SELFSUSTAINED CROSS-BORDER CUSTOMIZED
CYBERPHYSICAL SYSTEM EXPERIMENTS
FOR CAPACITY BUILDING AMONG EUROPEAN STAKEHOLDERS

EPTATHLON
A robotic system for soil laboratory testing

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SCIENTACT BG LTD

SCIENTACT BG LTD, has a big experience in the design, assembly and installation of automatic and unattended monitoring and analysis systems. Decades of such systems are installed on rivers and lakes. The systems measure automatically electrochemical and physical parameters and are equipped with automatic systems for sampling, cleaning and reporting processes. Similar system has been designed and installed for application in the air quality monitoring. Most of the systems are innovative design by the company's staff.

SCIENTACT BG LTD, having long experience in the diagnostic tools of the agri-food sector and cooperating with EU SMEs in the use and management of relevant tools, **wants to be active in the field of soil analyzers**, looking for specialization and technology transfer from specialized partners

Soil Science Laboratory (SSLab) – Univ. of Patras

UPATRAS is one of the leading research and teaching institutions, and the fourth largest in Greece, constantly aiming for excellence through the creation, utilization, transfer and application of knowledge. The Soil Science Laboratory (**SSLab**) is part of the Dept. of Agriculture of the University of Patras. Also is **member of the Global Soil Laboratory Network (GLOSOLAN)** which was officially established within the framework of the Global Soil Stakeholder (GSP) Initiative at the United Nations Food and Agriculture Organization (FAO) **and plays a regional key role in promoting and networking Soil Science** and implementation of the Thematic Strategy (COM(2006)231 adopted by the Commission.

The Laboratory of Soils is leading or has participated in many National or European co-funded projects, thus a **concrete experience in project management and transnational cooperation** has been established (ETCP GR-IT 2007-2013 IRMA project, FP7 EUROLEGUME, AGROTRACE, SOILSYS, HYDRERO, OPORA, ETCP GR-IT 2014-2020 TAGs, IR2MA project etc.). Adopting a multidisciplinary Soil Science approach with artificial intelligence, computer vision, sensor networks, and robotics, **is steering farmers to integrate and leverage data to improve and manage their farm under soil sustainable practices**.

Interaction between partners

The partnership **is based on their expertise**, as well as on their role as core players in the development of innovative solutions for soil testing.

They own the equipment and special knowledge in order to develop a fully customizable robotic analyzer to match the project goals.

This strategic partnership is also motivated **by the will of both parties** to focus on the design and development of the **EPTATHLON** solution **as a product** while boosting the opportunities for future projects and markets.

What is the problem?

Until today, soil analyzes are done manually, a process that required financial resources but also time and staff.

The automation of the soil testing process will reduce testing time for many analyzes from days to minutes.

Robotic systems can change the character of the soil nutrients testing lab by allowing significant increasing in the numbers of samples that could be processed.

Samples used in the analyzers include, but are not limited to, soil extractants for essential plant nutrients such as nitrates, phosphates, ammonium, boron, potassium, sodium and other fluids from within the plant or soil matrix.

What is the agricultural testing market ?

Agricultural Testing Market[1] **was worth USD 5326 million in 2020** and estimated to be growing at a CAGR of 5.96%, to **reach USD 7114 million by 2026**. Agriculture Testing Market can be characterized as the testing of different samples including water, **soil**, seed, and so forth, to decide quality and contaminant content.

The market for soil testing projected to be the 2nd fastest-growing segment during the end of 2022.

The growing contamination of soil, has been propelling the importance of soil testing and drives the market, with spectroscopy technologies recognized as the most innovative.

[1]**Based on www.marketdataforecast.com "Agricultural Testing Market - By Sample Type (Soil, Water, Seed, Bio-solids, Manures And Others)" - Global Industry Analysis, Size, Share, Growth, Trends, And Forecast To 2026**

The cooperation

SCIENTACT BG LTD is specialized in CPS and IoT systems with **experience in the agri-food sector** but **lacking knowledge in protocols of soil analysis** and **spectroscopy,** know-how that offered from research partner. SCIENTACT BG LTD provided its experience to the automation of the soil lab processes by using a robotic system.

