Programmable Logic Controller  |
| ISM    | Industrial, Scientific and Medical   |
| RF     | Radio Frequency  |
| LoS    | Line of Sight  |
| TRL    | Technological Readiness Level  |
| TFT    | Thin-film transistor   |
| ESD    | Electrostatic discharge  |
| I2C    | Inter-Integrated Circuit)  |
| ROS    | Robot Operating System   |
| EIP    | European Innovation Partnership  |
| AHA    | Active and Healthy Ageing  |
| MAFEIP | Monitoring and Assessment Framework for the European Innovation Partnership on Active and Healthy Ageing |

# 1 Introduction

DIATOMIC's vision is to establish a sustainable ecosystem to facilitate digital innovation in the health, agrifood and manufacturing sectors (Figure 1), all of which are under-digitized<sup>2</sup> and of prime importance for society and the economy. The majority of Small Medium Enterprises (SMEs) and midcaps in these sectors are characterised by a low Digital Innovation Index (we name these enterprises “non-tech” hereafter).

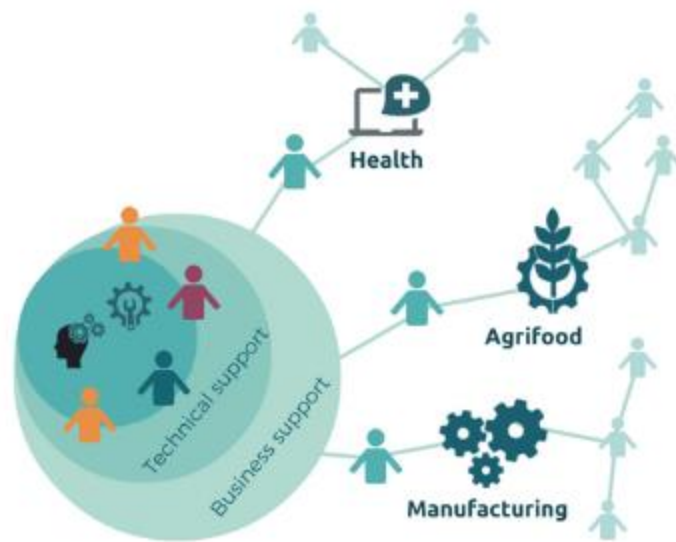


Figure 1: DIATOMIC Application Areas

Initially, DIATOMIC draws from the advanced technological excellence of the DIATOMIC consortium to execute three cross-border Application Experiments in the project's target sectors. These experiments are setup to bring concrete economic benefits to technology adopters, end-users, smart solution developers, investors and policy-makers. In-house excellence in dissemination and communication are leveraged to resonate results beyond the immediate context of the application experiment, and to ignite further conceptualisation of digital products, processes and business models from non-tech SMEs and midcaps in the three targeted sector; thus promoting interest in experimentation with Advanced Micro-Electronics (AME) and System Integration (SSI).

In this course, DIATOMIC takes actions to

- Set up three in-house led testbeds to implement representative applications of smarter processes and products, **“PUSHing” smart technologies** to target sectors that are not familiar enough or traditionally not relevant to AME/SSI. These experiments are set up early in the project, capitalizing on technologies already available through DIATOMIC partners to ensure a fast jump start. All three testbeds come with tools for rapid development of additional applications.
- Communicate the value of AME/SSI-based innovation by exploiting the results of the in-house application experiments. The aim is for beacons' light to permeate to all European SMEs and midcaps of the focus sectors.
- Stimulate SMEs and mid-caps from the selected sectors to define novel products exploiting AME and SSI technologies i.e. **PULLing smart technologies** from the market.
- Assist them in the development of and experimentation with smart products and applications. Offer them: access to complementary competences and resource through brokerage services (to build small consortia that can give birth to the ideas), support to develop a validated business model,

access to *direct funding* (through open calls), *strong technological and business support* to develop high quality application and successfully cross the valley of death.

This deliverable sets the framework with respect to PUSH Experiments in all implementation aspects of the DIATOMIC project. In this way, it will establish a solid and definitive architecture of the solution chosen for the project

PUSH Testbeds are different Pilots where the DIATOMIC technology will be shown to users and will exploit partner's technological competencies and use them to ignite digital innovation thinking in non-tech SMEs, to push AME/SSI technologies. These experiments will be described in this document and will help future DIATOMIC Open Call participants to understand the technologies that they have at their disposal and will serve them as inspiration.

## 1.1 Document Structure

Deliverable D3.1: “DIATOMIC PUSH Experiments Coordination” is structured in the following sections:

- Chapter 2 Describes the PUSH experiments. It provides conceptual, technical and architectural details on the way that the experiments are structured. Moreover, it provides details on the way that 3<sup>rd</sup> parties may utilise them in order to create their own experiments.
- Chapter 3 provides a timeline of the PUSH Experiments explaining their initial stage and the time plan till they are ready to be offered to 3<sup>rd</sup> parties (which will be invited via the Open Calls).
- Chapter 4 describes the expected results in each area that DIATOMIC is targeting, namely the expected results with respect to AME/SSI technologies in the eHealth, Agriculture/Agro-food and industry areas
- Chapter 5 provides the Key Performance Indicators (KPIs) in each direction, and
- Chapter 6 highlights the expected exploitation results.
- Chapter 7 draws some conclusions.

Finally, Appendix I – Catalogue of Sensors provides some details on the main sensors provided by the MySignals and the SynField solutions offered by Libelium and Synelixis respectively in the PUSH experiments, while Appendix II gives information on developing applications for the eVida platform.

## 2 Description of the PUSH experiments

In this chapter a set of typical real time scenarios which will take place in the DIATOMIC infrastructure will be presented. During this section three PUSH Testbeds implementation will be defined in detail.

Taking a close look at the Health and Agrifood experiments, it will focus on the development and implementation of communications between different platforms and Internet-of-Things (IoT) devices belonging to Health and Agriculture world. All these integrations will end up into closed solutions where sensors collect data from different applications and all the information will be stored on clouds to be available for end users or applications.

The Manufacturing Testbed is focused on Industrial Automation and 3D Printing activities, forming a Cyber-Physical Production System (CPPS), a mechanism controlled and monitored by computer-based algorithms, and tightly integrated with the Internet and its users. All the devices will be controlled without the need of a Programmable Logic Controller (PLC) and will adapt to the user's order and optimize production according to their characteristics.

With these three experiments the group aims to show and demonstrate DIATOMIC technology and its modularity: all the hardware and platforms can be used independently, combined or even replaced by different ones. Moreover, future DIATOMIC Open Call participants will be aware of all the technology that they have ready to be used and decide their next steps.

### 2.1 Description of Agro Application Experiments

The objective of the Agro Application Experiments in DIATOMIC is to create fully functional service that will offer the opportunity to farmers/agronomists/farm logistics managers to access all important parameters to accomplish efficient and self-sustainable agricultural production and offer innovative and specialized services in the agricultural domain. The service will be created by integration of Synelxis SynField solution/platform and BioSense Plant-O-Meter systems to offer unprecedented flexibility to prospective developers and an enhanced experience to technology adopters and users.

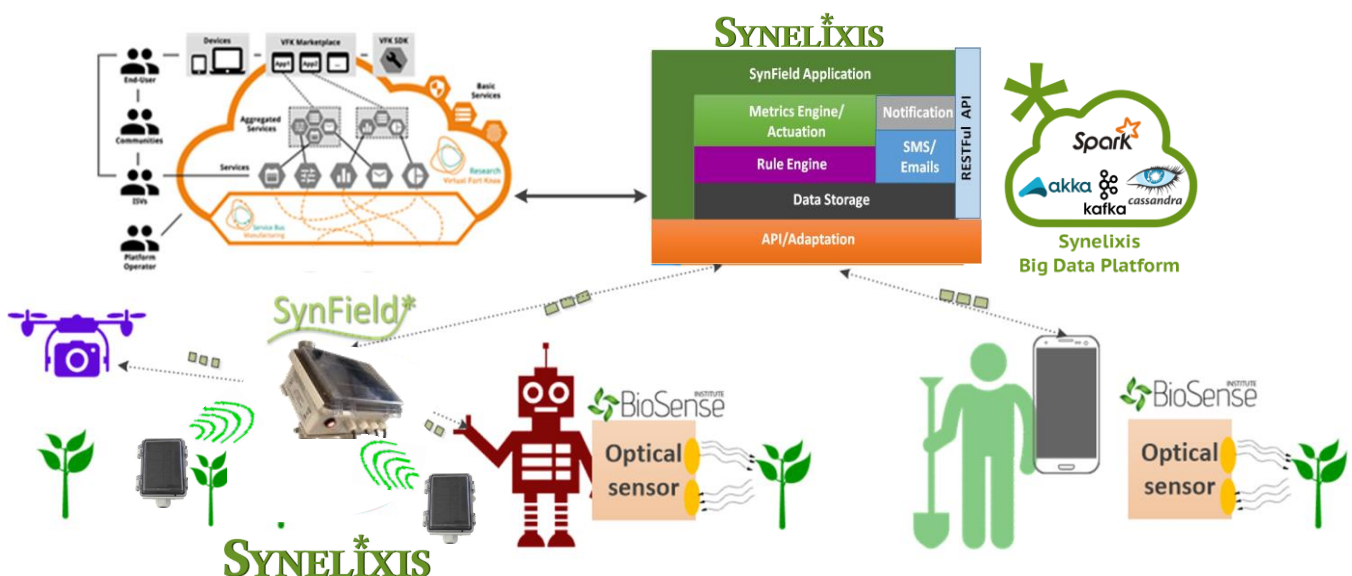


Figure 2: Agro Application Experiment



## 2.1.1 The SynField Monitoring System

SynField is Synelixis' flexible, vendor independent solution for smart agriculture applications. It comes to fill the gap of remote monitoring of the environmental conditions (i.e. air temperature, wind level and volume, rainfall level, soil and air humidity, leaf wetness) and rule based/remote control of the irrigation system, which is also expandable to other relay-controlled systems, based not only on time-parameters but also on sensed values.

SynField offers solutions that help farmers control their farming procedures remotely, with high accuracy and at low cost to meet the needs, not only of large, but also, of small and medium sized farms. The sensed data are delivered to the SynCloud Cloud platform where commands for actuations are decided. The system (currently TRL-9) also alerts the farmer under specific user-defined conditions so that they may take appropriate action.

### 2.1.1.1 Applications

SynField system is an advanced control and monitoring platform for small-medium sized farms that performs the following two main functions:

- ✓ **Monitoring** of soil, atmospheric and plant conditions, in order to predict for crop diseases probability
- ✓ **Automatic irrigation and fertilization control**, based on calendar, crop growth or environmental conditions (i.e. soil-moisture levels and low-temperatures/ice prevention)
- ✓ **Alerts/notification initiation** through email/SMS when certain conditions/rules are met

### 2.1.1.2 Reference Deployment

The SynField ecosystem comprises of SynField nodes, which are sensor-logging and actuation systems installed in the field. They periodically or on demand collect values from various analogue and/or digital sensors and log them to the SynField Cloud Server via a cellular (GPRS/Edge) or WiFi connection. Moreover, they act as actuators to enable remotely controlled smart irrigation by handling solenoid valves, pumps start/stop or relay-switches. Thanks to its state-of the art and expandable design, SynField nodes can be interconnected in the field by means of a multi-hop mesh network (at the sub-GHz ISM band, 868/915MHz) supporting Line-of-Sight (LoS) distances of at least 1km.

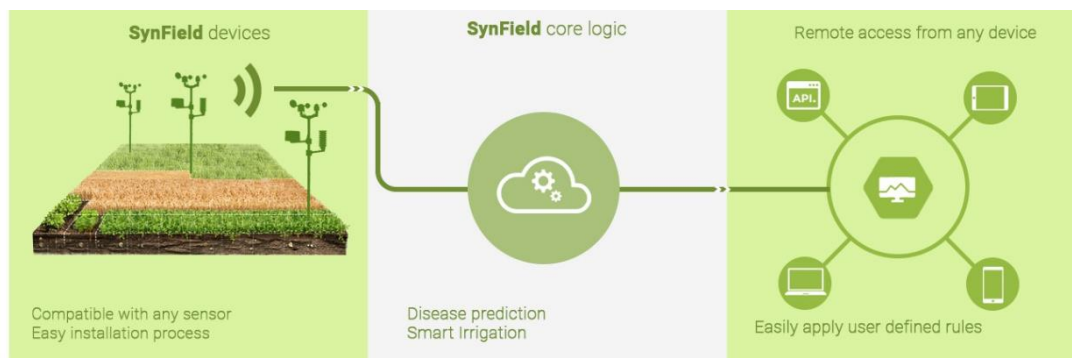


Figure 3: SynField ecosystem

The SynField Cloud Server portal enables the user to remotely monitor various environmental and soil parameters in his/her field and provides the means to define sophisticated rules that can trigger alarms (i.e. SMS/email messages) or remote control actuators (i.e. solenoid valves, relay-switches).

Typically, a SynField installation (see Figure 2) consists of:

- A SynField Head Node (SynField-HN), which is connected to the cloud utilizing cellular or WiFi interface.
- Optionally, several (up to 20) SynField Peripheral Nodes (SynField-PN), interconnected to the SynField-HN device by means of a mesh multi-hop RF network.

- Environmental/soil sensors and actuators (i.e. solenoid valves and relay-switches) attached to the SynField-HN and the SynField-PN devices.

The SynField web app communicates directly with a SynField-HN. All SynField-PN are associated with a SynField-HN, which is used as communication gateway/relay. When the distance between the SynField-HN and a SynField-PN is more than the above distance or in case of obstacles that reduce the communication distance multi-hop communications are utilized.

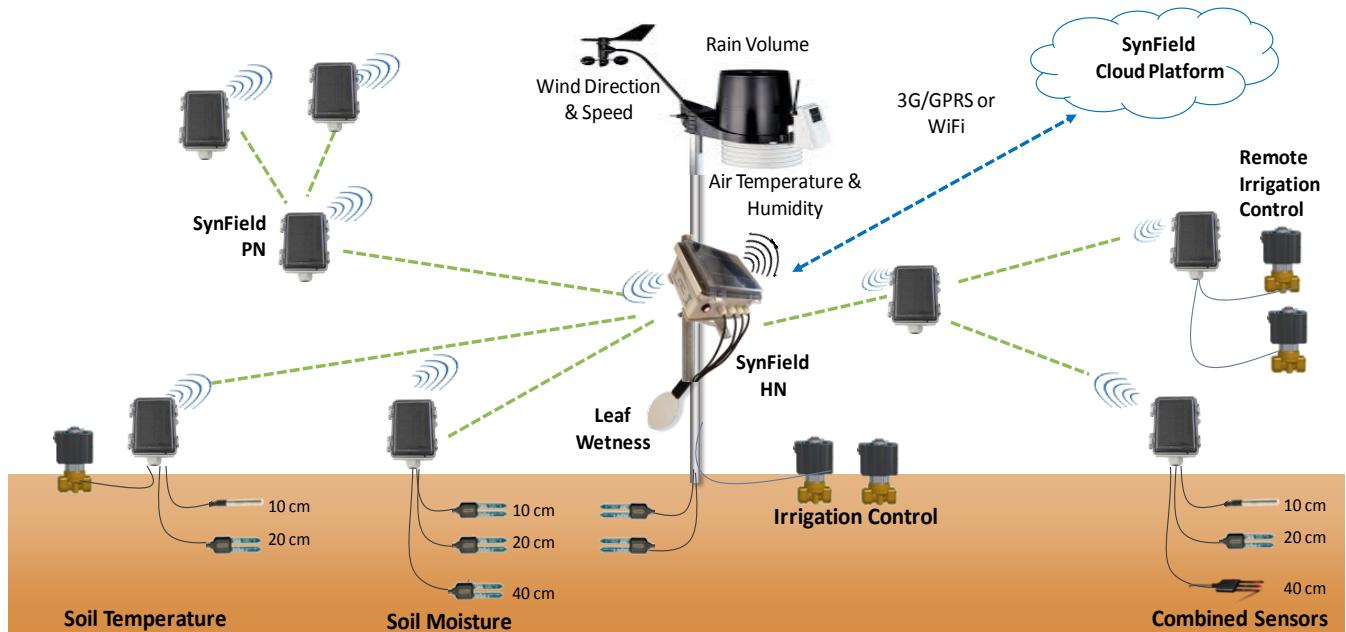


Figure 4: Typical SynField installation

In the case of multi-hop communications, SynField-PNs that are located between the associated SynField-HN and the communicating SynField-PN operate as communication relays. However, synchronization and message forwarding/relaying between the SynField-HN and the SynField-PNs is transparent to the cloud server, which considers that communicates each time with one SynField Device, either HN or PN.

