FINAL REPORT

Water Network Sensors for Widespread Use

605802

WIDESENS

Water Network Sensors for Widespread Use

FP7-SME-2013

Final report

Period covered: from 1st Sept 2013 to 29th February 2016 (30 Months)

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http://www.widesens-project.eu/

Participant no.	Participant organisation name	Participant short name	Type of participant	Country
1 (coordinator)	Wellness Telecom	WTELECOM	SME	ES
2	T.E Laboratories Ltd	TELLAB	SME	IR
3	Hydrelis	HYDRELIS	SME	FR
4	CSIC- Consejo Superior de Investigaciones Científicas	CSIC	Research Institute	ES
5	National Institute of Research and Development for Mechatronics and Measurement Techniques	INCDMTM	Research Institute	RO

1. Final publishable summary

1.1. Executive summary

The main objective of the **WIDESENS** Project is to develop, implement and test a novel multiparametric analytical probe based on unconventional sensors that will be economically viable for widespread use in water networks. The **WIDESENS** probe shall measure pH, conductivity, bio-fouling, redox-potential and chlorine, for the evaluation of the water quality, and pressure, for the evaluation of the quality of the service and leak detection. Furthermore we will the telecommunications system and the processing and data acquisition software.

The project will last 30 months starting in September 2013.

WP3. Sensors R&D. Design and fabrication of sensor devices.
The fabrication of devices and their initial characterization has been completed. They have been fabricated in the Clean room of the IMB-CNM according to standard microelectronic technologies. 1) ISFETs & REFET for pH 2)Interdigitated electrodes & 4-bar electrodes for conductivity & fouling 3)Pt microelectrode for ORP 4)Au microelectrodes for Chlorine 5)Reference electrode.

All these devices have been fabricated and encapsulated on a multi-sensor PCB and have been evaluated in lab & field according to ISO 15839 specifications. The results in the lab demonstrated that sensors accomplish the required specifications of measurement.

Parameter	Conc. range. Expected/obtained	Limit of detection Expected/obtained	Precision (repeatability)* Expected/obtained
pH	pH 4,5-10,5/idem	na	5% /3,7% pH 7 and 1,4% pH 9.
Conductivity	0-3.000 µS/cm**	50 µS/cm / 4.5 µS/cm	5%/ <1% for 600 µS/cm and 2400 µS/cm
Chlorine Free	0-5 mg/l/idem	0.01 mg/l/0.06 mg/l	10%/ 3% 4 ppm and 5% 1 ppm
ORP	100-300 mV/idem	na	10%/< 1% for 200 mV

*Precision (=100*repeatability average/analyte conc.)

Two versions of the final multi-sensor PCB have been developed. Version 1: 25 mm wide, 60 mm long and 1.5 mm thick. Version 2: 19 mm wide, 60 mm long and 2mm thick.

Probe´s body, mechanics, electronics & software. INCDMTM has developed 3 prototypes for the body and housing: 1) "Insertion version" for pipes of large dimensions, 2) "Mini version" for pipes of small dimensions, 3) Polycarbonate "by pass version" for compatibility with analytical panels. The original objective of self-calibration was abandoned as the first designs were too sophisticated and did not accomplish the objectives of the project (low energy, low cost, long maintenance).

Telecommunications module (hardware and software) with different communications options (wired & wireless) so it can get adapted to different situations

Field Validation Results. The field validation was carried out in the water network of the water utility EMALCSA in Spain. It was taken up to the end date of the project. It was validated with comments. Validation has not been achieved completely as the measurements were not accurate few days after installation. The reference electrode must still be improved. Several solutions have been devised in D6.3. The duration of the battery is too short (15 days). The main cause is the radio module which in the first version was always on, in the last version an ON/OFF strategy has been implemented and the battery is expected to last much longer.

1.2. Project context and objectives

WIDESENS is a project financed by the FP7 Capacities program for the benefit of SME´s. It is formed by 5 partners:

- Wellness Telecom, Spain (Coordinator)
- T.E. Laboratories, Ireland
- Hydrelis, France
- CSIC- Institute of Microelectronics of Barcelona, Spain
- INCDMTM, Romania

In recent years the water sector has become a widespread user of Information and Communication Technologies (ICT) for planning and operation. These technologies are need not only to comply with stricter regulations and safety measures, rising quality standards and challenging social and environmental demands but also to face serious problems of aging infrastructure, which includes leakage and quality issues related to the water supply network.

As a result, there has been a growing demand for Real Time (RT) water management solutions, however, these technologies are still far from mature and they do not provide a real solution to the water sector needs for analysis, control and data measurement. Current water probes/sensors have traditional inconveniences that limit their usage for water quality control in supply networks:

- Unsustainable energy consumption
- Fragility
- Manual calibration at laboratory
- High maintenance needs
- Electrolyte leakage (for reference electrode)
- Lack of accuracy

These technical inconveniences have made sensor grids very difficult to implement but also the total cost of ownership (TCO) (equipment + installation + maintenance) makes economically prohibitive a widespread use. Besides, the key ICT challenges for the water sector relate to the economics of providing arrays of low cost sensors that could be deployed in remote locations, to data communications from these remote locations and to the powering of such sensors and communications.

Therefore, the water sector demands the incorporation of new technologies to increase the efficiency of operation without increasing the costs, basically they need an instrument with the features proposed by WIDESENS device. These features are:

- It measures the most important parameters related to the quality of water
- It is able to detect leaks
- It is easy to install
- It requires low maintenance and little number of visits
- It is low cost
- It consumes low power

The main objective of the **WIDESENS** Project is to develop, implement and test a novel multiparametric analytical probe based on unconventional sensors that will be economically viable for widespread use in water networks.

The **WIDESENS** probe shall measure pH, conductivity, bio-fouling, redox-potential and chlorine, for the evaluation of the water quality, and pressure, for the evaluation of the quality of the service and leak detection. Furthermore we will develop mechanics that allow self-calibration and cleaning of these sensors, the telecommunications system and the processing and data acquisition software.