On the other hand, the deep knowledge of the University of Patras on soil sample testing and soil management protocols **created a modern and complete project implementation environment**.

SCIENTACT BG LTD sees the collaboration with the University of Patras **as a long-term relation**, from which will receive and give added value, trying to be business active in the field of soil robotic analyzers.

The University of Patras (SSLab) aims to take advantage of the collaboration by **increasing the quality and efficiency of tests**, while reducing the cost and the environmental footprint of the related services, due to reduction of the used reagents with a covid19-free solution.

SSLab after KTE will offer better services in the field of soil testing automation with the use of smart robotic system knowledge get from SCIENTACT BG LTD.

The workplan

The workplan adopted a sequential design and knowledge transfer process as well as discrete horizontal tasks for continuous collaboration with the S4All consortium and communication activities

	WEEK											
	1	2	3	4	5	6	7	8	9	10	11	12
P1, Week 1-3 : Collaboration with the S4All Consortium												
P2, Week 4 : Knowledge transfer design and KPIs												
P3, Week 1-12: Implementation and execution of knowledge transfer - Interim Report												
P4, Week 5 : 1st demonstration of the results of the project												
P5, Week 10 : 2nd demonstration of the results of the project												
P6, Week 1-12 : Communication plan activities												
P7, Week 10-12: Final Report												

Materials and methods - Hardware

Random access robotic analyzer

SAMPLING ARM
1 sampling needle,110 mm needle stroke
Capacitive liquid level detector
Needle shock sensor
DILUTER SYRINGE
Long life plunger
Syringe capacity, 368 µl
Syringe resolution, 0.14 µl
HYDRAULIC SYSTEM
8 self-priming peristaltic pumps (life 1000 hrs) with replaceable neoprene cassette (life 500 hrs)

WASH STATION Needles: 6 dispensing, 6 aspiration, 1 cleaning (8 step washing sequence for each cuvette)
REAGENTS TRAY Removable rack, 30 bottles, 50 ml or 24 ml (up to 1500 ml total)
SAMPLES TRAY Removable tray, 60 numbered positions,
CUVETTE ROTOR
REACTION CELLS, 80 washable BIONEX® cuvettes which allow up to 30 000 tests per rotor
OPTICAL GROUP
PHOTOAMPLIFIER photoelectric detector, Signal amplifier
Response range, 340 nm to 900 nm, Photometric range, 0 to 2.5 Abs, Linearity, ±0.5% full scale
CONTROL Real-time multitasking microprocessor based control

Materials and methods - Software

SAM, continued

(1) (1a)

Touch select any tray position to display color coded information panels;

Remove from tray | Inspect

Commands to remove a sample or display the "SAMPLE INSPECTION" work form

(2)

List of samples with no assigned tray positions; Activate any item and touch-select a tray position to place that item

Place all (3)

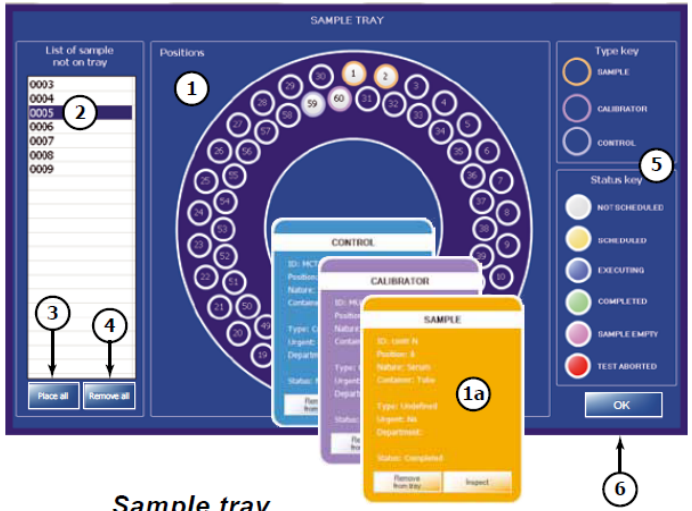
Auto placement of samples listed to any empty tray positions

Remove all (4)

Remove all samples from the tray

8 This work form shows the positions assigned to urgencies, samples, calibrators and controls, with the color coded status of each.
It can be displayed by pressing **"Sample tray"**.