### 2.1.1.3 SynField Main Features

- ✓ Support a wide range of analogue and digital sensors (Vendor independent): weather, environment, crop, soil, irrigation, hydrometer. Any combination of up to 5 analog sensors or 5 pulse counters may be directly connected. Moreover, via an I2C bus may interface up to 16 digital sensors. SDI-12 interface is also offered for specific sensors.
- ✓ Automatic/manual remote control of up to 4 actuators (several types of solenoid valves, pumps start/stop or relay-switches are supported)
- ✓ Internet connectivity through Wi-Fi (802.11b/g/n) or GPRS/EDGE networks.
- ✓ Internodes multi-hop RF connectivity. Up to 20 Peripheral nodes may be attached to a SynField Head node, utilizing sub-GHz ISM RF channels. The standard Line of Site (LoS) with embedded antenna is up to 1Km. By utilizing external antennas the LoS distance may be extended up to 2Km, while long RF solutions of more than 4Km are also available on demand.
- ✓ Cloud based data acquisition, processing & rule based engine provision
- ✓ Energy autonomous nodes (based on solar panel & rechargeable battery).
- ✓ Easy on-site setup/control via a mobile application and Bluetooth 2.1 interface
- ✓ User friendly access via web/mobile applications and personalized interface.
- ✓ Extension memory card support and offline operation mode

- ✓ User defined Alarms & Notifications
- ✓ Configurable data acquisition/logging frequency
- ✓ Outdoor/weatherproof devices (IP65)
- ✓ ESD/lightning protection

#### 2.1.1.4 Supported Sensors/Actuators (vendor independent)

A list of currently supported is depicted in the following figure and is also further analysed in chapter 9. Other sensors (e.g. atmospheric pressure, trunk/stem/fruit Diameter etc.) available on request.

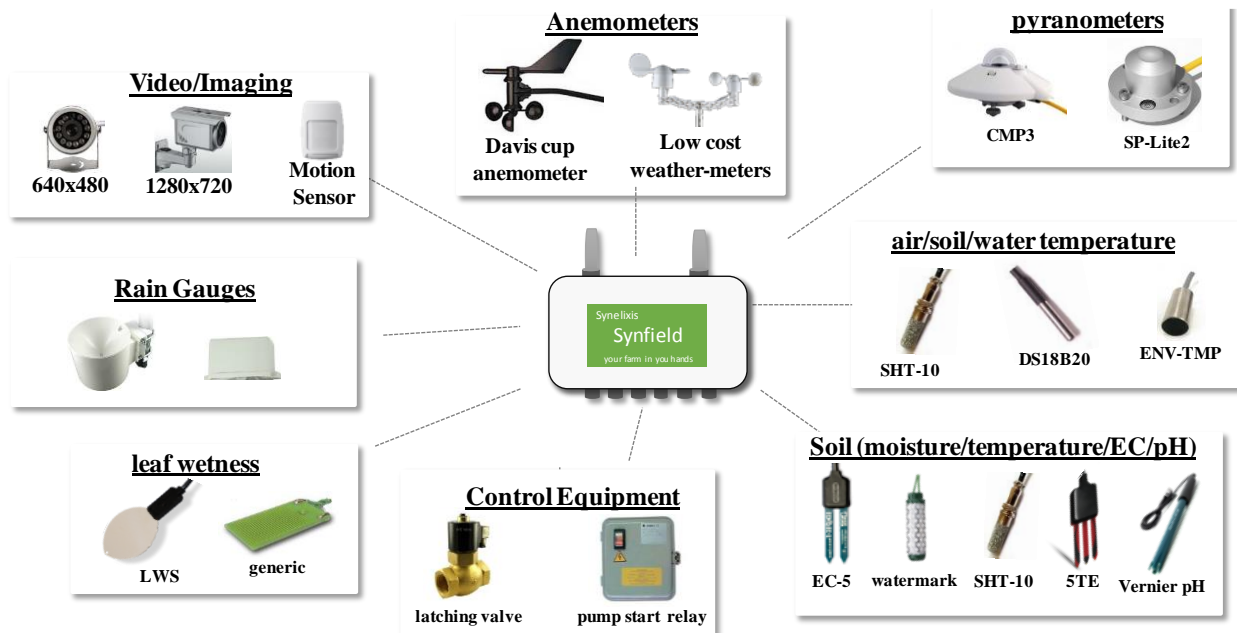


Figure 5: Supported sensors & actuators

#### 2.1.1.5 SynField Devices Description

There are two types of SynField devices: the SynField-HN and the SynField-PN (the device type is shown on the device label). At each SynField deployment, there is only one SynField-HN that establishes the Internet connection to the SynField server and also acts as a gateway for the SynField Peripheral Nodes (Remotes). Figure 6 shows the SynField (release 3) external view, while the Figure 4 shows the internal view. As can be seen, in order to further simplify installation, the new release has integrated the photovoltaic panel and utilizes embedded Printed Circuit Board (PCB) flexible antennas.

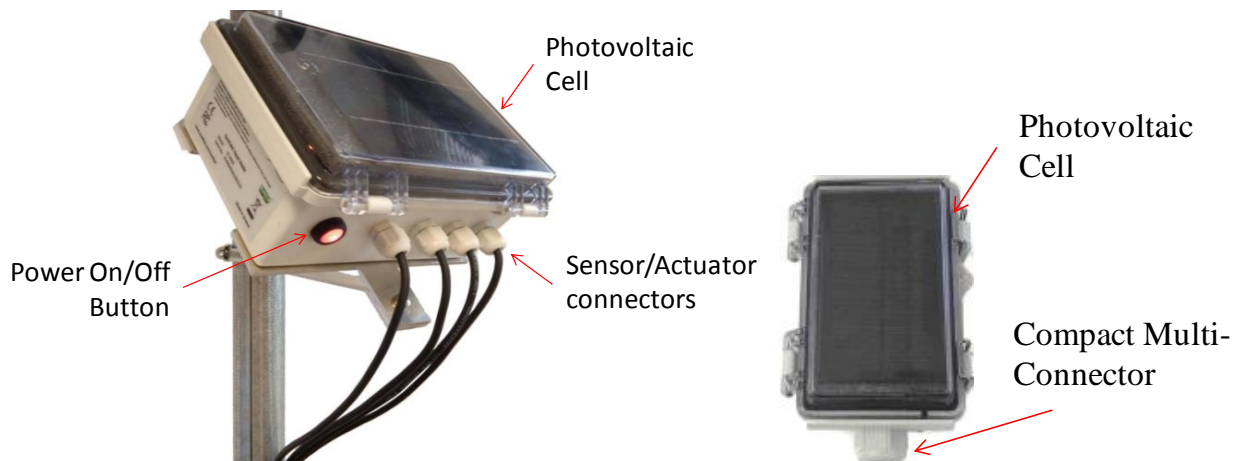


Figure 6: External view of SynField-HN (left) and SynField-PN (right) device

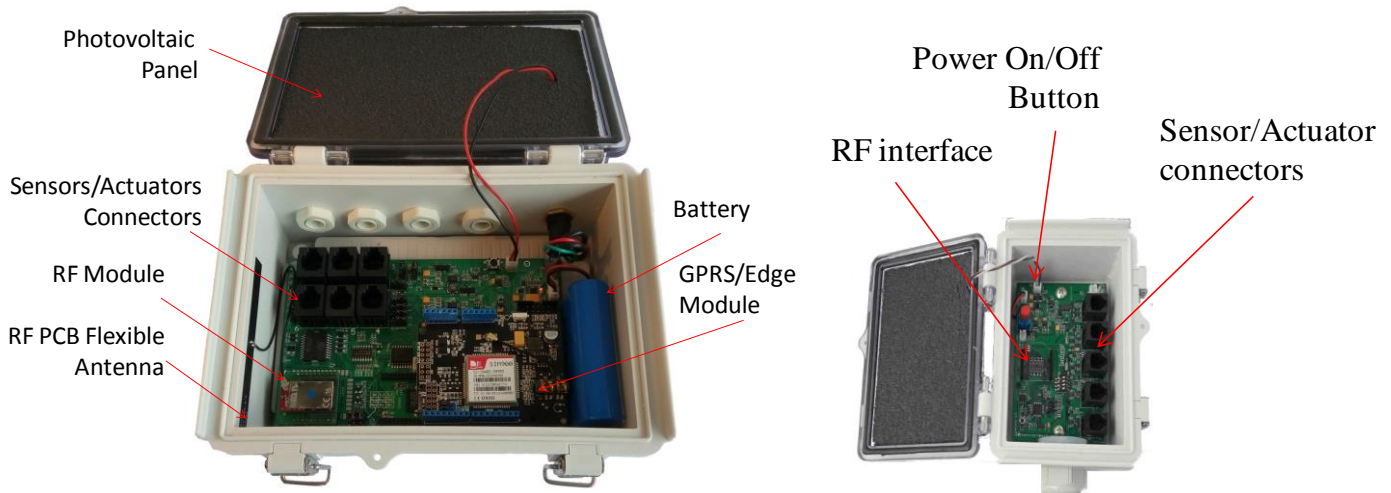


Figure 7: Detailed Internal view of SynField-HN (left) and SynField-PN (right) device

### 2.1.1.6 SynField Platform High Level Description

SynField platform offers a modular approach as shown in Figure 8. At the lower level there is an **adaptation & communication Layer**, which communicates with the SynField devices (directly with the SynField-HN and indirectly with the SynField-PN). This layer is responsible for all messages exchanges and conversions/adaptation. In order to maximize flexibility and support sensors and actuators from many vendors, network and devices/nodes configuration is stored in a relational database at the **structure data layer**. In this layer, use profiles, sensing data and (irrigation) rules are stored. Moreover, via a Restful API all sensed and monitored data can be exposed to 3<sup>rd</sup> party applications.

At the **application Layer**, SynField offers a User Management and Network Configuration application, along with a Precision Agriculture Smart Irrigation Application. Finally, a native Android application is provided for in-field configuration of the devices utilizing a Bluetooth 2.1 interface,

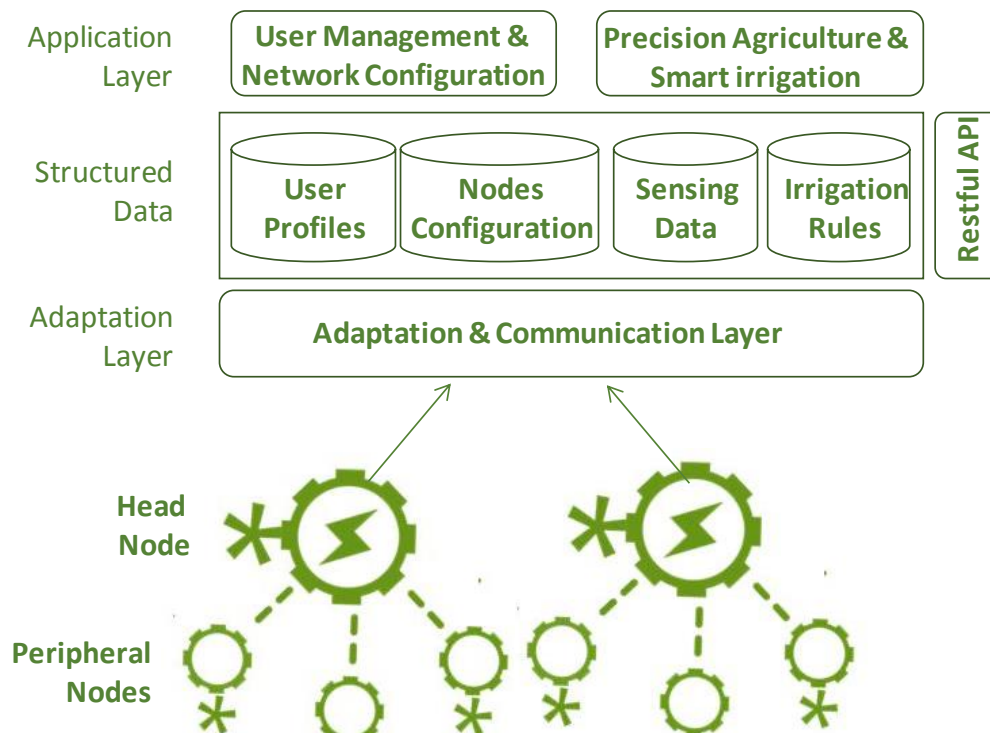


Figure 8: SynField Platform

### 2.1.1.7 SynField API

SynField offer an on-line comprehensive Application Programming Interface (API) dynamically documented at the swagger toolbox [1].

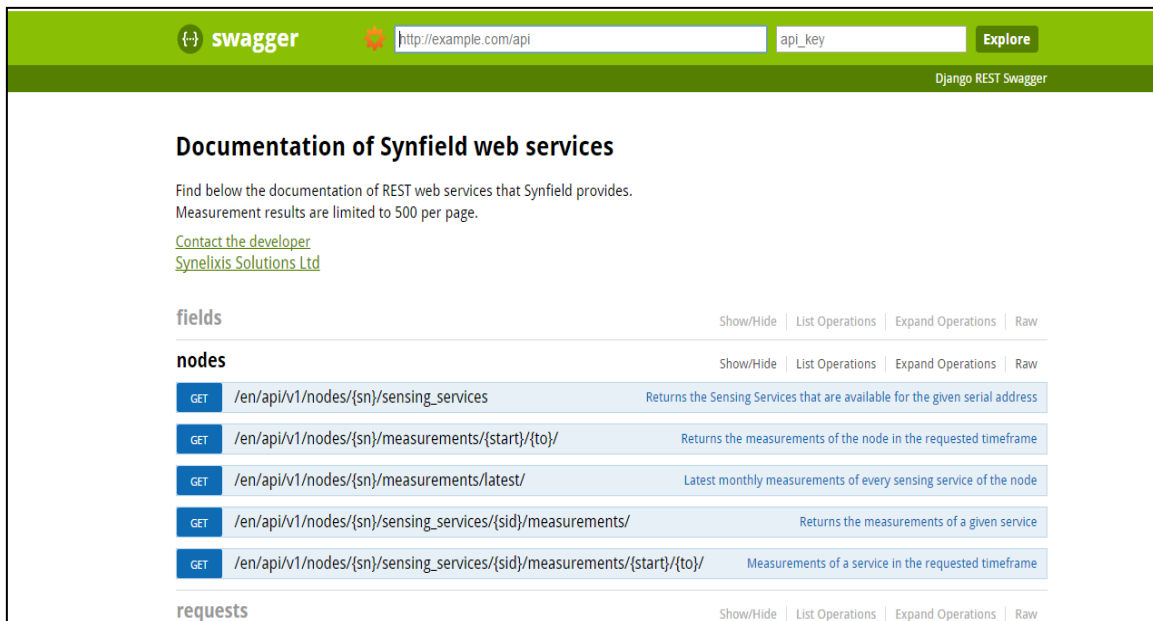


Figure 9: SynField API Documentation at swagger

The RESTful API exposes functions for:

- Retrieval of data/configuration
- Issuing explicit commands to the actuation services (bypassing automation) e.g. irrigation
- Retrieval of actuation logs

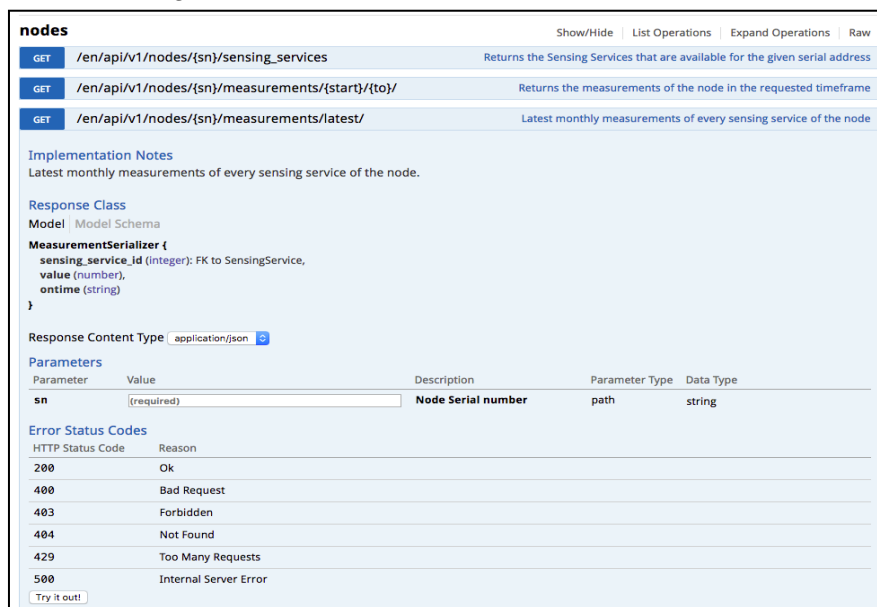


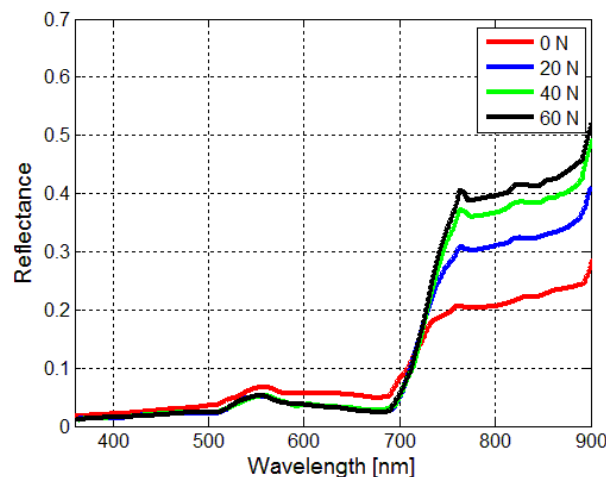
Figure 10: SynField API testing/experimentation

After successful authorization, the users are able to test and experiment with the API sending direct JSON messages to the SynField Cloud platform.