The project will last 30 months starting in September 2013 and it shall result in several functional prototypes that will be validated in one real drinking water network.

1.3. Main S&T results/foregrounds

During the project (month 10 to 30), the consortium has worked towards the consecution of the Widesens probe according to the chronogram of the project. The main result have been the **WIDESENS** system formed by:

- R1. Multiparametric probe
- R2. Central Station Software
- R3. Telecommunications module

WP1. Project Management. The structures and procedures necessary for the execution of the project have been established in D1.1. Project Management Plan.

WP2. Definition of requirements. This WP was completed in period 1.

WP3. Sensors R&D. Design and fabrication of sensor devices. The fabrication of devices and their initial characterization has been completed. They have been fabricated in the Clean room of the IMB-CNM according to standard microelectronic technologies.
WP4: Probe´s body, mechanics, electronics & software.INCDMTM has developed 3 prototypes for the body and housing: 1) insertion version for pipes of large dimensions, 2) Mini version for pipes of small dimensions, 3) Polycarbonate by pass version for compatibility with analytical panels.

Electronics. The electronics module is a microcontroller (MCU) based module for acquisition, compensation, processing and interface. The MCU includes UART interfaces for debugging and communication.
Software**.** The software developed includes modules on two levels: multiprobe controller and central station.
WP5: Telecommunications module. INCDMTM has completed the development of the telecommunications module (hardware and software) with different communications options (wired & wireless) so it can get adapted to different situations

WP6: Integration and validation. Two main sets of tests have been carried out: 1) At TELLAB´s premises in the internal water circuit of the building (insertion version & bypass version) 2) In the water network of the city of La Coruña . The probe was validated with comments.

WP7: Dissemination, Exploitation and IPRs. Maintenance of D7.1 Project Website (www.widesens-project.eu), creation of D7.2 video (check website) and D7.3 Final Plan for the Use and Dissemination of Knowledge including: IP protection plan, exploitation plan, dissemination plan and market penetration strategies.The project was disseminated in several international events included as part of the stands of WT, TELLAB and Hydrelis, leaflets were handed and discussions were sustained with attendants.

1.3.1. Work progress and achievements by WP

WP3 Sensors R&D
Summary of progress towards objectives and details for each task;
The different tasks covered within this WP are: **T3.1 Design and Fabrication of sensor devices, a REFET and a reference electrode.**

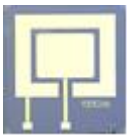
The sensors fabricated are:

- ISFETs (Ion Sensitive Field Effect Transistor) for pH and REFET (reference ISFET).
- Interdigitated electrodes (IDEs) for fouling and 4-bar electrodes for conductivity.
- Pt microelectrode for ORP and Au microelectrodes for Chlorine.
- Integrated Reference electrode.

D3.1 20 units of each sensor: ISFET, IDE, ORP and Chlorine microelectrodes. REFET (5 units) and reference electrode (5 units)" have been produced.

h- ISFET

Conductivity 4 bars



Chlorine Au Amperometric

Reference electrode

Figure 1 Individual sensors

All these devices have been fabricated and encapsulated on a multi-sensor PCB and have been evaluated in next WP6. The evaluation of sensors have been carried out according to ISO 15839 specifications. The results in the lab demonstrated that sensors accomplish the required specifications. For more info on validation see WP6.

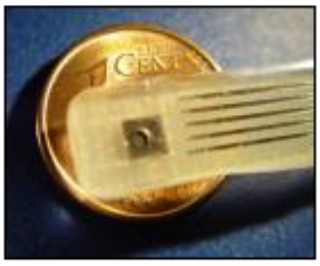


Figure 2 Individual sensor encapsulated

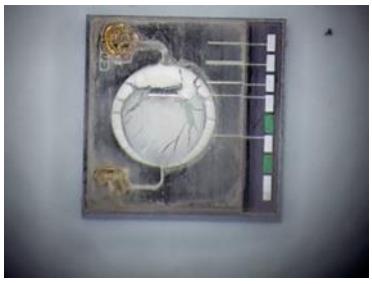


Figure 3 REFET

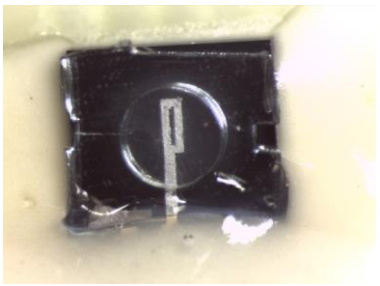


Figure 4 Ag/AgCl reference electrode

T3.2 Evaluation of sensors under laboratory conditions.

Sensors have been evaluated in the laboratory with IMB electronics using aqueous solutions to obtain their

performance characteristics. The calibration of sensors during several days and months provides parameters like: Sensitivity, linearity, Limit of detection (LD), Limit of quantification (LQ), Short term drift, Day to day and on the same day repeatability, etc.

The sensors have demonstrated their good performance regarding to reproducibility and stability.

The analytical evaluation of sensors have been carried out according to ISO 15839 specifications. The results demonstrate that sensors accomplish the required specifications (Table).

Further work is being addressed to determine the long term drift (1 month) and the calibration frequency for all sensors.