Sample tray



Sample tray

This effective management tool makes it is possible to remove or place samples, and monitor type, location and status of tests displayed.

(5)

Color coded key permits identification of the position of samples/urgencies/ calibrators/controls, and the status* of each in the testing process

Code examples

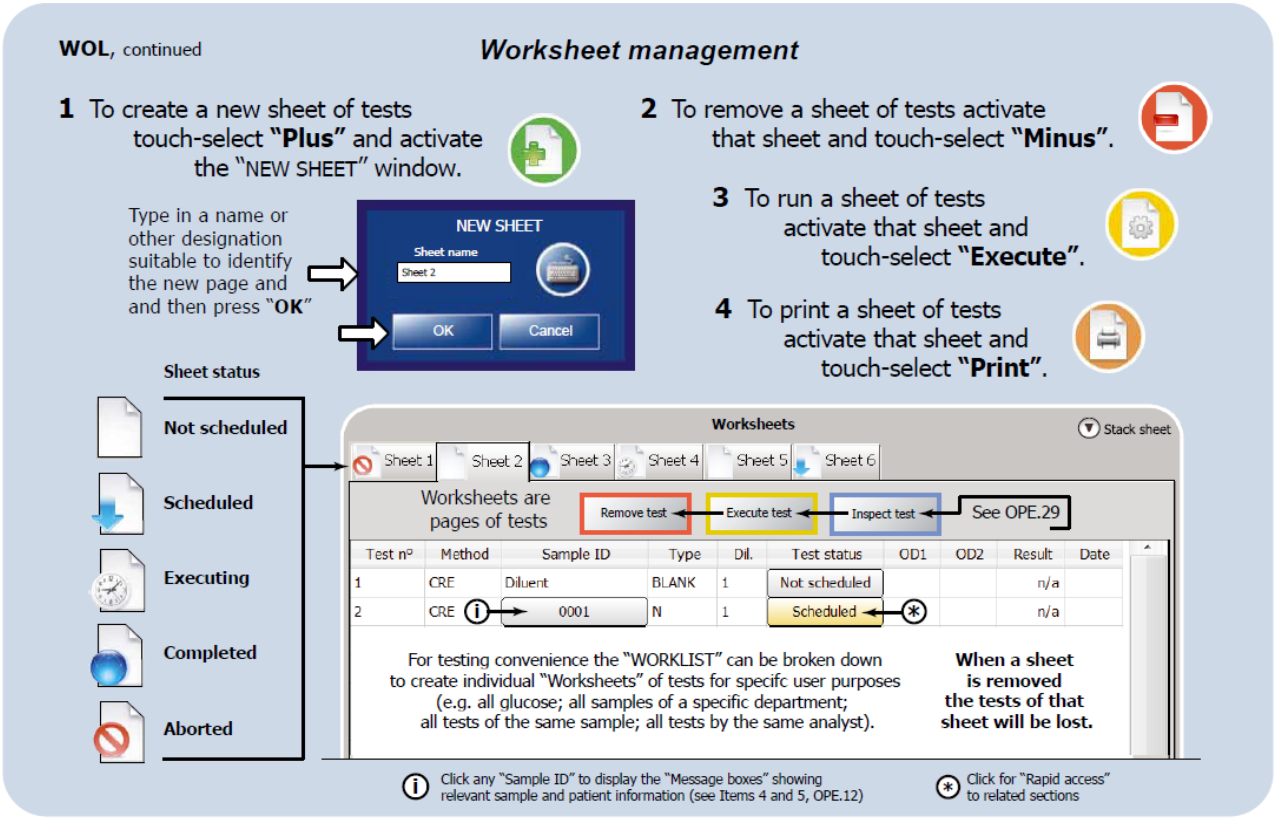
SAMPLE (orange ring)
+
COMPLETED (green center)
=
SAMPLE COMPLETED (orange and green)