## 2.1.2 PLANT-O-METER

BIOS has developed a solution for effective nutrient balance management in precision agriculture, through the integration of an innovative instrument for on-the-fly monitoring of nitrogen needs into a versatile and low-cost system for expert support to farmers through a combination of disciplines like soil science, agronomy, economics and information technology. One of the cornerstones of precision agriculture is the maximization of the efficiency of the use of fertilizers through variable rate application technologies. Knowledge of soil nutrients available for plants, particularly nitrogen, and its spatial variability within a field is critical for a successful harvest. Plants which grow in nitrogen deficient soil develop two distinct syndromes: reduced number of chlorophyll molecules in leaves (chlorosis) manifested as gradually leaning plant to yellow and reduced absorption in red region, and reduced canopy size, compared to healthy plants, Figure 11.



**Figure 11: Reflectance spectra of a leaf as function of available nitrogen in soil**

This change in reflectance spectra can be detected by Plant-O-Meter, an active handheld optical sensor (the current version is TRL 7) developed by BIOS. The sensor head contains a multispectral light source, a photo detector and a basic electronic circuitry for signal amplification and power supply. Multispectral source allows analysis of plant spectrum at four most indicative wavelengths. Accordingly, this approach enables calculation of multiple vegetation indices thus providing more reliable plant status detection. The sensor is connected to a smart phone using Bluetooth or Wi-Fi, Figure 12. It records the plant canopy reflectance and the location of and sends the measurements to the BIOS's server several vegetation indices can be calculated providing the ability to define the fertilizer needs supporting the farmer/agronomist to take the appropriate decisions.



**Figure 12: Plant-O-Meter and specifically designed smartphone application.**

### 2.1.3 Description of Agri Food Experiment

PUSH experiment will be performed on two farms, one in Serbia and another one in Greece. To maximize the impact of the implemented experiment and ensure that such applications can be applied in different countries and crops, it is important to include farms from different countries. In Serbia, farm will be selected from a User Panel of the Precision Agriculture Living Lab (PA4ALL) hosted by BIOS. The selected farm will sign a contract according to which it will have to monitor specific aspects of the crop yields to enable appropriate experimentation and quantification of results.

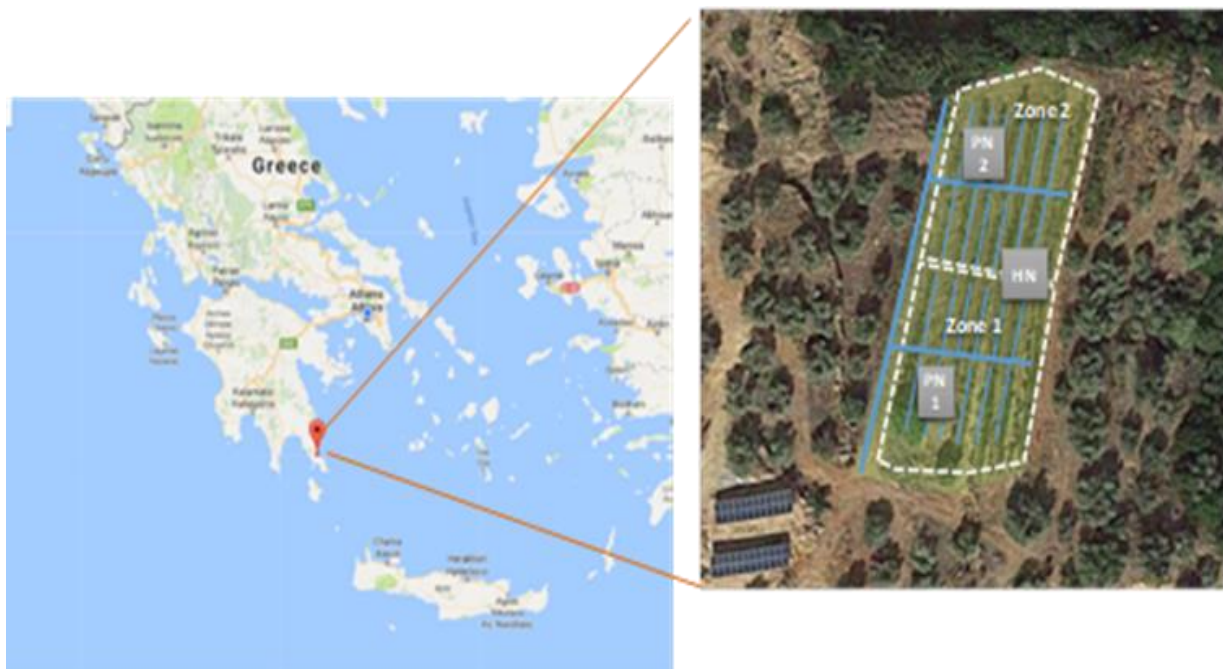
The first task within setting up Agro Application experiment will be to integrate Plant-O-Meter measurements data with SynField system to offer an opportunity to farmers/agronomists/farm logistics managers to monitor plant, environmental and soil conditions from a single point of access. The integration of Plant-O-Meter and the SynField system will be realized through SynField Cloud RESTFul API. It should be noted that in the current version, data processing of the Plant-O-Meter measurements is performed using the smartphone application, Multiple vegetation indices are calculated (NDVI, SIPI etc.), georeferenced and transferred to BIOS's server. Transfer of data is done by android application which uses RESTful API to send data by HTTP requests to server. For the purpose of integration of handheld Plant-O-Meter with SynField system, the application will be modified to adjust and send data according to RESTFul API used by SynField Cloud.

There are two parts of Agro Application experiment:

- 1) Experiment with the Smart Irrigation application in a field of peppers
- 2) a. Use the Plant-O-Meter directly by farmers or experts as a handheld device and/or  
b. Integrate the Plant-O-Meter with a robotic platform (Clearpath robotics Husky A200) to automate the data collection process.

#### 2.1.3.1 Smart Irrigation Experiment

The 1<sup>st</sup> experiment associated with the SynField will take place in Monemvasia, Greece. A field of 1.5 hectares will be split in 2 irrigation zones. Each zone will be irrigated using a network of pipes and irrigation pipelines/water valves of 1 inch.



**Figure 13: SynField Smart Irrigation Experimentation**

The field will be connected with a SynField HN and each irrigation zone will be controlled by a SynField PN. Zone 1 will be irrigated manually, while zone 2 will be irrigated using automatic irrigation rules. During

the experiment, the water consumed in both zones will be evaluated (keeping the soil moisture at the same level), while at the end the crop volume will be evaluated to check if there was any difference between the two irrigation zones. Table 1 summarizes the sensors and actuators that will be connected to each SynField node (either HN or PN).

|                    | SynField HN | SynField PN 1 | SynField PN 2 |
|--------------------|-------------|---------------|---------------|
| Air Temperature    | 1           |               |               |
| Air Humidity       | 1           |               |               |
| Wind Direction     | 1           |               |               |
| Wind Speed         | 1           |               |               |
| Rainfall Collector | 1           |               |               |
| Soil moisture      | 2           | 1             | 1             |
| Hydrometers        |             | 1             | 1             |
| Solenoid Valves    |             | 1             | 1             |
| Water pressure     | 1           |               |               |

Table 1: SynField Testing equipment

### 2.1.3.2 Plant-o-Meter as Handheld device experiment

The experiments for the handheld Plant-O-Meter option of Agro Application will be performed on crops such as wheat, rye, barley, maize etc. Within this option of experiment device's measurement data will be related to appropriate SynField HN or SynField PN that is representative for location in the field where it is positioned. In this way higher level of integration of these two systems will be accomplished. Measurements of vegetation indices will be done manually by farmer or expert at each location where SynField HN and SynField PN are positioned in homocentric circles with radius of 5, 10, 25 and 50 meters from the node. On each radius total of 8 point measurements will be done with the angle shift of 45°. These canopy measurements will estimate the health status of the plant surrounding the nodes with respect to nutrients levels based on vegetation indices provided by the device. All the point measurements and their average will be automatically related to appropriate node and uploaded to the SynField cloud. These data, together with the data obtained by sensors connected to the SF HN and SF PN, will be used to select appropriate agrotechnical measures. If significant variance or abnormal values of indices are recorded, alert message will be send to the user to do additional measurements to extend scan area. Handheld Plant-O-Meter measurements will be done periodically in accordance with observed crop growth stages.

### 2.1.3.3 Integrated Robotic Platform experiment

For the purpose of another option of experiment Plant-O-Meter will be integrated onto a mobile robotic platform Clearpath robotics Husky A200. In this way, automation of measurement and data collection process will be enabled. All-terrain Husky A200 comes with highly accurate RTK GPS system which achieves 2 cm accuracy. With the help of this system Plant-O-Meter will generate precise maps of a series of vegetation indices that will be correlated to end-of-season yield. The Husky A200 Robot Operating System (ROS) will initiate, collect, and process the measurements from Plant-O-Meter and send it to the SF HN. For this option of experiment, manually adjustable by height and angle sensor holder will be manufactured to attach Plant-O-Meter to the robotic platform so that optimal position with the respect to canopy can always be obtained. This system is intended to be used on arable crops (wheat, maize etc.) and vegetable crops (cabbage, lettuce, tomatoes, egg plants, peppers etc) that are not higher than 70 cm.



The main reason for this is in uneven terrain in the fields which will cause significant change in angle and consequently will dislocate Plant-O-Meter from target leading to unreliable measurements.

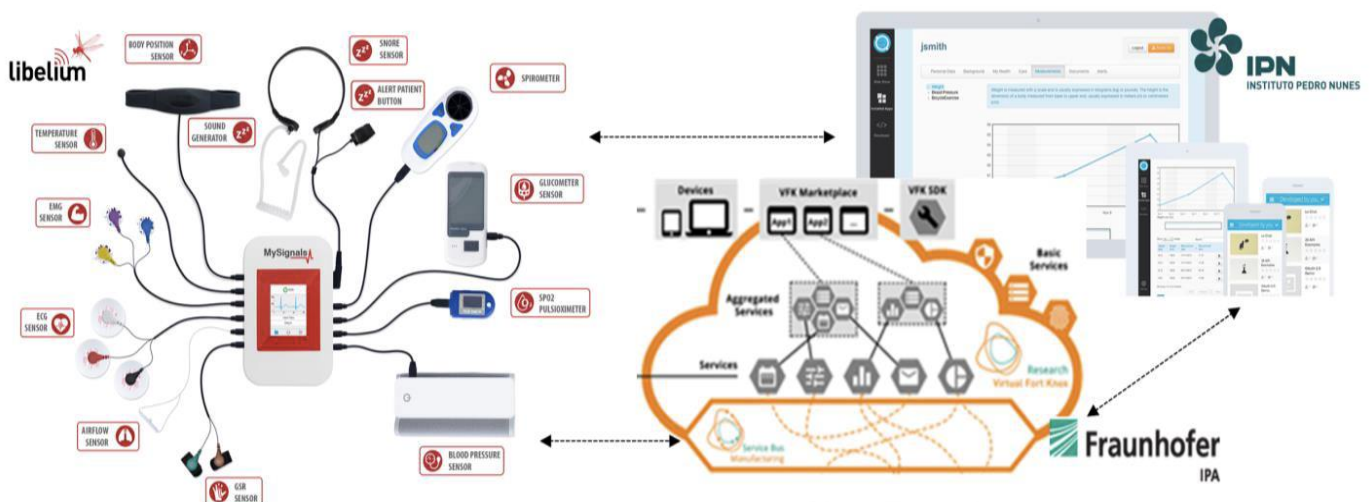
For the purpose of this type of experiment robotic platform will always move on predefined routes in the fields. Measurements will be attained every 20 cm which will ensure smooth and continuous measuring of the canopy's reflectance since the width of the sensor's beam footprint hitting the canopy is approximately 30 cm. Each measurement will be sent to the appropriate SF HN and stored to SynField Cloud. Several measurements will be done during the growing season according to the crops' growth stages.

Integrating the Plant-O-Meter with the robotic platform has several benefits. First, it will prove the concept of automatic on-the-fly Plant-O-Meter measurements. Later this concept can be easily transferred to agricultural machinery such as tractor-mounted or can even be mounted on center-pivot irrigation systems. Next, this system can be activated on user's demand, unlike in the case of satellite imaging which is done every 5 days, with much lower resolution (~10 m) and is heavily influenced by weather conditions. In addition, the robotic platform offers the potential of adding more layers of information to the measurements such as landscape maps (using the RTK GPS) and data from a series of sensors that can be mounted on it such as hyper-spectral and thermal cameras, LiDAR sensors etc. This will enable the automated multi-layer data collection from the fields.

## 2.2 Description of Health Application Experiments

The Health Application Experiment in DIATOMIC aims to be an example of an ICT based solution for Active and Healthy Ageing, as this is a central topic defined by the EU under Societal Challenge 1, “Health, demographic change and wellbeing”. The overall strategic orientation for the “Health, Demographic Change and Well-being” Work Programme 2016-2017 is 'promoting healthy ageing and personalised healthcare'. Its main policy objectives are: (i) to improve health and well-being outcomes, (ii) to promote healthy and active ageing, (iii) to promote market growth, job creation, and the EU as a global leader in the health area. Moreover, cross-sector actions will support the development of evidence-based health and care policies, resulting from scientific research data, ICT solutions and good practices in interventions, improving efficiency and quality of health and care systems. A large number of health application rely on the scheme: sense - monitor - support action in the reading from bio-sensors are processed to trigger human actions (either from the patient/elderly or the caregiver/doctor with wearable/portable sensors playing an important role.

DIATOMIC integrates: a) Libelium's hardware platform for healthcare My Signals which consists of a gateway collecting readings from various bio-metric sensors sensing more than 20 biometric parameters, b) IPA's cloud-based Virtual FortKnox platform collecting the sensed data in the cloud for processing and c) IPN's eVida platform for managing health-relevant applications and thus accelerate development and prototyping of health applications based on AME and SSI technologies. The integration of other than LIB's sensors in the VFK and eVida platform is also possible.



**Figure 14: Overall architecture of DIATOMIC Health Application Experiment**

eVida platform, as mentioned previously, is a technological tool and a framework (i.e. eVida platform) which supports the connection to self-hosted, packaged and mobile applications to promote a rich and all-inclusive ecosystem. The main features of the platform are those of managing users, managing applications and providing interoperability mechanisms for the applications. This platform can directly receive data from the sensors, which is then consumed by the applications and can be shared using the common data repository, being this responsible to store clinical and demographic information. Any application that wants to have access to the platform resources must be registered and follow the adequate security policies.

While eVida comes with connectors for a set of devices, DIATOMIC applicants will also have the opportunity to use VFK for integrating additional devices and to further enhance flexibility in bio-metric sensor selection we will also develop a connector between My Signals and VFK. Additionally, applicants will be able to use the flexible VFK SDK to develop applications that combine data from multiple sensors. The developed applications can then be managed through eVida, leaving the developers concentrate on the business logic (without developing user management components). The aim is to maximise flexibility for makers and accelerate, as much as, possible AME and SSI based application development, prototyping and experimentation.

In DIATOMIC we will first define the applications that we will develop for demonstration purposes, specifying at the same time the setup of the experiment, including details about the interconnection of the eVida, My Signals and VFK platforms, as well as about the target users which will be recruited to experience the in-house DIATOMIC health applications. Furthermore, within the scope of DIATOMIC new components will be developed to enrich current support to connecting different devices. Thus, in this task we will create a middleware entirely focused on integrating smart devices and IoT based approaches. This will initially accomplished through the integration of eVida, My Signals and Virtual FortKnox platforms, and will further extend in a joint effort to create new connectors to support communication with medical devices (e.g. compliant with IEEE11073 standard). Similarly to the previous experiment, this task will also take care of collecting data to quantify KPIs (defined together with technology users) and will also collect feedback through semi-structured questionnaires and interviews. The output of the experiment will be: (i) familiarisation of end users with AME/SSI based applications, and (ii) delivery of a platform for technology developers that allows for rapid application development, using almost any sensor and processing/combining its readings towards new application development, experimentation and prototyping.

### 2.2.1 MySignals

MySignals is a revolutionary eHealth platform that received several worldwide prestigious awards from healthcare, technological, innovative and social organizations.

It has been defined as one of the most complete development platforms for medical devices and eHealth applications. It allows the measurement of more than 15 biometric parameters and let users the possibility to add their own sensors to build new medical devices.

The user can choose between three different to visualize the data measured by sensors:

- **Standalone mode**, which uses the basic graphic Thin-film transistor (TFT) display integrated in the device. The navigation touch interface allows instantaneous transitions between menu screens offering a great user experience.
- **Mobile Apps**: using the native Android/iOS connectivity to send all the data to the smartphone, those applications may be downloaded from the official App markets.
- **Web Server**: it is possible to access to the history of the information gathered by connecting to the Libelium Cloud through a web browser.