Parameter	Conc. range. Expected/obtained	Limit of detection Expected/obtained	Precision (repeatability)* Expected/obtained
pH	pH 4,5-10,5/idem	na	5% /3,7% pH 7 and 1,4% pH 9.
Conductivity	0-5.000 / 0-3.000 µS/cm**	50 µS/cm / 4.5 µS/cm	5%/ <1% for 600 µS/cm and 2400 µS/cm
Chlorine Free	0-5 mg/l/idem	0.01 mg/l/0.06 mg/l	10%/ 3% 4 ppm and 5% 1 ppm
ORP	100-300 mV/idem	na	10%/< 1% for 200 mV

*Precision (=100*repeatability average/analyte conc.)
**This reduction was discussed with SMEs and considered more adequate for potable waters

T3.3 Encapsulation & adaptation of sensors

One the wafers are processed the individual chips are diced and fixed in a printed circuit board (PCB) strip. Two PCBs will be used in order to reduce volume and facilitate massive encapsulation. The size of this PCB is 25 mm wide, 60 mm long and 1.5 mm thick (Figure 12). Each PCB has a connector for external electronics connexion. First the chips are sealed with an epoxy (Epotek H77, Epoxy Technology, USA) and then the pads are wire-bonded to the tracks of the PCB. Finally, the tracks and wires are covered with a polymer to protect from liquid entrance. Different encapsulant materials have been used and finally the best option is a silicone (Silicone RTV 3140, Dow corning). The complete probe contain two PCBs:

1.-One with the ISFET, REFET and IDS chips. This probe will be called **ISFET probe.** This PCB also contains the TVS (Transient voltage suppressor) for avoiding voltage peaks that could affect the ISFET.

2- Another with the Pt electrode (ORP), the reference electrode, the Au electrode (chlorine), the 4-bars electrode (conductivity), and a NTC commercial sensor (Murata, ref. NCP15XH103F03RC). This probe will be called **Multisensor probe**.

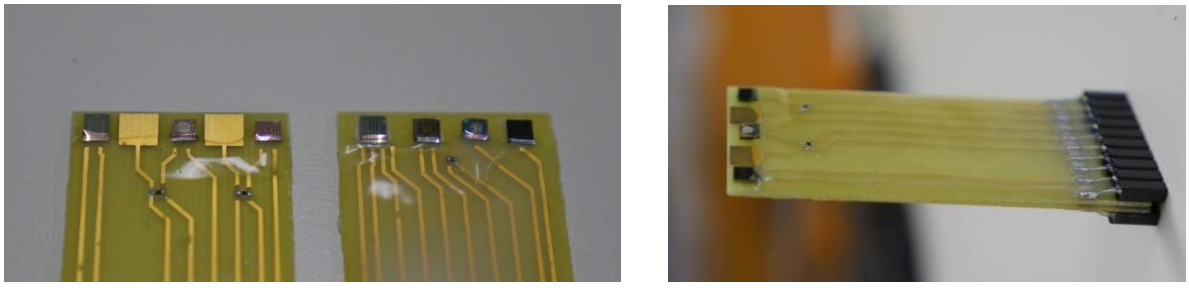


Figure 5 Multisensor Probe

Both PCBs are fixed together with an epoxy resin (Poxipol). The final thickness of the complete PCB is between 5.5 - 5.7 mm (considering encapsulation and wire bonding). The PCB pair is fixed with the same epoxy to a metallic piece to insert this in the body.

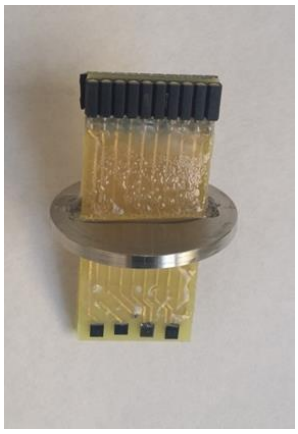


Figure 6 Multisensor Probe + metallic support

Significant results

- D3.1 Fabrication of sensors
- D3.2. Evaluation of sensors under laboratory conditions

WP 4 Probe´s Body, Housing, Electronics and Software

Summary of progress towards objectives and details for each task;

T4.1 Development of the body, mechanics, electronics & software

Within the first period of the project in WP4 we have be started the tasks for:

- Design and fabrication of the probe body and housing
- Design and fabrication of the electronics and software

In the first 9 months of the several designs have been elaborated by INCDMTM and discussed among partners, next we present the final prototypes chosen:

INCDMTM has developed 3 prototypes for the body and housing: 1) insertion version for pipes of large dimensions, 2) Mini version for pipes of small dimensions, 3) Polycarbonate by pass version for compatibility with analytical panels.