* see descriptions of "Sample status", OPE.20

(6)

Exit
"SAMPLE TRAY" work form

Materials and methods



Method - KPIs

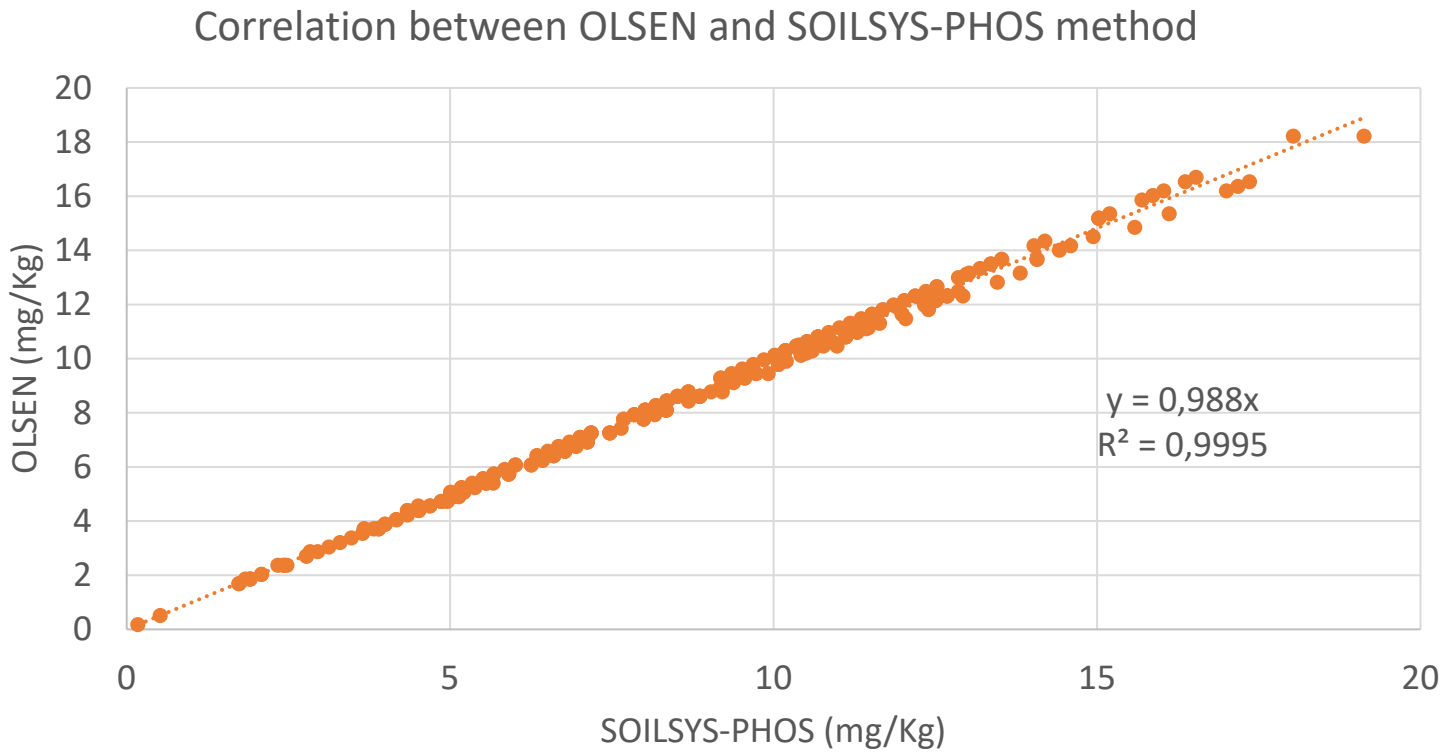
Soil testing method according to Olsen (*Page et al., 1982*) was modified using a small volume of reagents and soil sample extract using sodium bicarbonate ($NaHCO_3$)

Page, A.L., R.H. Miller and D.R. Buxton. (eds.). 1982. Methods of soil analysis, Part 2. Chemical and microbiological properties. Agronomy 9. 2nd edition. Am. Soc. of Agronomy, Inc. Madison, Wi.