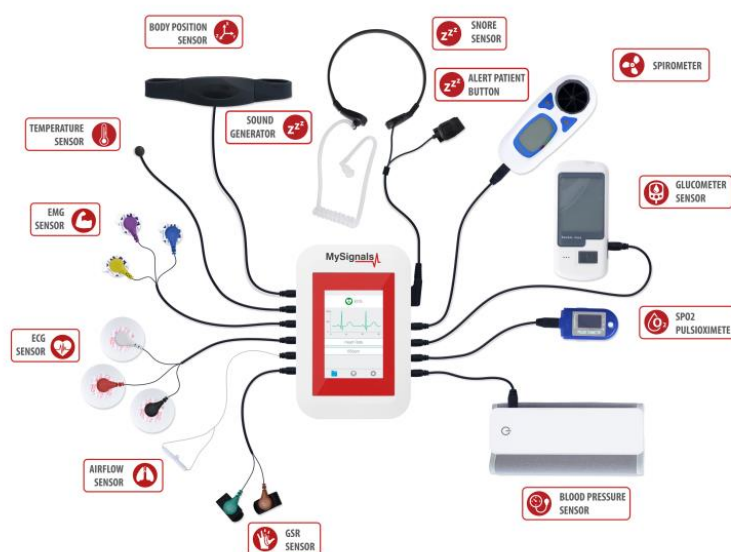
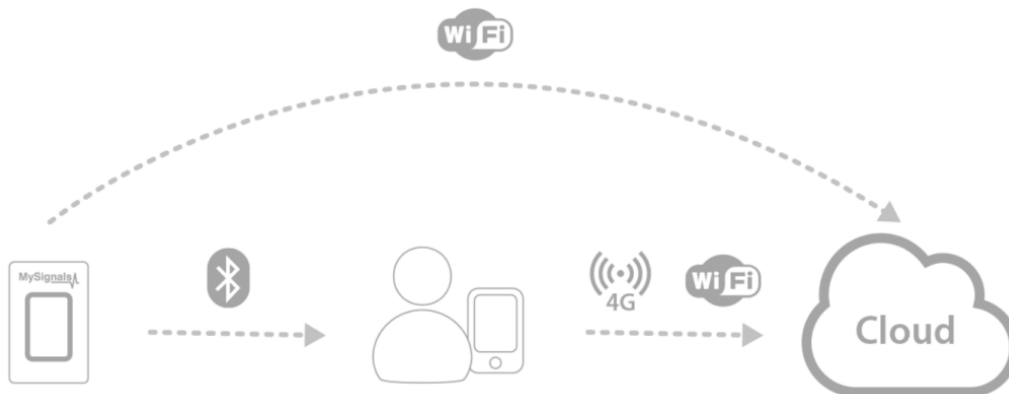


Figure 15: MySignals Overview

MySignals Software have two connectivity options available integrated: WiFi or Bluetooth Low Energy 4.0. All the data gathered by MySignals is encrypted in order to assure the safety of the users, and can be sent

to the developer's private MySignals Cloud account directly to the cloud via WiFi or using your smartphone (BLE)



**Figure 16: MySignals Cloud Communications**

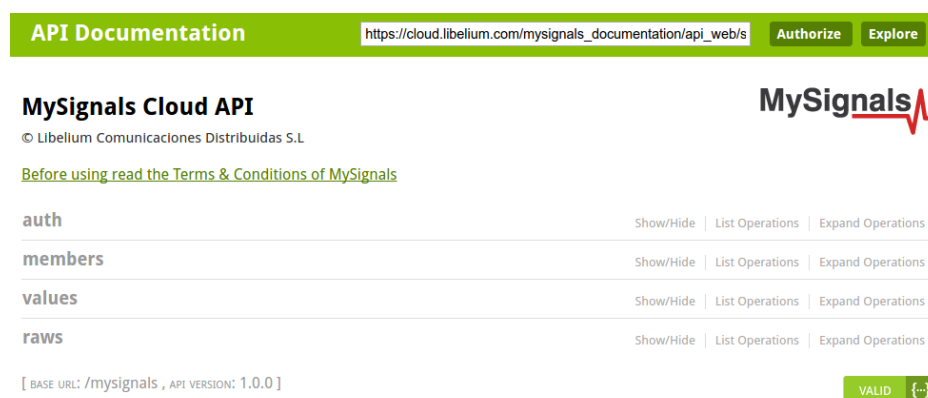
This device allows to share data with the cloud and perform real-time analysis, given that MySignals Web Server Application is a real-time viewing and plotting tool and has built-in data analysis functionality. It is very user friendly and contains many powerful built-in features. The Web Server Application allows users to configure MySignals for creating profiles and users, and help them to visualize the measured data.

MySignals web allows to playback previously recorded sessions and zoom in and out of specific periods. It includes sensor data acquisition from multiple devices and users.

Developers may migrate easily the information stored in the Libellium Cloud to a third party Cloud server using the API Cloud provided, where it is possible to see a list of members and read the values measured for a user by MySignals.

Going into technical details, MySignals users can read the data stored in the Cloud by using the Open API available. It allows users to authenticate and save their information to a third Cloud platform or visualize it in an external web or mobile App through the RESTful API:

1. Open API Features
2. HTTP Rest Calls
3. JSON Files Management
4. Authentication + Read Calls
5. Retrieve your data and visualize it into own Apps
6. Duplicate the data in an own Cloud Server



**Figure 17: MySignals API Documentation at swagger**

### 2.2.1.1 MySignals Sensors

As mentioned before, MySignals allows to measure more than 15 biometric parameters such as pulse, breath rate, oxygen in blood, electrocardiogram signals etc. These broad sensing portfolio makes MySignals the most complete eHealth platform in the market. Some of the sensors are wireless, as they use BLE, while others are wired directly to MySignals. More details about MySignal sensors are available at the section §9.1 MySignals Sensors.

### 2.2.2 Fortnox

Virtual Fort Knox is an IoT platform designed for manufacturing companies that offers needs-based manufacturing IT solutions, the description of the platform and the features and possibilities that it can offer, are described in depth on section 2.3.1

### 2.2.3 eVida



The eVida platform (<http://evida.pt>) aims to bridge the gap between the demands for care and care providers. eVida is a web-based platform that focus on delivering services for personal health and wellbeing. The main objective of the platform is to provide the infrastructure and tools to quickly develop new applications and deliver them to end-users.

Therefore, eVida platform provides an answer to patient health self-management supported by technology (<https://www.youtube.com/watch?v=fwHnHbcpVHY>). The platform already provides an electronic personal health record and supports remote monitoring from devices.

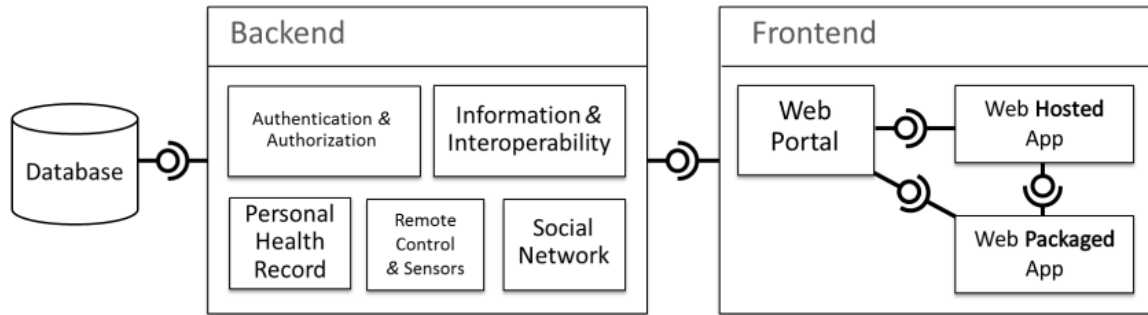
Additionally, eVida promotes the creation of a diversified ecosystem harnessing the connection to self-hosted, packaged and mobile applications that promote self-monitoring and self-management of health and wellbeing.



Figure 18: eVida conceptual Architecture

Moreover, it does not impose any technological restrictions in terms of self-hosted and mobile applications, and guarantees data integration through its APIs. Packaged applications are similar to widget applications and facilitate the developers to submit and publish their applications without the need of acquiring their own hardware infrastructure. The platform doesn't impose on the applications business processes. Therefore, the main features of the platform are those of managing users, managing applications and provide interoperability mechanisms for the applications.

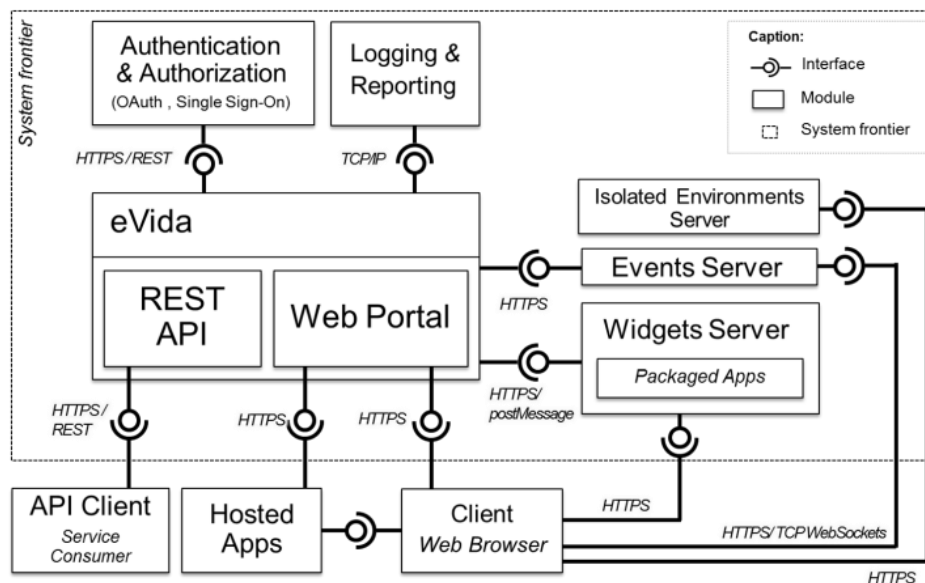




**Figure 19: eVida Backend-Frontend Architecture**

eVida platform is aligned with the trends for eHealth and mHealth. In fact, the majority of the applications in the ecosystem are accessed using a web browser or a using a mobile application. The data produced and consumed by the applications can be shared using the common data repository, which is responsible to store clinical and demographic information. Any application that wants to have access to the platform resources must be registered and follow the adequate security policies.

Regarding some technical aspects, the platform was developed using state-of-the-art web-based technologies. The front-end uses html, javascript and css to provide the user an appealing and responsive look and feel. To develop the front-end we created a Bootstrap (<http://getbootstrap.com/>) template to ease developers to use a similar GUI in their applications. The back-end was developed using several open-source frameworks, and is developed mostly in Python and Java. The most relevant framework used is Django (<https://www.djangoproject.com/>), which provides a full-stack to develop web-based applications.



**Figure 20: eVida Internal Architecture**

Moreover, opportunities were identified in the development and integration of medical devices that allow the automation of biometric parameters acquisition. Therefore, the eVida platform is compliant with the most common standards for health related data (e.g. HL7) and device communication (e.g. IEEE11073). Thus, it has the potential to become part of the mainstream healthcare.

Nevertheless, implementing real-life scenarios with such technological approach imposes a challenge due to the lack of engagement of the different stakeholders involved in health care. However, challenges can be overcome with strategic partnerships that facilitate the adoption of innovative practices. In fact, reference sites from the EIP-AHA constitute the perfect environment to apply this tool and harness individual efforts into mobilizing efforts. eVida is already taking advantage of the synergies provided by the Portuguese reference site (aka. Ageing@Coimbra), where organization with complementary backgrounds

from Research, Innovation and Education joint efforts to promote pilot actions based on the technology provided by eVida. In spite of local efforts, this example may be replicated to other reference sites, and by doing so the platform can also act as an integration channel that guarantees interoperability between different reference sites. This means, one reference site can create its own solutions locally and find an easy mean to share its technological solutions, without the need of refactoring what was already validated.

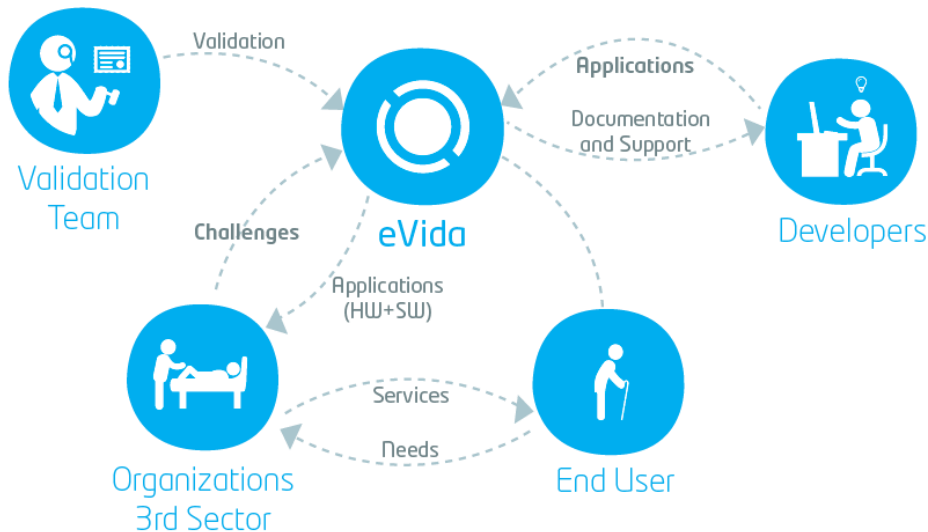


Figure 21: eVida eHealth Scenario

## 2.2.4 Integration between platforms

The goal of this experiment is to offer end users a cost effective platform for medical devices that could be utilized as an alternative for measuring different health parameters without the need of a big investment in equipment.

Talking about health, it is very important that doctors have as much information as possible before diagnosing patients' diseases. Commonly this is a hard task, as hospitals cannot afford having a doctor or a nurse taking care of a patient during all day. This solution will help them to have all the information needed about their patients, and access to the data remotely for an efficient and personalized diagnosis. They will have the opportunity to set alarms to be notified in case any anomalous behaviour would be detected so that they may take appropriate action.

Within this experiment the following actions will be taken:

1. **Basic integration** where the product value will be increased progressively. This way, the first goal is to make a very basic integration where some health sensors from the MySignals eHealth platform send data to Virtual Fort Knox, Fraunhofer's IoT Cloud Service, and this last will interact with eVida platform, specialized in eHealth applications. This will offer doctors, nurses and other users to monitor medical conditions from a single point of access.
2. **Remote meetings** which allow the rest WP members to be aware of the progress. These meetings can also help with the resolution of technical doubts and problems that can arise during the integration.
3. **Test and Revision** meetings will be set in order to revise the implementation, check that the functionalities fit the project necessities and give feedback. Moreover, during this reunion the group will revise the work plan followed and the process itself for detecting problems, solving them and improving it on future iterations. On the other hand, the group will detail future tasks that will be performed during next iterations, to make them precise, clear and understandable.
4. **Advanced integration**: it is planned to reiterate and add new functionalities or improving the existing ones to add value, step by step, both to each platform and the whole experiment. This way future developers will have different technologies ready to use for their projects when they participate on DIATOMIC Open Calls.

During the development of these experiments, the modularity of the platforms must be kept in mind, meaning that, not only the whole solution should be functional, but also each platform should work independently and offer the same functionalities and integration possibilities separated from the complete solution.

This allows developers to choose between applying the whole application (MySignals, Fortnox and eVida), combining some platforms for the development of a new solution (eg MySignals and eVida), or apply only one of these with other external platforms (eg MySignals and an external Cloud) within DIATOMIC Environment.



## 2.3 Description of Manufacturing Application Experiments

Industry 4.0 demands a further consolidation of trade and technology. This requires the allocation of business processes in service-oriented tasks, which are then implemented in corresponding services. This leads to a higher flexibility of the process design and enables cost reduction through reuse of services in other process chains or redesign of existing processes. Service-oriented architectures (SOA) are required for the orchestration of individual services to an overall solution. Such applications can be operated via the internet or in a company's own cloud computing solution as a form of software-as-a-Service (SaaS). The loosely coupled communication between the services is carried out by exchange of messages via defined interfaces to the outside world.

Physical processes play a vital role in manufacturing. Therefore, the digitalisation, as in mirroring the physical state of machinery in the digital world, is necessary to mould manufacturing processes into a service oriented environment. This is achieved with the help of Cyber-Physical Systems (CPS), which can be considered a technical evolution of embedded systems and greatly expanding their capabilities. A CPS has, similar to an embedded system, a number of packaged integrated functions in its logic. However, it is possible to supplement and expand these functions from the software-side. This enables CPSs to gain certain self-directed skills, so-called "self-X". A CPS is able to identify itself (self-identification), communicate its capabilities and properties such as its interfaces (self-description) and to configure itself (self-configuration). In the context of industry 4.0, CPSs offer the following applications in automation and production technology: data collection and integration, data management, realization and processing, data analysis, visualization, control, regulation, marketing and sales. CPSs will therefore penetrate all aspects of everyday production. Another unique characteristic of CPSs compared to typical embedded systems is the general ability to communicate in real time over IP -based networks instead of peer-to-peer communication (often requiring dedicated hard-wiring).