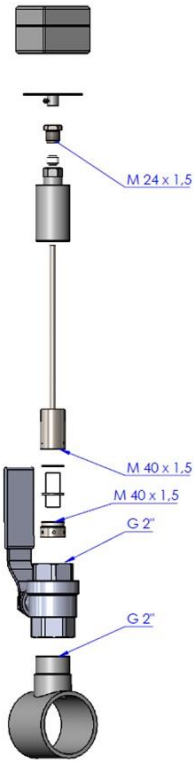


Figure 7 "Insertion version" Probe for pipes > 45mmØ

Figure 8 "Insertion version with pressure sensor". Probe for pipes > 45mmØ

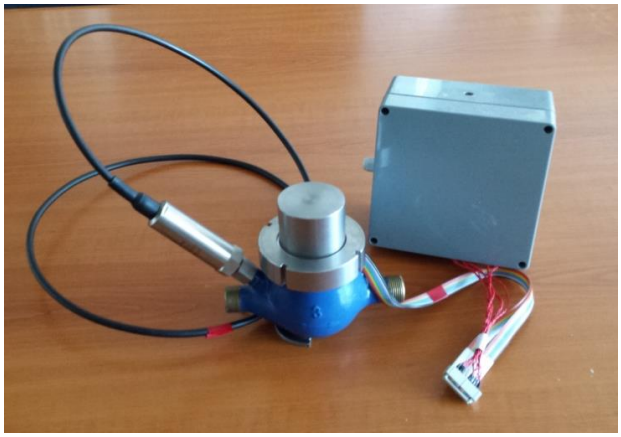


Figure 9 "Mini version" for pipes <45mmØ

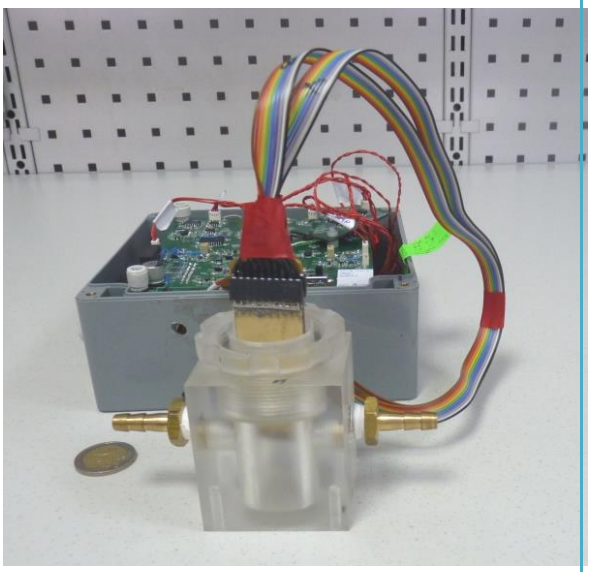


Figure 10 Bypass version

Pressure sensor

The pressure sensor is a commercial one with range: 0 - 10 bar, accuracy: ± 1%F.S, Operating temperature -10...+60 oC, Consumption < 1mA, Power supply 2.5 - 5Vdc, Dimensions M20x1.5, G1/4, G1/2, Output signal Digital RS485

Electronics

The electronics module is a microcontroller (MCU) based module for acquisition, compensation, processing and interface. The MCU includes UART interfaces for debugging and communication.

The interface between microelectronic sensors and signal processing electronics was an important research issue. It includes the pre-amplifiers + conditioning modules depending on the specific sensor output specifications.

The sensors used have different electronics requirements since they are based on four detection fundamentals:

- pH with ISFET-REFET is based on potentiometric measurement
- Conductivity is based on impedimetric measurement with a fixed frequency
- ORP measurement is a potentiometric detection
- Chlorine detection is based on amperometric measurement.

The solution assures:

- Pre-amplifier gain
- Offset and noise rejection
- Temperature and drift compensation
- low power consumption - battery supply

The implemented testing schematic is described in the next figures:

Figure 11 Sensor interface electronics- FRONT

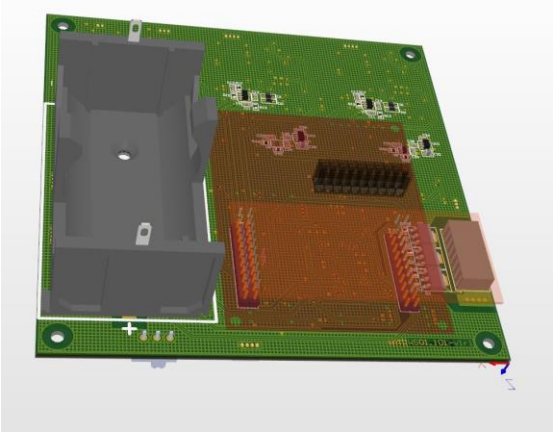


Figure 12 Sensor interface electronics -BACK

Battery

- type: Lithium: D format
- operating voltage : 3.6 V / up to 17000 mAh
- low self-discharge capacity, enable high peaks.

Housing

Electronics are stored inside a water proof box of dimensions 15.5 x 15.5 x 8.5 cms

Software

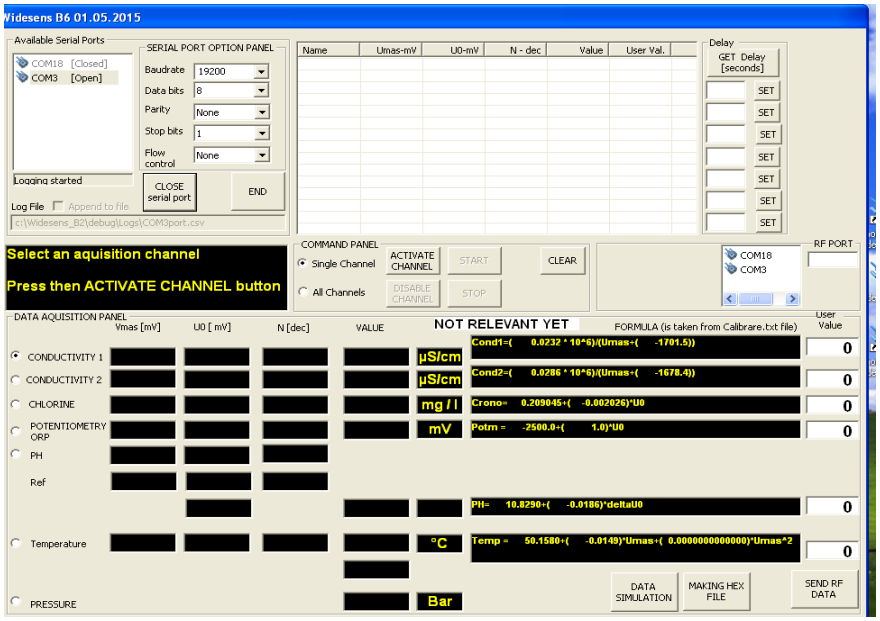
The software developed includes modules on two levels: multiprobe controller and central station.

Multiprobe controller: It is a desktop program that it is used for obtaining data directly from the probe connected to a laptop through a serial cable. In the program we can see the brute values (mV) and also we can introduce the calibration formulas to translate mV to real units of pH, conductivity (µS/cm), chlorine (mg/l), redox (mv) and pressure (bars).