KPIs

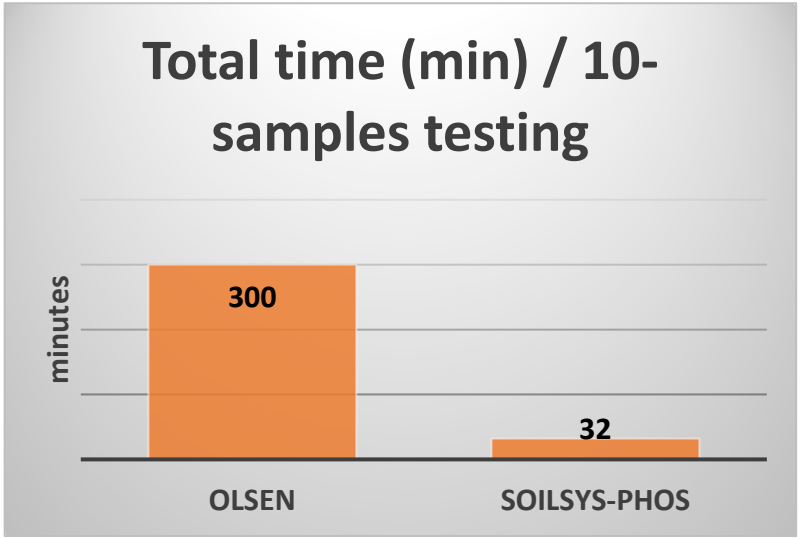
Sample and Reagent Volume		EPTATHLON	STAFF
Solution	Reagent Name (Code)	Volume (µL)	Volume (µL)
Sample		300	5000
REAGENT 1	R1 Phosphate-SL	40	5600
REAGENT 2	R2 Phosphate-SL	17	2400
REAGENT 3			
REAGENT 4			
Spike			
Diluent	WATER	0	37000

Results - Validation



Results - KPIs

	STAFF	EPTATHLON
	OLSEN	SOILSYS-PHOS
Process	Time	
Reagents' preparation	3 hours	-*
Calibration	45 min	30 min
Quality control	5 min	11 sec
10-Samples testing	50 min	110 sec
10-Samples calculations	20 min	
Total time (min)	300	32



* Ready to use reagents

Results

The EPTATHLON project gave the opportunity to design and implement a different process in soil testing.

Both the partners were collaborated to build a total solution (process) that solve the important business problem of soil analysis automation and delivered the required integration of such a state-of-the-art solution

SSLab took advantage of the collaboration by increasing the quality and efficiency of tests, while reducing the cost and environmental footprint of the related services, due to reduction of the used reagents with a covid19-free solution.

Results

SSLab, the day after KTE, will offer better services in the field of soil testing automation with the use of smart robotic system knowledge get from SCIENTACT.

SCIENTACT sees the collaboration with the University of Patras as **a long-term relation**, from which will receive and give added value, trying to be business active **in the field of soil robotic analyzers.**

Comparison of the new SOLSYS-PHOS robotic methodology with the Olsen phosphorus soil testing according to OLSEN showed a high linear correlation (R^2=0.99, $p<0.05$).

The proposed modified method may contribute to a faster assessment of the phosphate fertilization required by crops with a view to optimal soil management, protection and improvement of soil health

Results

The new robotic method can be adopted by Soil Testing Laboratories in the European Market with two main advantages:

- ✓ *The reducing of the final 10-soil samples testing result time about 90% with the use of the automatic robotic system and the modified methodology in conjunction with an appropriate LIS.*
- ✓ *The use of small volumes of samples and reagents resulting to a lower environmental footprint and the lowering of the reagents costs.*

*In case of the development and merchandizing of the product, the customer target group for **Scientact BG LTD** can be increased in a European or a Global level, showing a high perspective for high annual growth rate.*

Thank you for your attention!!

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UNIVERSITY OF PATRAS