Existing solutions for production aim at giving the user more freedom of action, but also require the management of the services by the customer. The users create the services themselves and deploy them into the provided environment. Distribution and allocation of resources is usually not permitted at this level. In this context, Platform as a Service (PaaS) is mostly used as a development environment in which the users can test and deploy their programmed software. PaaS includes the lower level Infrastructure as a Service (IaaS) as shown in Figure 22. IaaS represents the lower layer of the business models in cloud computing. The user can allocate resources, i.e. processor time, memory and networks at runtime and can set up or remove operating system images. One of the advantages is the dynamic scalability. However, the offers favour proprietary solutions and standards have not existed for a long time which prevents a quick change of the supplier.

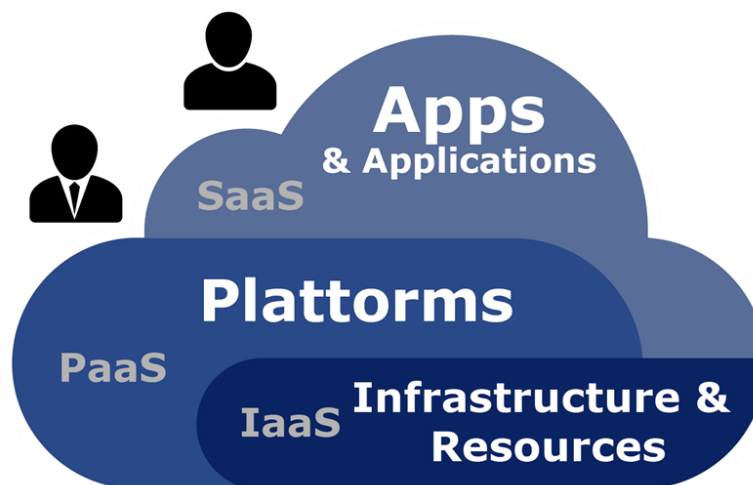


Figure 22: Layer model for Everything-as-aService (XaaS)

The CPPS Manufacturing Application Experiment is focused on industrial automation, and more precisely 3D printing activities, targeting emerging industries such as creative industries and eco industries. The application experiment implements an automated 3D-Printer equipment in the form of a cyber-physical

production system (CPPS). It will be set up so that the personalized product requirements are fed to the platform, which searches for appropriate machinery to conduct the task, with the customer receiving personalized products at the end of the process. To conduct the complete production task several CPPSs within the physical confines of the equipment, as well as several cloud-based software services have to collaborate. This will demonstrate the services developed by Fraunhofer IPA on the VFK platform, which will represent an instance of the Platform as a Service business model.

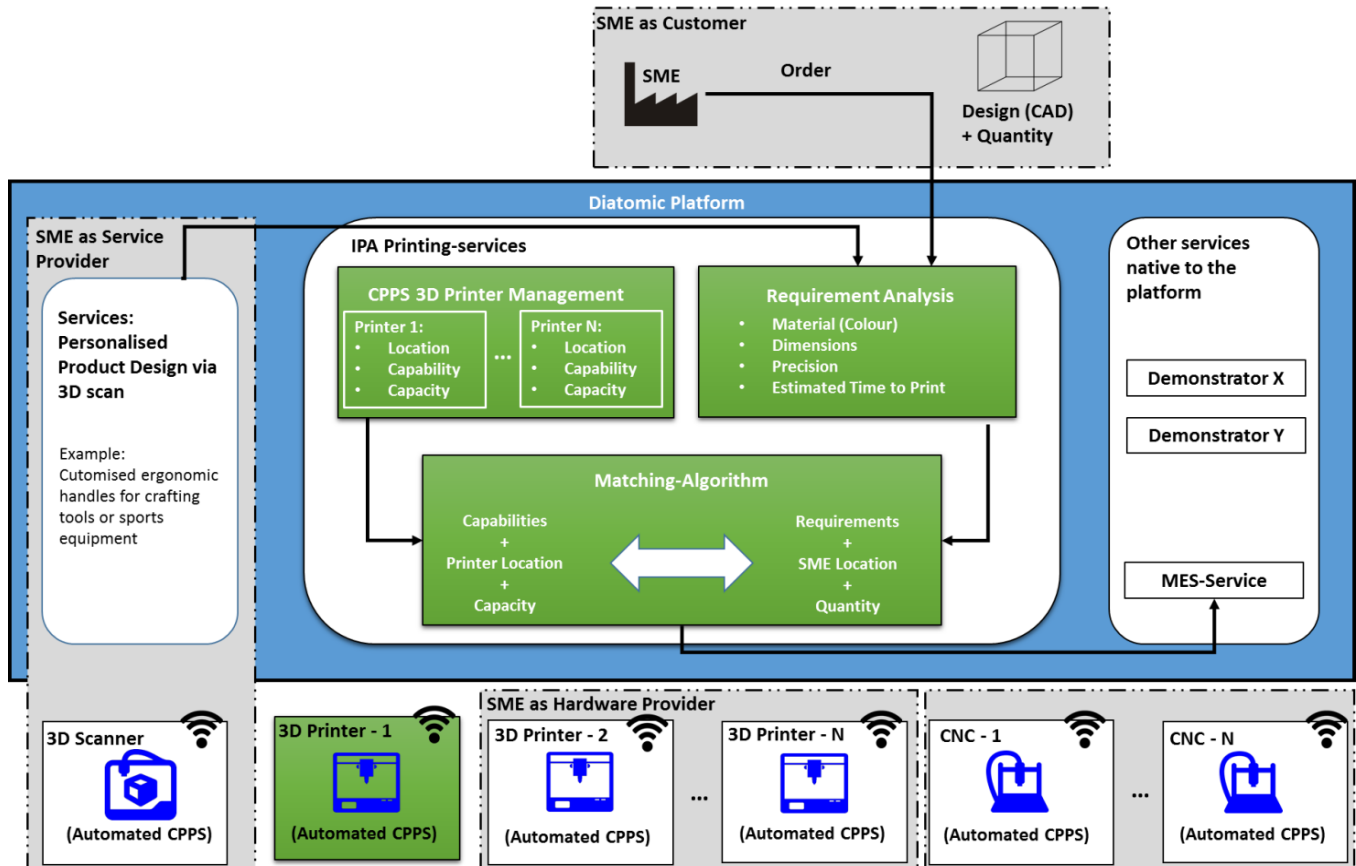


Figure 23: Fraunhofer IPA CPPS Manufacturing Application Experiments

The 3D-Printer CPPS is designed as a system of systems. This means that it consists of several cyber-physical systems (CPS) which are orchestrated by a superordinate service. Each CPS propagates its functionality via interfaces to its environment. These functionalities are used by CPPS to supply a fully automated printing process. Every CPS can therefore be replaced by a new, compatible system with very little adaption to the orchestration.

The following smartified systems will be included: work piece holders, two 3D-printers, a handling unit and a conveyor belt. For each order, a work piece holder will be supplied from a buffer rack to the printer by the handling unit. Some 3D-printing processes require a temperature-controlled surface to ensure appropriate quality of the final product. Therefore, the smart work piece holder can heat itself up if required and communicate its current surface temperature to the other CPPS participants (i.e. to trigger the printing process once the required temperature is reached). Once the printing process is completed, the printer can then trigger the handling unit to pick up the work piece holder with the product and transport it to the conveyor belt. To avoid injury to humans outside the equipment, the surface temperature must be monitored before transportation outside of the equipment. The smart conveyor can therefore detect if work piece holders are present and will only initiate operation once safety regulation (here temperature) are met. In cyber-physical equivalence, virtual world and physical production environment or product are synchronised, often even with real-time requirements.

This CPPS consist of the following key components:

- The **CPPS-framework** is the physical compound for the included CPSs and supplies the required energy and internet connectivity for the incorporated CPSs, as well as the machine's safety logic. The CPSs can be positioned inside two separated shelves, while a handling unit is situated on the back. The framework allows a fluent production process by automatically delivering the finished products to the surrounding for further processing via a conveyor belt and grants easy accessibility to the service personnel for the restocking of material and maintenance.
- The **automation unit** is physically attached to the backside of the framework. It allows the handling of materials and tools inside the framework through its corresponding software services. In the DIATOMIC configuration, the automation unit is used to manoeuvre smart work-piece-holders from their storage facility in the first shelf into the 3D-printer in the second shelf and thereafter to conveyor belt for ejection.
- The **two 3D-printers** use plastic material to create 3D-products via the fused deposition modelling procedure. Incoming orders and production commands are received via a web based software interface. Several smart work-piece-holders (WPH) are stored within the framework. Once they are positioned inside one of the printers by the automation unit, they can be commanded to heat up to the appropriate process temperature and maintain it throughout the printing process.

The components are confined to a physical housing and can be orchestrated from a software service in the Virtual Fort Knox platform. This set up makes the machine very flexible and can allow SMEs to develop other CPSs that can replace parts of the machine to alter or optimise the machine. An example would be the transfer of the concept from 3D-printing to milling or cutting.

### 2.3.1 VIRTUAL FORT KNOX

Fraunhofer IPA operates the only open, federal IT cloud platform specifically for manufacturing. Virtual Fort Knox is a platform designed for manufacturing companies that offers needs-based manufacturing IT solutions. IPA considers the cloud to be an uncomplicated way for manufacturing companies to enter the world of digital production, or to adapt to the rising demand for networked and flexible production. Virtual Fort Knox features the following benefits:

- a. Everything from one source via a one-stop shop for manufacturing companies,
- b. Selection of the desired services via an online marketplace
- c. Availability as a research or commercial platform
- d. Function- and needs-based billing model without requirement for major hardware or software investments
- e. Fast implementation and integration of new solutions through the cloud concept and the use of open standards
- f. Safe operation of the "Virtual Fort Knox" platform, complying with national data protection laws and using Germany as a server location
- g. Optimised networking beyond geographical and company boundaries.

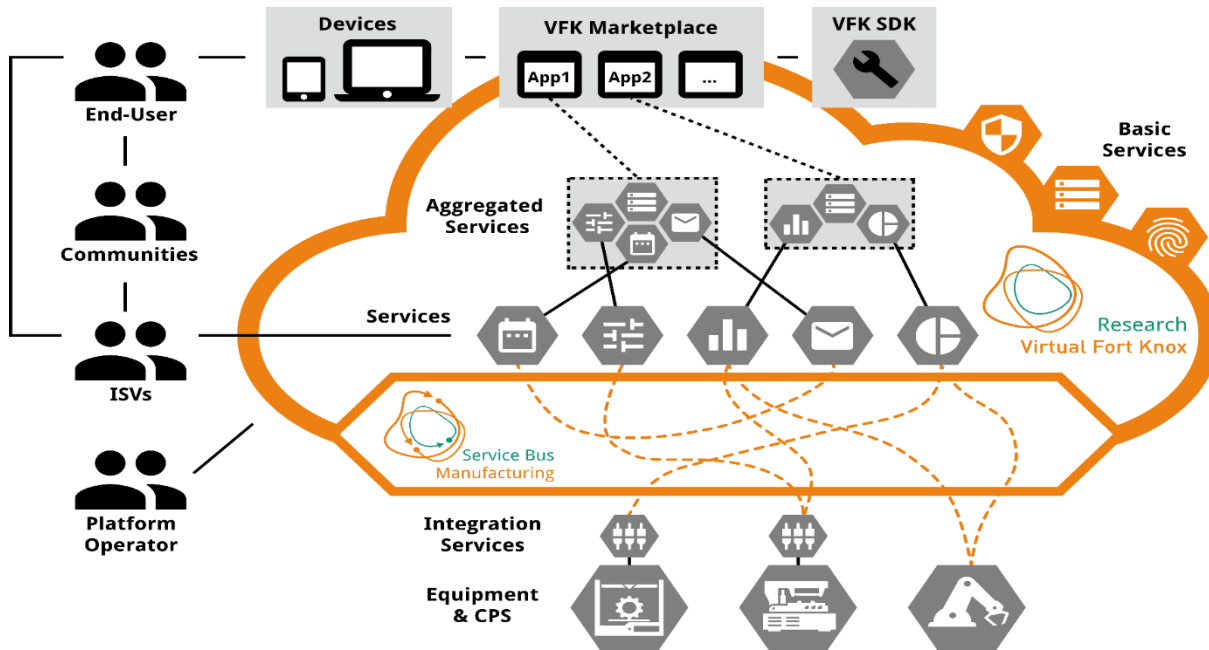


Figure 24: Virtual Fort Knox Components and Roles

Figure 24 shows the overall architecture of the Virtual Fort Knox platform. A central component is its newly designed middleware, Manufacturing Service Bus (MSB), which takes care of the orchestration of all partners, both hardware-based (equipment and CPS) and software-based services. The capabilities propagated by the self-description of the CPS within the CPPS-3D-printing framework (i.e. 3D-printer, handler, etc.) to the MSB are then orchestrated via a graphical user interface and arranged in order to perform the task of automated 3D-printing.

### 2.3.2 Manufacturing Application Experiment - Tasks Overview

In order to carry out this experiment, six main tasks will be performed:

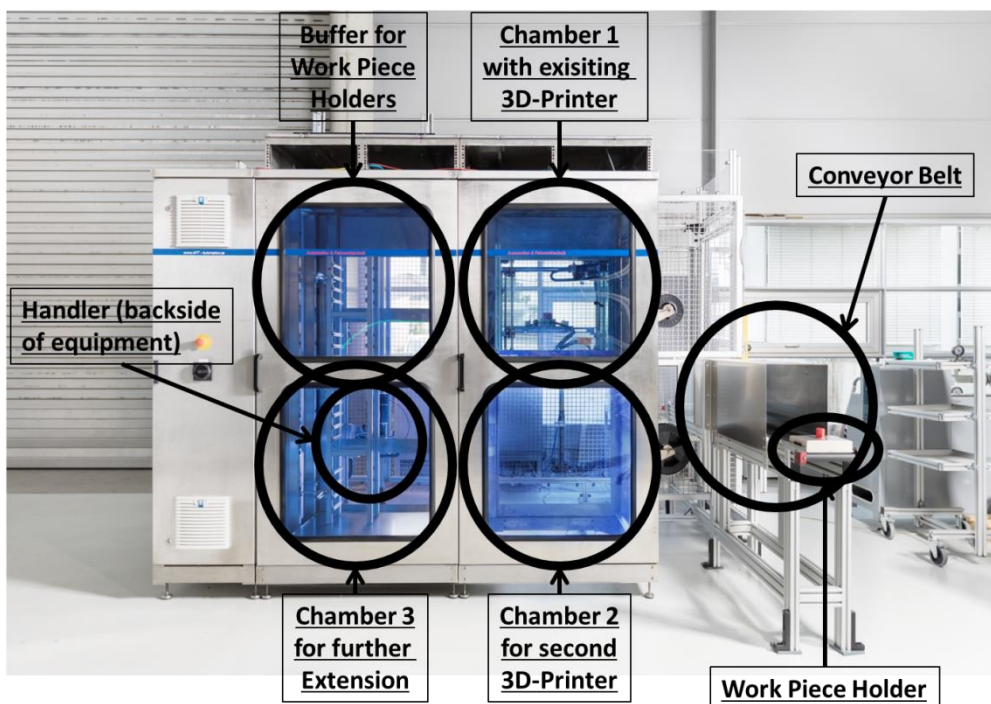


Figure 25: Existing Setup of CPPS-Framework



### 2.3.2.1 Hardware Selection

Figure 5 shows the existing setup of the CPPS Framework. Currently, CPPS's operability is tested with one existing 3D printer (chamber 1). In order to demonstrate the capability matching and more complex order management, another 3D printer will be selected and procured. The selection of the second printer is limited by several boundary conditions, namely the available housing size within the process chambers, accessibility for the automation unit, power supply by the framework and software interfaces for transformation of the printer into a CPS through extension by new software. To enable a consistent production process, more work piece holders, based on the adapted design will be procured.

### 2.3.2.2 Integration of second Printer into CPPS

It is expected that both hardware and software modifications to the new printer, the work piece holders and possibly the handler will be required to allow fluent physical and IT-based interaction between the systems. Additional software services will be developed to allow the transformation of the printer into a CPS and integration of the printer functionalities into the orchestration via the MSB on the VFK-platform.

## 2.3.3 Smartification of Conveyor Belt

The existing conveyor belt is "always on", as it is not integrated into the CPPS. This task will ensure the transformation of the belt with adjoined motor into a full CPS and integration of the conveyor belt CPS into the VFK middleware (Manufacturing Service Bus - MSB). It will extend the conveyor belt's capabilities to ensure safety compliance of the CPPS by allowing it to detect if any work piece holders are present on the belt and to check their surface temperature. Transport will only be allowed once no risk for the environment (e.g. human operators) is present.