USER SCREEN for debugging and setting-up

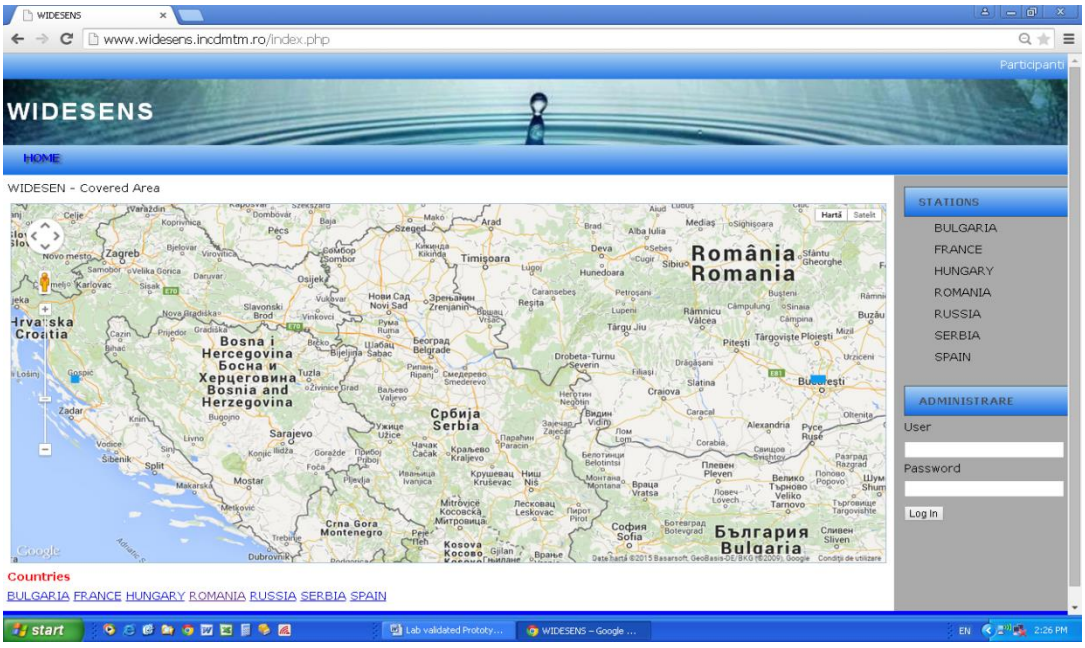
The following screen shows a debugging version on a PC. The final version has the ADC values in mV and

the calibrated values in specific units.



Central Station: It is a web application that acquires and stores the raw values, the operator can introduce the calibration formulas. The operator can access both brute and processed data through a web interface with tables and graphs.

START SCREEN: Start page for Widesens Central station site it includes a general location for the Widesens stations



Map selection: In order to visualize measurement data performed by a station, we can click directly on the station on the map or we can expand Country List, pick a city and its corresponding stations and choose a certain station from those in that particular city

Onsite tests

In addition to these activities a measuring draft stand is being drawn up for laboratory testing of the multiparametric probe in accordance with ISO 15839/ 2007

INCDMTM purchased some equipments necessary of the stand.

For testing were purchased **Multiparameter for laboratory inoLab® Multi 9430 IDS** which measures the following parameters: pH, mV, saturation, concentration, partial pressure, conductivity, specific

resistance, salinity, TDS, temperature and **Free and Total Chlorine Photometer HI 96711**
Significant results
• Design of 3 body versions: Insertion, mini & by-pass. • Design and fabrication of electronics & software

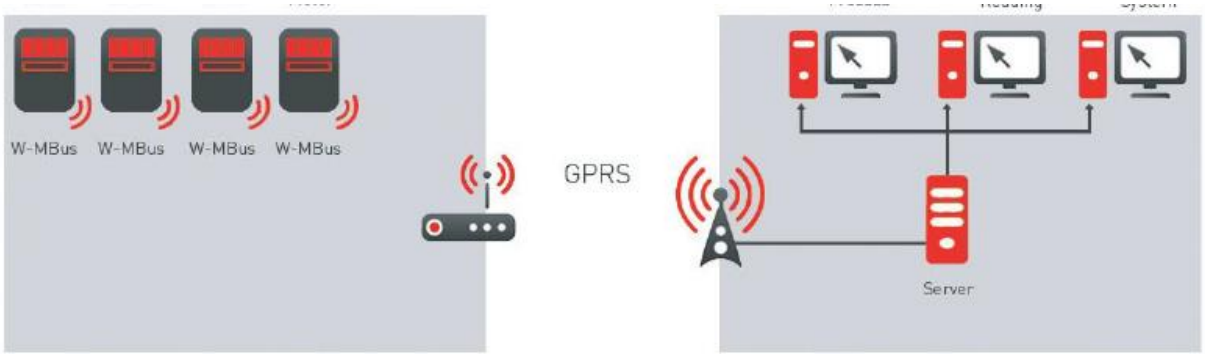
WP 5 Telecommunications Module

Summary of progress towards objectives and details for each task;

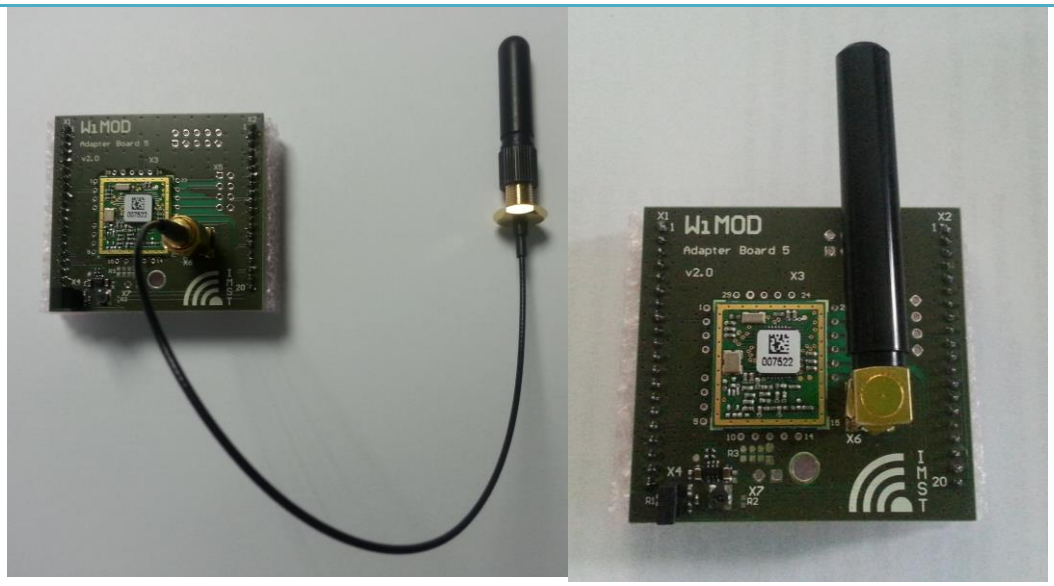
INCDMTM has completed the development of the telecommunications module (hardware and software) with different communications options (wired & wireless) so it can get adapted to different situations