### 2.3.3.1 Slicer Integration

A slicer is a software that is required for the pre-processing of a 3D-printing order. It transforms the geometric design of the product idea from a CAD-file into the machine-readable path, which the printer head can then follow to manufacture the product. Slicing is typically done manually by the manufacturer for each new product, by loading the CAD-file into the program and setting the process parameters according to the utilised printer. We will integrate a slicing program into the Virtual Fort Knox Cloud Platform as part of the automated tool chain for the 3D-printing process, which will enable the automated manufacturing.

### 2.3.3.2 Capability Matching

Based on an incoming customer order, the optimal production resource (i.e. 3D printer) has to be selected. This selection will be based on a number of factors, such as product size, material and colour. A capability matching service will be developed by Fraunhofer IPA and deployed into the Virtual Fort Knox platform to be used by the CPPS application experiment. This matching algorithm can be extended by SMEs to accommodate other manufacturing processes (e.g. CNC-milling) which they may add to the experiment through the open calls later in the project. The result of the matching algorithm will be the most optimal production resource (from the pool of printers) which can then be fed into the order management (see following task)

### 2.3.3.3 Order Management

The 3D-printing framework requires the ability to manage incoming 3D printing orders: First, the optimal production resource (3D-printer) needs to be identified through forwarding the information attached to the order to the capability matching algorithm. With the resulting feedback, the order management service needs to schedule the optimal production order schedule to enable production within the set due date or trigger feedback to the customer, that the order will be delayed. Once scheduled, the order management will have to deploy the information flows between the CPSs to the Manufacturing Service Bus accordingly, including the CAD-file for the slicer.

### 3 PUSH Experiments Timeline

This section describes the steps planned to follow during the development and planning of tasks contained within WP3. The complete PUSH experimentation will last for one year (1/9/2017 to 31/8/2018), though some guidance dates will be fixed to allow the internal organization of the members that will participate on the DIATOMIC PUSH experiments.

|                                 | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12 |
|---------------------------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| Diatomic KickOff                | ■  |    |    |    |    |    |    |    |    |     |     |     |
| Design of Experiments           | ■  | ■  | ■  | ■  | ■  | ■  | ■  | ■  | ■  | ■   | ■   | ■   |
| Basic Platform integration      |    |    | ■  | ■  | ■  | ■  | ■  |    |    |     |     |     |
| Validation and Test             |    |    |    |    |    | ■  | ■  |    |    |     |     |     |
| Process Improvement             |    |    |    |    |    | ■  | ■  |    |    |     |     |     |
| Advanced Platform Integration   |    |    |    |    |    |    | ■  | ■  | ■  | ■   | ■   |     |
| Validation and Test             |    |    |    |    |    |    |    |    |    | ■   | ■   |     |
| Launch of Experiments           |    |    |    |    |    |    |    |    |    | ■   | ■   | ■   |
| Feedback and Results Collection |    |    |    |    |    |    |    |    |    |     | ■   | ■   |

Figure 26: DIATOMIC PUSH experiments timeline

On one hand, from the beginning of DIATOMIC project, and until the D3.1 delivery date, the team will focus on the **design and planning of PUSH experiments** that compose the project. Some guidelines and lines of action will be established and also the platform integration will be defined in order to serve as a guideline for the real implementation on next stages.

From the date of delivery of D3.1, DIATOMIC WP3 members will start with a **basic phased-integration among platforms**. Each experiment will be planned independently, and each task leader will define a detailed schedule for it so that the rest of partners could organize themselves. Once achieved the preliminary integration, the team will **validate and test it**. Developers will have the opportunity to propose improvements for the process in next periods of the integration.

Once completed, a second phase of **advanced integration** will be defined. In this phase the DIATOMIC team will define new functionalities that will be offered to the end users. This version will be **validated and tested** until the launch of the experiments, when the impact and efficiency of the platform will be shown. Users may test different experiments within their own developments, and will give feedback through different methods of gathering user's opinions that will be defined during this deliverable.

## 4 Expected Results

First of all, it is expected that this task has a right accomplishment on the management, coordination and evaluation within the project through the correct design and development of the experiments.

With the design of these testbeds, DIATOMIC consortium also intent users to be aware of the need of using technological features on a project or daily life tasks, and the great opportunities of improvement. Moreover, it is expected to be a reference for future investigations or project developments.

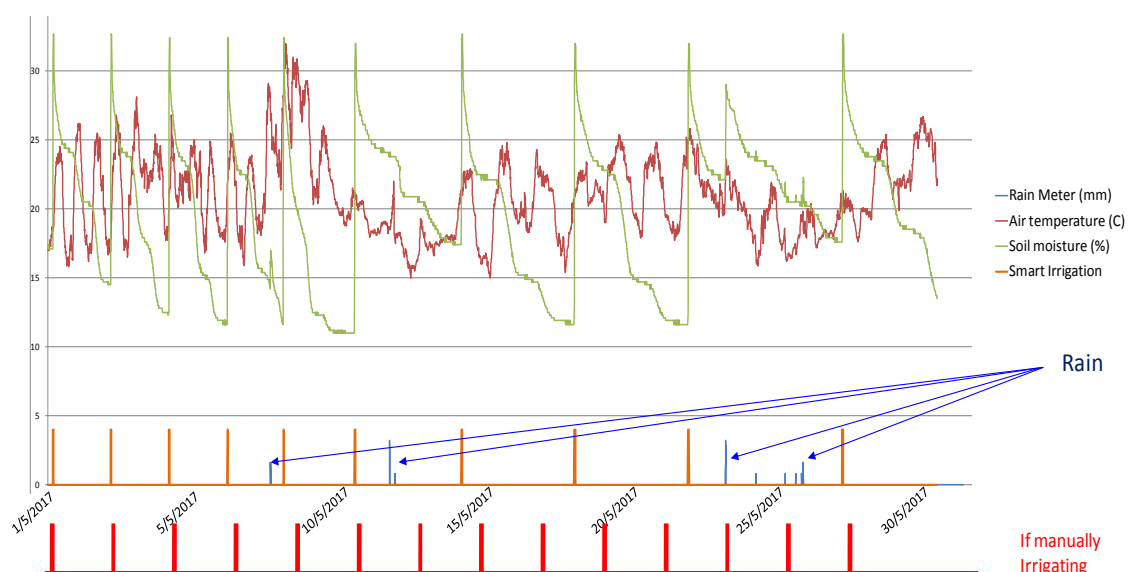
As a global objective it is planned to show all the technologies available on DIATOMIC environment, and let other users use the tools adopted on PUSH experiments for their own PULL experiments that will be presented on DIATOMIC Open Calls afterwards. In order to offer the best platforms to other developers, the team will focus on the platform integration, the usability and the features included.

### 4.1 Expected results for Agro PUSH experiments

End users on selected farms in Serbia and Greece will have the opportunity to experience the ease and benefits of the SynField and Plant-O-Meter integrated system. Face-to-face interactions of the development team with the end users will be conducted in regular meetings for feedback collection. To structure the feedback and make it easier to interpret, a semi-structured questionnaire will be used. The questionnaire will be designed in joint efforts of the development team and end-users to ensure relevance and quality of the feedback loop. End-users will be asked to qualitatively and quantitatively asses the provided solution in terms of ease-of-use, usefulness and marketability. They will also be prompted to define the five top strong points, an equal number of weak points of the use of the system and to point out potential improvements.

A feedback on impact in cost and inputs reduction will be asked since it is expected that the system will potentially reduce expenses for natural and human resources, reduce use of fertilizers and reduce related costs. A reduction over 10% in water is estimated and similarly for fertilizers which represents 30% of farmers' expenses.

Users of the DIATOMIC Agro PUSH experiments will be able to gain access to very important information such as the soil moisture at different levels in the soil, the leaf wetness and historical data related to the micro-clima conditions and the irrigation history.



**Figure 27: Example of Agro PUSH experiment results**

Moreover, they will be able to gain information on calculated parameters such as the Growing Degree Days (GDD) and the evapotranspiration in order to provide seasonal adjustment. For example Figure 27

shows some important parameters such as the rain falls (in mm), the air temperature (in Celsius), the soil moisture (in %), the rain level and a comparison between manual and smart irrigation in a field of Pomegranates Field (Thessalia, Greece).

Users will be asked to keep records of all applications performed in the fields as well as the growth stage and health status of the crops, since this data can be related to vegetation indices provided by Plant-O-Meter and used for future predictions by agri-application developers. In the end of the experiment a huge amount of data will be created thanks to the multispectral source of the device enabling numerous indices to be measured. The most important is red NDVI ( $NDVI_r$ ) which normalizes green leaf scattering in the near-infrared wavelength and chlorophyll absorption in the red wavelength. It is a good indicator of plant stress caused by drought, and nitrogen deficiency. The value ranges from -1 to 1 where healthy vegetation's  $NDVI_r$  generally falls between values of 0.30 to 0.80 depending on the growth stage and the leaf area. Furthermore, green NDVI ( $NDVI_g$ ) will be measured since it is more sensitive to chlorophyll concentration than  $NDVI_r$ . Each chlorophyll molecule contains four nitrogen atoms and accordingly, chlorophyll is the most indicative nitrogen-containing molecule. Another important parameter that will be monitored is Blue NDVI ( $NDVI_b$ ) which replaces the red band in the  $NDVI_r$  by the blue band. Blue light is absorbed during photosynthesis by chlorophyll and it is also absorbed by anthocyanins - pigments that protect vegetation from UV radiation damage. In the case of  $NDVI_b$ , theoretical values are in the range from -1 to 1. The last index that will be tracked is Structure Insensitive Pigment Index (SIPI) that relates carotenoids to chlorophyll, whilst minimizing the impact of the variable canopy structure. In the end, farmers will be asked to provide end-of-season yield to relate it to all parameters monitored by integrated system. This large amount of data can be used in a scientific research that will discover new relations with the help of advanced Big Data analysis techniques.

## 4.2 Expected results for Health PUSH experiments

Nowadays, it is practically imperative that devices are connected to Internet simplifying users daily life. On health environment, it is critical to have updated information from medical patients for preventing injuries and searching for disease. New technologies can help to improve the health and well being on people in local communities and around the world.

Creating new healthcare applications or medical devices requires access to prototyping platforms that were once very costly to obtain, limiting development to research labs or well-funded corporations. The Health PUSH experiment will let developers know the high possibilities that an inexpensive prototyping platform like MySignals can offer, combined with Fortnox and eVida that can be commercialized in the future.

Regarding the experiments, the first goal is that users can adopt these technologies on their projects, with this aim some physical units will be available for participants on PULL Experiments, but all the data capted by hardware devices will be open to everyone so that developers that do not manage to obtain a unit can also work on their experiments. Users' opinion is important for continuous improvement, the team will gather feedback through questionnaires jointly designed by developers and WP3 partners. These polls will help the team to plan future upgrades on user friendliness, usability and interfaces both on the experiment and on the platforms independently.

In the framework of DIATOMIC, LIB, IPN and IPA will:

- **Enrich current eVida and Virtual Fort Knox support for medical devices and hardware application** for health, well-being and quality of life starting from the integration of My Signal platform. This will be achieved by creating new “connectors” focused on integrating smart devices and IoT based approaches. (IPN is leading the adoption of SIGFOX technology at national level, positioning itself as a top player in the development of IoT based infrastructures development.)
- **Integrate eVida with Virtual Fort Knox** as a middleware to promote IoTization of health, well-being and quality of life oriented solutions.
- **Develop two example applications** built on My Signals (to be specified in the first month of the project) to demonstrate the easiness and low application development time. The developed solutions



will be offered to users of the platform residing in different countries, preventing any of these solutions of being geographically bounded. A transnational and diversified work group allows tapping into the different realities of the countries, enabling any developed solutions to be universal and thus support a wider audience.

Technologies tackled will include diverse bio-sensing technologies, electronics, combined sensing, smart system integration

DIATOMIC main output for solution developers is an experimentation platform that offers extremely rapid solution development enabling:

- a) to select among a large set of different health sensors from the LIB catalogue and sensors from other manufacturers supported by VFK and eVida
- b) to easily process the data exploiting the VFK services and SDK for combining them towards development of cloud based applications and
- c) easily complete their application prototyping without having to care about user management and easy integration of 3rd party sources.

For end users, DIATOMIC based applications will bring reduced expenses for adopting technological solutions, and more integrated and interoperable solutions. For society, DIATOMIC will bring sustainable care and cure services, better quality of service.

## **4.3 Expected results for Manufacturing PUSH experiments**

Manufacturing is a key driver of employment and wealth creation in Europe, and therefore contributes significantly to improving the quality of life of citizens. Manufacturing industry produces more than three-quarters of Europe's exports and generates more than 15% of European GDP.

The fundamental challenge for European manufacturing is to shift from a cost-based to a high-value-added competitive advantage. Particularly SMEs are limited by large induced cost and setup-times for manufacturing lines for new products. In this context, Factories of the Future should deliver European added value by helping manufacturing companies, particularly SMEs, to make the required adaptations in terms of manufacturing excellence and flexibility in order to capitalise on the increasing demand for more customised and higher-quality products. This requires a transition to a flexible, digitalised and demand-driven manufacturing. The conversion of classical manufacturing equipment and tools into cyber-physical systems which describe their functionalities and supplied data enable user, such as SMEs, to orchestrate these components with the help of platforms like Virtual Fort Knox, rather than having to integrate them in a time consuming and therefore costly process. Additionally value adding services can be supplied to enrich the surrounding ecosystem.

The industrial demonstration in the manufacturing application experiment will show the full potential of the automated additive manufacturing processes in near-real manufacturing conditions and it will serve as a flagship example for other stakeholders within DIATOMIC.

Within the DIATOMIC ecosystem, IPA and LIB would be able to demonstrate Virtual Fort Knox support for smartified manufacturing equipment as well as the benefits of CPS application within the manufacturing sector. This will be achieved through the setup of new CPS and their integration into the VFK-Platform for further utilization within more complex manufacturing processes. In addition physical manufacturing processes may require enablement through software-based information enrichment within the VFK-platform. The CPS-technology will enable components to interact with other partners from the ecosystem shop floor beyond their usual physical boundaries through simplified digital interaction via the VFK-platform.

The main output for the manufacturing push experiment is the development of a new Manufacturing Demonstration (MD), where SMEs will be able to test new technologies in cooperation with technology providers in order to develop real industrial products and services, and where business and technological training is offered. The MD will act as a cyber-physical production system in form of a system of systems.

The middleware, supplied by the VFK-platform will be a key component for the seamless and smart integration of the participants of the MD-ecosystem. Such participants will be value adding software service

and CPS. Furthermore, VFK-platform will supply an environment for the real-time deployment of new software components into its cloud infrastructure and enable cost reducing scalability of the software components of the MD-ecosystem. The basic manufacturing processes supplied by the MD will be additive manufacturing. The selection will demonstrate requirement-based selection of production resources while supplying a high degree of flexibility for SMEs for further extension of the value chain in later stages of DIATOMIC. The CPS incorporated into the MD-ecosystem will display the capabilities of smart sensors and actors through supply of status information such as position, process parameters and filling state as well as remote triggering of action through the VFK-platform.

## 5 Key Performance Indicators (KPIs)

The KPIs will be defined so as to reflect the extent to which technology adopters/users needs are satisfied as well as the ease with which technology users developed and prototyped new applications that exploit AME and SSI.

- **Equipment Performance:** this KPI will track the performance of the hardware devices provided for this project counting the number of devices that will need to be replaced due to a failure if any.
- **User-friendliness:** this indicator will measure if the platforms and its integration are easy to understand and operate for the users without the need of very specific instructions. This can be a measurable parameter if the team counts the number of support solicitations and users questions related to DIATOMIC environment platforms.
- **Satisfaction:** the opinion of the users will be encompassed through a short poll where they will be asked about different aspects of DIATOMIC and its platforms.
- **Activity on platforms:** with this indicator the team will measure the influence of new users that decide to use the platforms proposed on DIATOMIC actively for the development of their projects.

### 5.1 Key Performance Indicators for Agro Applications

Within DIATOMIC Agro application KPIs will focus on all the benefits that integrated SynField and Plant-O-Meter can offer. KPIs will help to further improve integrated system and indicate in a quality and quantitative way all improvements that integrated system provides to an agricultural production.

- **End user impressions** in terms of ease-of-use, usefulness and marketability. The questionnaire will be designed to help users point out strong and weak points of the system.
- **Reduction of costs** of expenses for natural and human resources, use of water, fertilizers and related energy costs. A reduction over 20% in water is estimated and similarly for fertilizers which represents 30% of farmers' expenses.
- **Crop disease prediction** based on micro-clima parameters monitored by SynField.
- **Prediction of vegetation indices** regarding end-of-season yield relation it to all indices monitored by Plant-O-Meter.

### 5.2 Key Performance Indicators for Health Applications

In DIATOMIC, we frame the Key Performance Indicators for Health Application in European initiatives for Active and Healthy Ageing. In particular, these key performance indicators relate with priorities and good practices supported by the Reference Site Collaborative Network of the European Innovation Partnership on Active and Healthy Ageing (EIP on AHA). Therefore, the outcomes of Health Applications associated with DIATOMIC Health Digital Innovation Hub will result in a direct benefit for economic competitiveness of European eHealth industry, insurance companies, local business offering activities and services for the older adult; and will materialize key concepts of the European blue print on digital innovation and will promote healthy living of citizens in Europe. See figure below.

To achieve the EIP on AHA objectives to improve the quality of AHA of European Citizens, to contribute to the sustainability of health and care system and to contribute to the economic growth of Europe, the EIP on AHA has delivered the "Monitoring and Assessment Framework for the European Innovation Partnership on Active and Healthy Ageing" (MAFEIP). This framework attends to the best practices in Europe and brought together a set of qualitative and quantitative metrics that can be applied to innovation activities with technological readiness level (TRL) from 1 to 9. The most updated information regarding the conclusions of this framework has been compiled in the "MAFEIP Second report on outcome indicators"

| Quality of Life [3]  |  | Sustainability of Health and Care Systems   |
|--|--|---|
| Primary indicators   | Secondary indicators   |   |
| <ul style="list-style-type: none"> <li>Health related Quality of Life (HRQoL)</li> </ul> | <ul style="list-style-type: none"> <li>Risk Factors</li> <li>Physical Activity</li> <li>Adherence to treatment</li> <li>Frailty</li> <li>Cognitive decline</li> <li>Functional status</li> </ul> | <ul style="list-style-type: none"> <li>Health and care resource use (e.g. number of visits to primary care; measures of hospital / emergency admission and length of stay)</li> <li>Unit cost data (to value health and care resource use)</li> </ul> |

In addition to these aforementioned generic indicators defined by EIP on AHA, during this first stage of the project the group have established some other KPIs that will help to centre the experiment and let all partners be aware of the success of the experiments and possible weaknesses that can be improved on the platforms.

- **Time reduction on patient evaluation:** it is a fact that is hard for health personal to monitor and be aware of the state of all their patients at any time, the tools offered on this experiment will help to fast diagnose patients and have the data directly on the network. This indicator measures the proportion of time that is saved by health personals thanks to the use of the combined platforms.
- **Number of measurements:** this KPI will count the number of measurements performed using the solution offered on the experiments, and compare them with the number of measurements performed without technologies.
- **Number of developers applying their solutions.**

## 5.3 Key Performance Indicators for Manufacturing Applications

The KPIs will be defined in order to reflect the extent to which technology adopters/users needs are satisfied as well as the ease with which technology users developed and prototyped new applications that exploit AME and SSI.

### KPIs for users:

- **Scalability:** in this context, scalability is the capability of CPPS system to handle a growing amount of work, or its potential to be enlarged to accommodate that growth. CPPS is considered scalable if it is capable of increasing its total output under an increased load when resources (3D printers) are added. In particular, we are going to measure Load scalability, i.e. The ability for the CPPS to easily expand and contract its resource pool to accommodate heavier or lighter loads or number of inputs.
- **Absolute Availability:** This KPI measures the proportion of time a system is up and running. In this experiment, this measures the percentage of time the CPPS can be in operation (e.g. 24/7 means 100%).
- **Manufacturing Cycle Time:** This KPI measures the speed or time it takes for CPPS to produce a given product from the time the order is released to production, to finished goods.
- **Human resources needed**
- **Customer satisfaction;** The level of increased customer satisfaction

### KPIs for providers:

- **Scalability:** In this context, scalability for service/machine providers measures the capability of CPPS in adding new services and/or machines with minimum effort. For example, it measures the ability to add/plugin other manufacturing process types into the system, such as CNC milling.

- ***Modularity and Flexibility*** of deployment to other cloud platforms and remote deployment of services into CPPS

## 6 Exploitation of expected results

This chapter provides the main exploitation directions of the results including benefits to the participants. We highlight two important areas: one related with the direct expected exploitation of the experiments and one related with the secondary processing of the experiments results, aka the processing and utilization of the collected data from researchers and scientist (after proper post-processing and anonymization).

### 6.1 Expected direct experiments exploitation

The results of the DIATOMIC PUSH Application experiment will support SMEs, System Integrators and individuals to build new Advanced Micro-Electronic devices (i.e. sensors, data loggers, specialized equipment), and Applications/ mobile apps developers to utilize the AME equipment offered by the PUSH experiments to create new knowledge and test their solutions in a real environment.

In more details, the direct expected exploitation of the DIATOMIC PUSH experiment per DIATOMIC trials category are summarized in the following sections.

#### 6.1.1 Agro Application Experiment

The DIATOMIC PUSH Agro Application experiment will have a direct impact in the SMEs, System Integrators and individuals who built new Advanced Micro-Electronic devices and applications/ mobile apps related to agriculture. Moreover, the PUSH experiment will result in a direct promotion to the wide public of the SynField and Plant-O-Meter solutions and give them the opportunity to validate this cost-effective and efficient technology.

Thus, the benefits of the DIATOMIC PUSH experimentations in agro applications will be:

- **For Solution Developers and System Integrators.** The DIATOMIC PUSH experimentation platform will offer extremely rapid solution development and prototyping support, enabling solution developers and System Integrators to a) built new Farm Management applications directly utilizing the SynField Cloud platform and the associated API, b) to test and integrate different sensor equipment and data logger devices using the SynField HN and PH, c) to define new innovative applications using micro-clima and plant-o-meter data.
- **For the Agriculture Scientist.** DIATOMIC based agro applications will offer significant scientific tools to agriculture scientist to better support their clients (farmers) with information on the crop irrigation and fertilization, along with disease alerts.
- **For the end users.** DIATOMIC based agro applications will bring help the farmers to reduce the irrigation and fertilization, along with spaying with chemical pesticides. The direct results of this reduction will be not only the crop cost reduction, even most important the reduction in the environment and the citizens helth
- **For DIATOMIC consortium.** The DIATOMIC consortium will study the possibility of commercializing the closed solution as a result from this testbed experiment, offering a ready to use kit for end users that need the use of a healthcare platform. Especially the questionnaire that examines the user experience will be useful and will contribute to do the right changes in the system and make it easier to use and more useful. Feedback from the farmers related to reduction of costs for natural and human resources, use of fertilizers and related costs will be used to have realistic estimation of contribution of the system to agricultural production.

#### 6.1.2 eHealth Application Experiment

On the eHealth experiment, apart from taking advantage of MySignals and let the users know about this cost-effective an efficient technology, the benefits will be:



- **For solution developers.** The DIATOMIC experimentation platform offers extremely rapid solution development enabling them a) to select among a large set of different health sensors from the Lib catalogue and sensors from other manufacturers supported by VFK and eVida b) to easily process the data exploiting the VFK services and SDK for combining them towards development of cloud based applications and c) easily complete their application prototyping without having to care about user management and easy integration of 3<sup>rd</sup> party sources.
- **For end users.** DIATOMIC based applications will bring reduced expenses for adopting technological solutions, and more integrated and interoperable solutions. For society, DIATOMIC will bring sustainable care and cure services, better quality of service.
- **For DIATOMIC consortium.** The DIATOMIC consortium will study the possibility of commercializing the closed solution as a result from this testbed experiment, offering a ready to use kit for end users that need the use of a healthcare platform. For this, Libelium has a dedicated platform called “The IoT Marketplace”, where it offers different IoT solutions on several vertical and horizontal applications.

### 6.1.3 Manufacturing Application Experiment

Within the DIATOMIC project, the CPPS application experiment will allow the first group of SMEs to extend the PUSH experiment using the open calls for the realisation of their business ideas, by extending the versatility of the CPPS. IPA is looking forward to various ideas that can be expected to be generated throughout the open calls:

- **Extension of Demonstrator Tools:** Similar to the tools provided by IPA, SMEs may develop tools for utilizing the CPPS PUSH experiment.
- **Extensions as Hardware Provider:** SMEs may act as hardware providers by supplying further 3D printers or 3D scanners to the manufacturing network and on-line rent them as a service.
- **Extension to other production processes:** SMEs may extend the printing service towards a different production process (CNC based processes such as milling, drilling, or lathing come to mind).

The second group of SMEs will be able to visit the CPPS demonstrator and gain knowledge on the modern production processes that CPPS enable.

Finally, the third group of SMEs will be able to:

- **Use CPPS as end-users:** SMEs will be able to use the demonstrator for the realization of their business ideas. For example, they may use services provided by the CPPS demonstrator and based on their prototypes to print their CAD-designed products.
- **Extension as Service Provider:** SMEs will be able to implement additional services on the CPPS platform. An example for this might be 3D-scanning of body parts for the personalized production of customized, ergonomic equipment, and tools or sports equipment.

## 6.2 Expected indirect experiments exploitation

Beyond direct exploitation of the experiments results, a significant indirect exploitation will come from the data that will be measured during the PUSH experiments. These experiments will origin significant volumes of data and information, as sensors will be measuring constantly different parameters and will send them to the cloud platforms for their visualization. Huge amount of data will be created in the end of the experiment thanks to the multiple devices that will serve as source. It is planned that data measured from the DIATOMIC PUSH experiments will become available as part of Open Data platforms, enabling other SMEs, System Integrators and users that do not participate directly to the DIATOMIC open calls to gain access, develop and validate new AME and IoT solutions.

As such data measure from the SynField nodes and georeferenced vegetation indices obtained by Plant-O-Meter may be used by Farm Management Application developers and Big Data analysts, who may get

significant insights. The results could be used in a scientific research and potentially lead to discovering new relations to end of season yield with the help of advanced Big Data analysis techniques. This will open possibility to introduce new services to the system.

Regarding the exploitation of ehealth experiments, one of the main goals is that they will generate data that other entities may decide to use for validation of their own developments. To achieve that goal, Libelium will have sufficient MySignals units available at disposal of developers which will be lent as test devices, so that users can work with them, measure data and apply their own IoT solutions.

It is important to note that all data will be collected, stored and shared meeting all required ethical requirements and following the procedures described in DIATOMIC Deliverables D7.1[4] and D7.2 [5].



## 7 Conclusions

This deliverable presents the DIATOMIC background tools and platforms and the foreseen integrated reference framework. Its main objective is to define on a clear and detailed way the guidelines that must be followed, and serve as a guide in order to ease the future development and integration among platforms.

This means also that the project reference framework and the corresponding planning of activities will be progressively refined throughout the duration of DIATOMIC, as the development activities will deploy the technical achievements. This deliverable will be therefore kept updated in order to remark the state of advancement.

It is important to underline, that all the platforms used on the PUSH Experiments will be flexible and modular, following open APIs: this means that they will be useful for developers both independently or through different combinations in order to develop and evaluate their own applications. This flexibility and modularity gives the potential to 3<sup>rd</sup> parties independently, collaboratively or even in collaboration with the DIATOMIC consortium to commercialize solutions developed through the DIATOMIC experiments and based on the DIATOMIC platforms, initiating further collaborations and keeping the partnership well after the DIATOMIC lifecycle.

Another great motivation that increases the DIATOMIC PUSH experiments significance is that experiment results will remain available both as technologies and as open data to participants from the Open calls, during the at the DIATOMIC PULL experiments, further accelerating development and integration of AME devices and applications.

## 8 References

- [1] Swagger, <https://swagger.io/>
- [2] Synelixis SynField, <http://www.synelixis.com/products/prod-synfield/>
- [3] <http://publications.jrc.ec.europa.eu/repository/bitstream/JRC93431/jrc93431.pdf>
- [4] DIATOMIC D7.1 “GEN - Ethics Requirements No 1,” September 2017
- [5] DIATOMIC D7.2 “H- Ethics Requirements No 2,” September 2017

## 9 Appendix I – Catalogue of Sensors

### 9.1 MySignals Sensors

The MySignals subsystem integrates the following sensors:

#### 9.1.1 Pulse and Oxygen in Blood

The pulse oxymetry is a noninvasive method of indicating the arterial oxygen saturation of functional hemoglobin. Oxygen saturation is defined as the measurement of the amount of oxygen dissolved in blood, based on the detection of Hemoglobin and Deoxyhemoglobin.



A pulse oximeter sensor is useful in any setting where a patient's oxygenation is unstable, including intensive care, operating, recovery, emergency and hospital ward settings, pilots in unpressurized aircraft, for assessment of any patient's oxygenation, and determining the effectiveness of or need for supplemental oxygen.

| Parameter | Unit | Range      |
|-----------|------|------------|
| Pulse     | Ppm  | 25~250 ppm |
| SPO2      | %    | 35-100 %   |

#### 9.1.2 ECG

The Electrocardiogram Sensor (ECG) is one of the most commonly used medical tests in modern medicine. It is a diagnostic tool that is routinely used to assess the electrical and muscular functions of the heart.



| Parameter                | Unit                   | Range     |
|--------------------------|------------------------|-----------|
| Pulse rate               | BPM (Beats per minute) | 0-200 bpm |
| Electrocardiogram Signal | Volts                  | 0-5 V     |

### 9.1.3 Airflow

Anormal respiratory rates and changes in respiratory rate are a broad indicator of major physiological instability, and in many cases, respiratory rate is one of the earliest indicators of this instability.

The nasal / mouth airflow sensor is a device used to measure the breathing rate in a patient in need of respiratory help or person. This device consists of a flexible thread which fits behind the ears, and a set of two prongs which are placed in the nostrils. Breathing is measured by these prongs.



| Parameter           | Unit                   | Range    |
|---------------------|------------------------|----------|
| Respiratory rate    | PPM (Peaks per minute) | 0-60 ppm |
| Breathing intensity | Volts                  | 0-3,3 V  |

### 9.1.4 Blood Pressure Monitor

Blood pressure is the pressure of the blood in the arteries as it is pumped around the body by the heart. Monitoring blood pressure at home is important for many people, especially if you have high blood pressure. It is available in both BLE and wired versions.



| Parameter          | Unit  | Range      |
|--------------------|-------|------------|
| Systolic pressure  | Mm Hg | 0-300 mmHg |
| Diastolic pressure | Mm Hg | 0-300 mmHg |
| Pulse              | Ppm   | 30~200 ppm |

### 9.1.5 Glucometer

Glucometer is a medical device for determining the Approximate concentration of glucose in the blood. A small drop of blood, obtained by pricking the skin with a lancet, is placed on a disposable test strip that the meter reads and uses to calculate the blood glucose level. The meter then displays the level in mg/dl or mmol/l. It is available in both BLE and wired versions.



### 9.1.6 Body Temperature

It is of great medical importance to measure body temperature. The reason is that a number of diseases are accompanied by characteristic changes in body temperature. Likewise, the course of certain diseases can be monitored by measuring body temperature, and the efficiency of a treatment initiated can be evaluated by the physician. It is available in both BLE and wired versions.



| Parameter   | Unit                | Range   |
|-------------|---------------------|---------|
| Temperature | Degree Celsius (°C) | 0-50 °C |

### 9.1.7 EMG

Electromyography (EMG) is an electrodiagnostic medicine technique for evaluating and recording the electrical activity produced by skeletal muscles. EMG is used as a diagnostics tool for identifying neuromuscular diseases, or as a research tool for studying kinesiology, and disorders of motor control.



An electromyograph detects the electrical potential generated by muscle cells when these cells are electrically or neurologically activated.

| Parameter     | Unit                          | Range    |
|---------------|-------------------------------|----------|
| Muscle rate   | CPM (contractions per minute) | 0-60 cpm |
| Muscle signal | Volts                         | 0-5 V    |

### 9.1.8 Spirometer

Spirometry (meaning the measuring of breath) is the most common of the pulmonary function tests (PFTs), measuring lung function, specifically the amount (volume) and/or speed (flow) of air that can be inhaled and exhaled.



| Parameter | Unit  | Range             |
|-----------|-------|-------------------|
| Volume    | L     | 0,01L ~ 999L      |
| Air flow  | L/min | 50L/min ~900L/min |

### 9.1.9 GSR

Skin conductance, also known as galvanic skin response (GSR) is a method of measuring the electrical conductance of the skin, which varies with its moisture level. This is of interest because the sweat glands are controlled by the sympathetic nervous system, so moments of strong emotion, change the electrical resistance of the skin. In skin conductance response method, conductivity of skin is measured at fingers of the palm.



| Parameter   | Unit    | Range         |
|-------------|---------|---------------|
| Conductance | Siemens | 0-20 Siemens  |
| Resistance  | Ohms    | 10K-100K Ohms |
| Voltage     | Volts   | 0-5 V         |

### 9.1.10 Body Position

Positions and movements made because of their relationships to particular diseases. Analyzing movements during sleep also helps in determining sleep quality and irregular sleeping patterns. The Patient Position Sensor monitors five different patient positions (standing/ sitting, supine, prone, left and right.)





| Parameter     | Unit                | Range                 |
|---------------|---------------------|-----------------------|
| Body Position | Human Body Position | 5 different positions |

### 9.1.11 Snore

This sensor attaches to the neck and records vibration. The sensor converts snoring, and other sounds in the audio range picked up through the skin, to a small analog voltage that provides a clear, reliable indication of the presence of these sounds



| Parameter    | Unit                   | Range    |
|--------------|------------------------|----------|
| Snore rate   | SPM (Snore per minute) | 0-60 spm |
| Snore signal | Volts                  | 0-5 V    |

### 9.1.12 Body Scale

Weighing scales (or weigh scales or scales) are devices to measure weight or calculate mass. This bathroom scale uses a BLE connection to sync your weight, BMI, and body fat readings with your personal health dashboard.



| Parameter | Unit       | Range    |
|-----------|------------|----------|
| Weight    | Kilograms  | 0-60 spm |
| Bone      | Percentage | 0-100 %  |

|              |            |            |
|--------------|------------|------------|
| Body fat     | Percentage | 0-100 %    |
| Muscle mass  | Percentage | 0-100 %    |
| Body water   | Percentage | 0-100 %    |
| Visceral fat | Percentage | 0-100 %    |
| BMI          | Kcal       | 0-500 kcal |
| BMR          | Kcal       | 0-500 kcal |

### 9.1.13 Pulse and Oxygen in Blood SPO2

Pulse oximetry a noninvasive method of indicating the arterial oxygen saturation of functional hemoglobin. Oxygen saturation is defined as the measurement of the amount of oxygen dissolved in blood, based on the detection of Hemoglobin and Deoxyhemoglobin.



| Parameter | Unit | Range      |
|-----------|------|------------|
| Pulse     | Ppm  | 25~250 ppm |
| SPO2      | %    | 35-100 %   |

### 9.1.14 Alarm Button (BLE)

Emergencies can happen at any time and anywhere in your house. The alert button provides immediate access to assistance with just the touch of the button. This call button can be worn as a help pendant around your neck or as an alert watch button around your wrist.