The communications systems has been designed considering the following strategy: The first transmission is carried out using a M-Bus RF module using a short distance wireless communication protocol 802.15.4 /EN 13757-2/3/4 (included in the hardware device, battery based) to a GPRS Gateway that is connected to the electric grid. This gateway carries out the largest range transmissions using GPRS. If other communication lines are available the device could be connected by in the included UART serial interfaces through different modules adapted to the condition. The data is transferred in to compatible databases (implemented on a server located now at INCDMTM Bucharest location) and is observed by a specially built internet based browser interface. It was developed also special software for local control and measurement by a PC laptop - used to make a local calibration, measurement and storage of the data.

The developed solution was based on IMST products - modules and gateway.
The wireless communication module is iM871A with external antenna, it operates in the European 868-870MHz band, the gateway is iG701A.



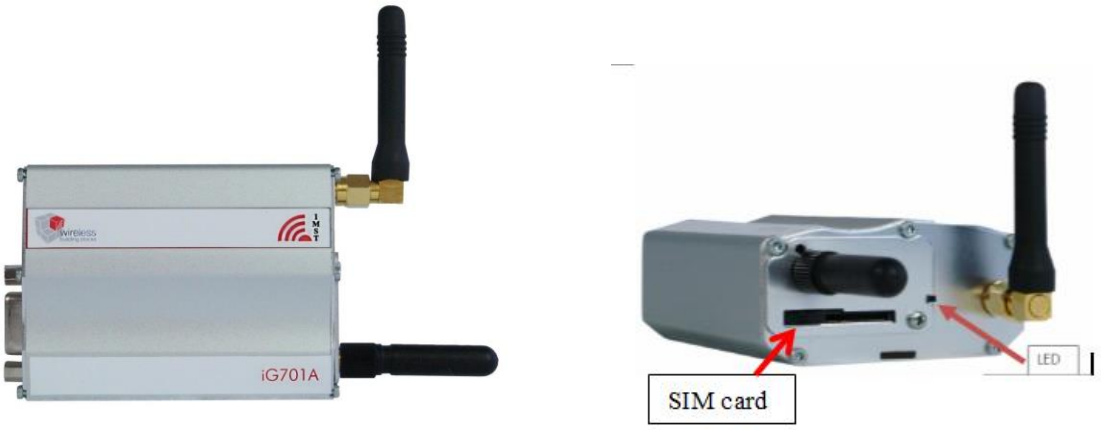
Communication case



RF WM-Bus module a) with antenna extender ; b) with antenna coupled on board

Could be used 2 modes for antenna coupling:
- one with antenna coupled on board, so the antenna will be in the box
- one with the antenna coupled by extender, the antenna could be used out of the box, it will have a better signal.
Both of them assured an IP68 protection factor for the device.

The Gateway used is also a IMST product.
It assured the conversion from WM-bus frequency to the GSM one (GPRS) .



RF Gateway solution

Significant results

- Study of options of technologies available, telecommunication protocols and suppliers
- M-Bus RF Communications Modules development ongoing
- Integration with interface electronics and software

WP6 Integration and validation

Summary of progress towards objectives and details for each task;

The work carried in this WP during 2nd period was the integration and lab validation of the sensors, electronics and probes and the field validation tests. During these activities different versions have been developed according to the results obtained.
The 5 prototypes of sensors &electronics were validated in lab by INCDMTM, CSIC and TelLab and then in field by subcontracted company EMALCSA supervised by TELLAB.

T6.1 Integration and lab validation of whole system.
Response characteristics of finals sensors & electronics under lab conditions according to ISO 15839 were validated and results are presented in D6.1 Lab Validation report.

Sensors were validated in the laboratory with IMB electronics according to ISO 15839. As shown in the deliverable 3.2, the sensors accomplish with the specifications established in the original requirements.

The results obtained demonstrate that the sensors have satisfactory analytical characteristics and comply with D2.2. Overall Widesens requirements specification architecture. A second analytical specification has been included, the accuracy, for comparison with standard methods. As shown all the values obtained with IMB sensors& INCDMTM electronics are lower or equal than the expected. Only in the case of conductivity for the low range the accuracy expressed as bias is high but acceptable for field purposes.

At this time sensors were evaluated for day-to day stability under laboratory conditions. ISFETs probes were stable for at least 3 months. Some of them were working after 1 year fabrication. Conductivity sensors were the most durable sensors, they were working even after 1 year. ORP and chlorine sensors lifetime was limited by the reference electrode. The maximum lifetime obtained for these sensors laboratory conditions was 2 months.

Regarding integrated reference electrode for chlorine and ORP measurements, the stability of this sensor is more critical because the internal solution needs to be maintained constant to get a stable reference potential. The agarose solution has demonstrated a relative stability of 79 days in controlled solutions (pH buffer and KCl constant).