## 9.2 SynField Sensors

The SynField subsystem integrates the following sensors:

### 9.2.1 Weather Station

SynField integrates the Davis Vantage Pro 2 which offers:

- Anemometer (Wind speed/direction)
- Rain collector
- Temperature/humidity sensors



| Parameter      | Unit             | Range               |
|----------------|------------------|---------------------|
| Wind Direction | degree           | 0 to 359            |
| Wind Speed     | Beaufort<br>Km/h | 0 to 10<br>1 to 320 |
| Rain Meter     | mm               | 0 to 50             |
| Temperature    | Celsius          | -40 to +65          |

### 9.2.2 Soil Moisture Sensor

SynField integrates the Decagon EC-5 sensor, which offers:

- Soil Moisture sensor
- Cable length 5m

The EC-5 determines volumetric water content (VWC) by measuring the dielectric constant of the media using capacitance/frequency domain technology.



| Parameter     | Unit | Range    |
|---------------|------|----------|
| Soil Moisture | %    | 0 to 100 |
| Accuracy      | %    | ± 2      |

### 9.2.3 Soil Electrical Conductivity

The SynField integrates the Decagon 5TE sensor, which offers:

- Water content
- Electrical conductivity
- Soil humidity
- Cable length 5m

The 5TE enables users to measure the EC response to salts and fertilizers in the soil. EC Measurements require good contact between the stainless steel electrodes on the sensor, and the soil.



| Parameter                        | Unit    | Range      |
|----------------------------------|---------|------------|
| Soil Volumetric Water Content    | %       | 0 to 90    |
| Soil Volumetric Water Accuracy   | %       | ± 3        |
| Temperature Range                | Celsius | -40 to +60 |
| Temperature Resolution           | Celsius | 0.1        |
| Temperature Accuracy             | Celsius | ± 2        |
| Electrical Conductivity Range    | dS/m    | 0 to 23    |
| Electrical Conductivity          | dS/m    | 0 to 7     |
| Electrical Conductivity Accuracy | %       | ± 10       |

### 9.2.4 Leaf Wetness Sensor

SynField integrates the Decagon's Leaf Wetness Sensor, which is designed to detect wetness (presence and duration) and ice formation right out of the box.



| Parameter    | Unit | Range                                 |
|--------------|------|---------------------------------------|
| Leaf Wetness | %    | 0 (completely dry)<br>100 (saturated) |

### 9.2.5 Pyranometer/UV Sensor

SynField integrates the Davis 6450 Solar Radiation Sensor. It measures global radiation, the sum at the point of measurement of both the direct and diffuse components of solar irradiance.



| Parameter | Unit             | Range     |
|-----------|------------------|-----------|
| Radiation | W/m <sup>2</sup> | 0 to 1800 |
| Accuracy  | %                | ±5        |

### 9.2.6 Water Pressure

This sensor is able to measure the liquid/water pressure, so that it may detect leakages at the water network/pipes.



| Parameter      | Unit | Range |
|----------------|------|-------|
| Water Pressure | Atm  | 0-5   |

## 10 Appendix II – Developing applications for eVida platform

This appendix provides information on the required steps to create an application using the eVida Platform

### 10.1 Preparatory Steps

#### 10.1.1 Create a new account on the eVida platform

The first step of this workshop aims to create an user account on the eVida platform. Go to <https://www.evida.pt> and register an account. As a logged user you can access the platform's web store.

By default, when a user access for the first time to the platform, the account is set to as a developer account. In this workshop we intend to develop an application, so we need to have a developer account. Log in, go to "**Settings**" in the sidebar, then "**Developer Settings**" and toggle the option "**Connect this account to a developer account**" to **\*\*\*"Yes"\*\*\***.

#### 10.1.2 Obtaining the skeleton of a packaged application

In this step you will download the skeleton code of the application to be developed. You can find this code in exercises/Skeleton folder on <https://github.com/evida/global-health-workshop>.

#### 10.1.3 Application configuration

Packaged apps need to have a properly configured config.xml file, which is a manifest file that contains a set of important information about the application.

There, you can change the application name, its dimensions and other fields like author, description, logo, etc:

```
<?xml version="1.0" encoding="utf-8"?> <widget xmlns="http://www.w3.org/ns/widgets"
id="http://widgets.tice.ipn.pt/<unique_id>" version="1.0.0">
  <name>Global Health Demo App</name>
  <description xml:lang="en">Check out your progress.</description>
  <description xml:lang="pt">Acompanhe a sua evolução.</description>
  <content src="index.html" />
  <author>Diogo Lucas, Miguel Oliveira, Nuno Rebelo</author>
  <icon src="styles/images/getfit.jpg" /> </widget>
```

As a first step, define the application's ID, following the format:

```
http://widgets.tice.ipn.pt/<unique_id>
```

where the <unique\_id> should be replaced by a unique identification of your application. This id will be used by eVida to identify your app, which will have the url: [https://www.evida.pt/app/<unique\\_id>](https://www.evida.pt/app/<unique_id>).

For the purpose of this workshop, we suggest you to replace the suffix <unique\_id> with your username, so we assure that this ID will be unique. You can also change too the fields name and description.

#### 10.1.4 User authorization

In this step, we aim to authenticate with the eVida platform using OAuth2, so further we can get information about a logged user.



To perform the OAuth2 flow, we first need a Consumer Key, which identifies your application. It should be generated in the "Developer" section (sidebar), "API access" tab.

Once you are there, click **\*\*\*"Create another Oauth Consumer"\*\*\***, fill the form, submit it, and you'll be given a "Consumer Key" and **\*\*\*"Consumer Secret"\*\*\***. The field Redirection URI may be left blank.

Now, in your code, go to /src/views/home\_view.js and complete the code below, by replacing <consumer\_key> with the previously generated Consumer Key.

```
requestOAuth: function(){
    oauth.setScope('user');
    //Consumer Key
    oauth.setClientID('<consumer_key>');
    oauth.requestToken(this, '#oauth_btn');
    $('#my_modal').hide();
}
```

Note that the scope was set to user, which will tell the platform we are asking the user for permissions to access its data.

### 10.1.5 Obtaining eVida's logged user information

In the previous step we completed the OAuth flow that asks the user for permission for the app to access its information.

Now, lets see get the actual information.

Check the file /src/views/home\_view.js for the function:

```
requestUser: function(){
    var self = this;
    oauth.requestUser(this.token, function(response){
        self.user = response.user;
    });
}
```

It uses the API that can be found in the file /src/utls/oauth.js. It requires the request to be authenticated with the oauth token, once it contains user private data.

Once we've obtained the user information, we can now manipulate the view.

```
requestUser: function(token, successFunction){
    $.ajax({
        url: "<users_api_url>",
        dataType: "jsonp",
        data:{
            bearer_token: token
        },
        success: successFunction
    });
}
```

You should replace the field <users\_api\_url> by the url to the eVida user's API, which is <https://api.evida.pt/users>.

Now go back to /src/views/home\_view.js. The object response contains the information from the user using the application. It is possible to get its username with user.username.

```
self.user = response.user;
```

Create an alert that shows the username when the application starts.

After this step, we'll submit the application in the eVida platform for the first time, by creating a widget that follows the Widgets 1.0 W3C specification.

1. zip compress all your application files in your root directory (not the directory itself, its content)
2. change the extension from .zip to .wgt
3. Go to eVida, access the Developer area and click Create an app
4. Click New Packaged App
5. Upload your .wgt

Your app will now be available in your "Developer" area, under the "Developed by you" tab.

All going well, when you access your app, it will ask for your authorisation to access your own data and display an alert with your username.

## 10.2 Application development

### 10.2.1 Styles

The look of your application is always very important. In case you want to match it with the portal's we can provide you the proper css to achieve it.

It was developed a theme, based in the widely known Twitter Bootstrap, that you can access on <https://evida.pt/css/apps/assets/bootstrap-v0.6.1.css>.

In index.html you should replace <css\_url> with the proper url

```
<head>
  <meta charset="utf-8">
  <title>Get Fit</title>
  <link rel="stylesheet" href="<css_url>">
  <link rel="stylesheet" href="styles/my.css">
  <script data-main="main.js" src="libs/require-jquery.js"></script>
</head>
```

Now resubmit the application and you'll be able to notice changes.

### 10.2.2 API Javascript interaction

In this step the aim is to interact with the platform's JavaScript APIs.

As an example, we'll be interacting with eVida to get the language is viewing the website in.

The user can choose the language by accessing `***"Settings"***`.

The file `/src/utills/i18n.js` contains the function `setLocale` which checks for the user language and defines the proper text to display.

```
setLocale: function(){
  var self = this;
  //TODO: call the Javascript API method to get locale
  $c().services("<api_method>", {}, function(args) {
    self.locale = args[0];
    if (self.locale=='pt'){
```

```
self.successOAuth = "<b>Sucesso!</b> Autenticação  
finalizada.</b>";  
    $('h1').text("Gráfico de medições");  
    $('p').text("Distância e calorias ao longo do tempo.");  
    } else {  
        self.setDefault();  
    };  
});  
}
```

You should replace `<api_method>` with the correct API method, which can be found in the documentation page: <https://developer.evida.pt/js-api/template.html#widget-properties-api/en>.

After that, you can resubmit the app and check how it now follows user set language.

### 10.2.3 PHR integration

To finish, we will integrate our application with another eVida application, called GenericEntity. This last application provides a PHR (Personal Health Record) that allows the user to store its clinical data. In this exercise, we will create a chart that contains all records about bicycle physical exercise.

At this point, we don't have any records, so we need to access to GenericEntity application through the eVida portal and insert some data.

Through the portal web store, select the "Generic Entity" application, and access to the menu "Measurements" and to submenu \*\*\*\*"Bicycle Exercise"\*\*\*\*. You can insert, for example, three records.

Now, we will handle these measurements in our application chart. In the file `/src/utils/chart.js` you can find the `loadGraph` function that receives an URL and draws the desired chart properly. This function is called through the file `/src/views/home_view.js`:

```
initialize: function(){  
    i18n.setDefault();  
    this.setToken( cookies.get() );  
    loadGraph("http://core.ge.evida.pt/BicycleExercise/items?apiRequest.username=insert_  
username_here&apiRequest.sidx=measurement_date");  
}
```

In the URL that is sent to the `loadGraph` function must replace the field `insert_username_here` by your username. Re-submit the application and you can visualize the graphic with the submitted measurements.

## 10.3 eVida Resources

Users API URL: <https://api.evida.pt/users>;

CSS URL: <https://evida.pt/css/apps/assets/bootstrap-v0.6.1.css> ;

OAuth2 protocol: <http://oauth.net/2/> ;

Twitter Bootstrap: <http://getbootstrap.com/>

## 11 Appendix III – The SynField API

The SynField System provide a set of REST web services so as the users can retrieve their fields, nodes and the measurements of their sensors. Furthermore, the users can access and manage their actuators as well.

**NOTE:** The format of the timestamp, included in each web service, is based to the ISO 8061. For instance, a timestamp looks like the “2017-05-25T14:24:29.125301Z”.

| Method | Endpoint  | Operation   |
|--------|---|---|
| GET    | /v1/fields  | <p>Fetch the list of fields that the user owns. Each field includes its name, its coordinates, its timezone and a list of associated Synfield devices (head and peripheral nodes). Each node contains its serial number, its coordinates, its hardware and firmware version and its name.</p> <p><b>Input:</b> None</p> <p><b>Output:</b> A list of field objects, HTTP status.</p> <p><b>Format:</b> JSON, XML</p>   |
| GET    | /v1/nodes/{sn}/sensing_services                                 | <p>Fetch the list of sensing services that the given (head or peripheral) node measures. Each sensing service includes its name, the value of the last measurement and its unit.</p> <p><b>Input:</b> The url parameter “sn” maps to the serial number of the Synfield node</p> <p><b>Output:</b> A list of sensing service objects, HTTP status.</p> <p><b>Format:</b> JSON, XML</p>   |
| GET    | /v1/nodes/{sn}/sensing_services/{sid}/measurements              | <p>Fetch the list of measurements by given sensing service of a specific Synfield device. Each measurement includes the the id of the sensing service, its value and the timestamp.</p> <p><b>Input:</b> The url parameter “sn” maps to the serial number of the Synfield node and the “sid” maps to the id of the sensing service.</p> <p><b>Output:</b> A list of measurements. Paging of measurements is available, HTTP status.</p> <p><b>Format:</b> JSON, XML</p>   |
| GET    | /v1/nodes/{sn}/sensing_services/{sid}/measurements/{start}/{to} | <p>Fetch the list of measurements by given sensing service of a specific Synfield device in the requested date range. Each measurement includes the the id of the sensing service, its value and the timestamp.</p> <p><b>Input:</b> The url parameter “sn” maps to the serial number of the Synfield node, the “sid” maps to the id of the sensing service and the “start” and “to” parameters define the date or datetime range. The format of the <b>start</b>, <b>to</b> parameters is the “YYYY-MM-DD” or “YYYY-MM-DDThh:mm:ssZ” (ISO 8061).</p> <p><b>Output:</b> A list of measurements, HTTP status. Paging of measurements is available.</p> <p><b>Format:</b> JSON, XML</p> |
| GET    | /v1/nodes/{sn}/measurements/{start}/{to}                        | <p>Fetch the list of measurements of a specific Synfield device in the requested date range. Each measurement includes the the id of the sensing service, its value and the timestamp.</p> <p><b>Input:</b> The url parameter “sn” maps to the serial number of the Synfield node, and the “start” and “to” parameters define the date or datetime range. The format of the <b>start</b>, <b>to</b> parameters is the “YYYY-MM-DD” or “YYYY-MM-DDThh:mm:ssZ” (ISO 8061).</p> <p><b>Output:</b> A list of measurements, HTTP status. Paging of measurements is available.</p> <p><b>Format:</b> JSON, XML</p>  |

|     |   |   |
|-----|---|---|
| GET | /v1/nodes/{sn}/measurements/latest          | <p>Fetch the latest measurement of each sensing service that a specific Synfield device measures.</p> <p><b>Input:</b> The url parameter “sn” maps to the serial number of the Synfield node.</p> <p><b>Output:</b> A list of measurements.</p> <p><b>Format:</b> JSON, XML</p>   |
| GET | /v1/actuators                               | <p>Fetch the list of actuators that a user has access to. Each actuator includes details such as its type, its mode (automatic or manual), its status and the associated Synfield device (head or peripheral node).</p> <p><b>Input:</b> None</p> <p><b>Output:</b> A list of actuators, HTTP status.</p> <p><b>Format:</b> JSON, XML</p>       |
| GET | /v1/nodes/{sn}/actuators                    | <p>Fetch the list of actuators by given Synfield device. Each actuator includes details such as its type, its mode (automatic or manual) and its state.</p> <p><b>Input:</b> The url parameter “sn” maps to the serial number of the Synfield node.</p> <p><b>Output:</b> A list of actuators, HTTP status.</p> <p><b>Format:</b> JSON, XML</p> |
| PUT | /v1/ actuators/{ actuator_id}/automatic     | <p>Set the mode of the given actuator as automatic.</p> <p><b>Input:</b> The url parameter “actuator_id” maps to id of the actuator.</p> <p><b>Output:</b> HTTP status.</p> <p><b>Format:</b> JSON, XML</p>   |
| PUT | /v1/ actuators/{ actuator_id}/manual        | <p>Set the mode of the given actuator as manual.</p> <p><b>Input:</b> The url parameter “actuator_id” maps to id of the actuator.</p> <p><b>Output:</b> HTTP status.</p> <p><b>Format:</b> JSON, XML</p>  |
| PUT | /v1/ actuators/{ actuator_id}/state/{state} | <p>Set the mode of the given actuator as manual.</p> <p><b>Input:</b> The url parameter “actuator_id” maps to id of the actuator and the “state” maps to the desired state of actuator.</p> <p><b>Output:</b> HTTP status.</p> <p><b>Format:</b> JSON, XML</p>  |