Parameter	Conc. range.	Limit of detection (Expected) obtained	Precision (repeatability)* (Expected) obtained	Accuracy (=Bias)** (Expected) obtained
pH	pH 4,5-10,5	na	(5%) 0,7%	(±5%) ±1%
Conductivity	600-3.000 µS/cm 0-600 µS/cm	(50 µS/cm) 20 µS/cm 2 µS/cm	(5%) [a] 2% 3%	(± 5%) ±3% ±12%
Chlorine Free	0-1 ppm	(0.01 ppm)/0.01 ppm	(10%) 5%	(± 10%) ±8%
ORP	100-300 mV	na	(10%) 1%	(±20%) ±17%

*Precision (=100 x repeatability average/analyte conc.)
**Accuracy (=100 x bias average/analyte conc.)

T6.2 Field validation tests.

D6.2 Field Validation report.

Two main sets of tests have been carried out: 1) At TELLAB´s premises in the internal water circuit of the building (insertion version & bypass version) 2) In the water network of the city of La Coruña

The WIDESENS results were compared against reference instrumentation and they were very similar in every case.

Sensors were previously calibrated using the certificated solutions form Tellab and after measurements in

tap water solution were performed. These were compared with commercial sensors. Results (deliverable 6.2) demonstrate that the values were in agreement between both sensors.

Tests in La Coruña were performed with the by-pass cell. For these tests 3 units were used and the total time of tests was 10 days. The results were quite good for conductivity sensors since they were stable for all tests. pH sensors were stale during the first 4 days and after they presented a drift (pH decreasing). This was related to the REFET internal solution leakage due to the flow of water. In the figure below is shown the recording of conductivity and pH during the longest period. However the value obtained during the first days was similar to that given by the Hach panel installed by the company.

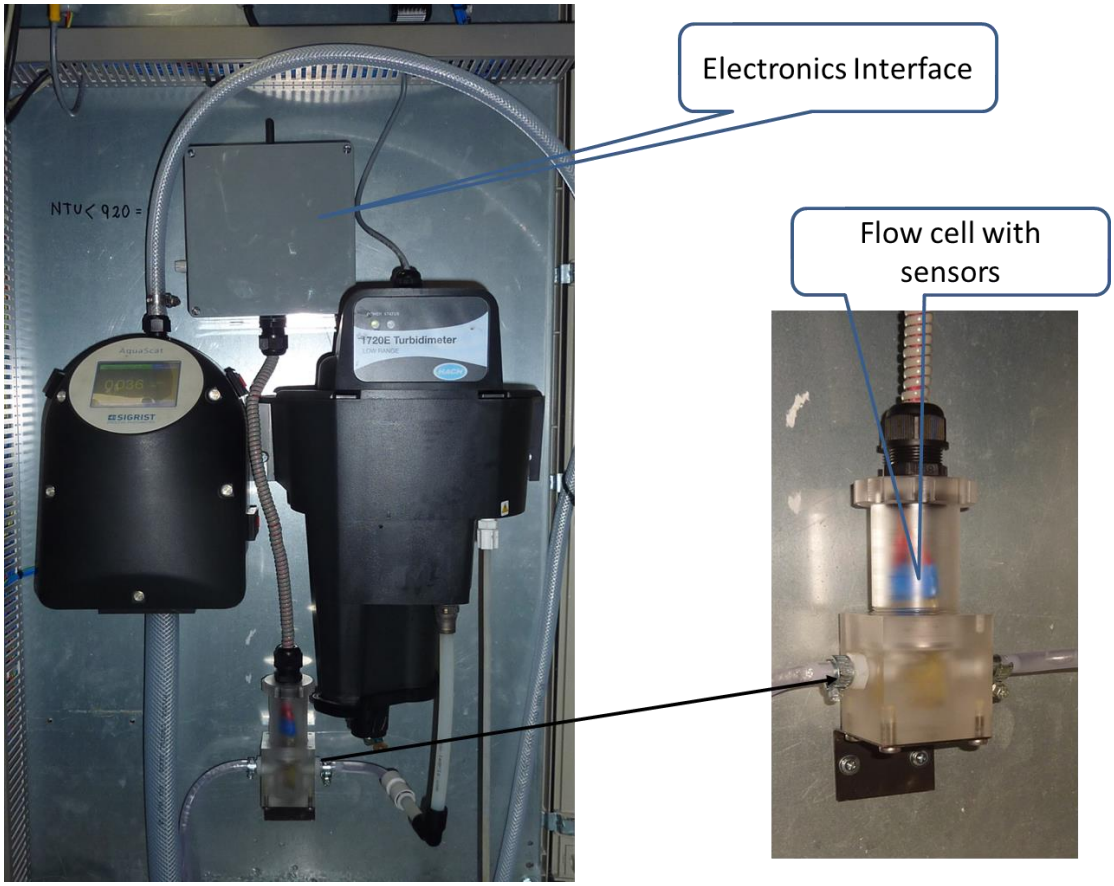
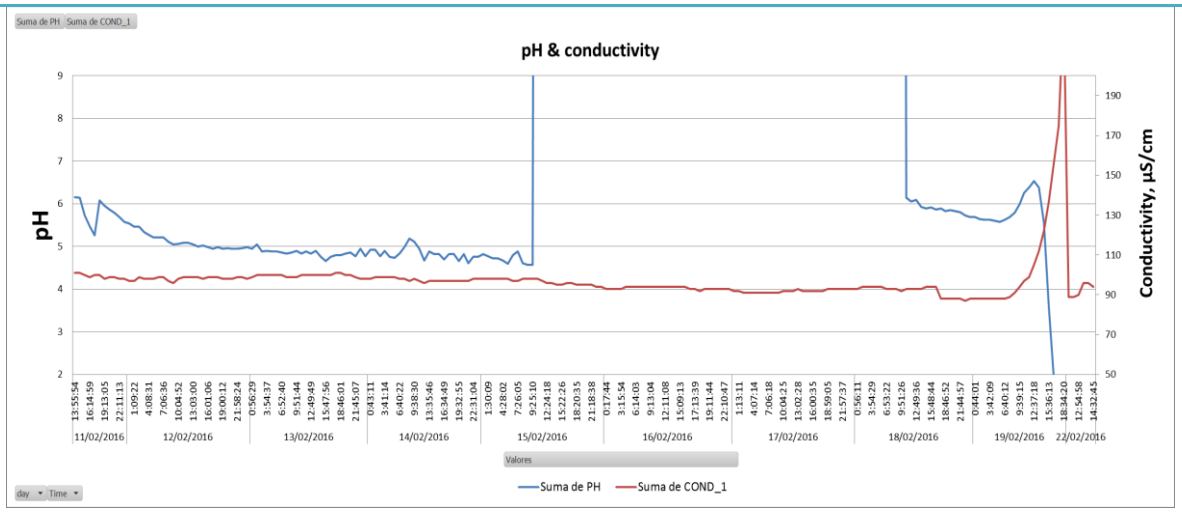
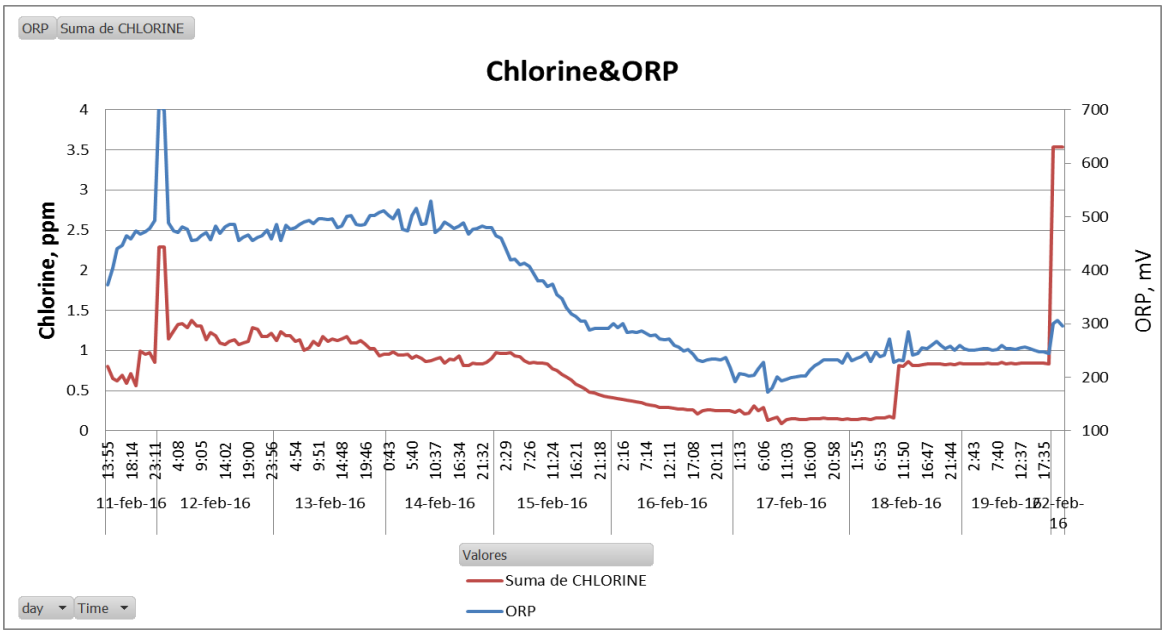


Figure 13 WIDESENSBy-pass version installed besides existing instrumentation (La Coruña)



Regarding chlorine and ORP, the stability results were poorest, achieving stable signal during only three days. In that case the reference electrode loss of internal solution affected more seriously the sensor response. However during stable measurements the chlorine value was comparable to that from the Hach panel the company has installed.



According to the obtained results in La Coruña we can conclude that conductivity sensors are working properly and are stable for long periods of time. pH, ORP and chlorine sensors are not stable more than several days and they need to be improved. Failing is mostly due to the internal solution of the REFET and the reference electrode, mechanisms to improve these sensors have been depicted in D6.3.

Regarding to the communications systems and protocols. The protocol implemented was a M-Bus standard. It was tested in different places (Romania, Spain and Ireland) and it demonstrated to work correctly. Regarding the electronics, it was tested in laboratory with simulated inputs and the stability was very good. During the project, different improvements have been required such as the isolation of the channels (chlorine and pH mainly from conductivity) to avoid interferences and the amplification of the amperometric signal for chlorine. Finally this electronics has been tested with the multiprobe sensors and according to ISO and the results are in conformity with the specifications described in Deliv. 2.2.

Battery lifetime depends of the scheduled sample rates. In Lab Validation period there were tested different sample rates, from minutes to hours. The sample rate used in Field Validation tests was one measurement per hour. The battery lifetime was 14 days, much less than expected, this was due to the radio module which was always on. In the final version some optimizations had to be included for implementing a very low-power regime including an ON/OFF strategy for the radio module.

Difference Lab tests and field tests

According to the results obtained in laboratory tests, if the measurements are carried out under static conditions, the reference solution is maintained within the chamber and the electrodes are working correctly. But as shown from continuous measurements in La Coruña, if there is a relative high flow and due to the pressure differences, the reference solution leaks outside very rapidly. That means that the potential of the REFET and the reference electrode is not constant and then the measurements become wrong gradually.

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Battery lifetime depends of the scheduled sample rates. In Lab Validation period there were tested different sample rates, from minutes to hours. The sample rate used in Field Validation tests was one measurement per hour. The battery lifetime was 14 days, much less than expected, this was due to the radio module which was always on. In the final version some optimizations had to be included for implementing a very low-power regime including an ON/OFF strategy for the radio module.

T6.3 Inclusion of improvements and final prototype

The study of probe, sensors &electronics during this period resulted in the evolution of these devices to obtain the final prototypes reported in Wp3, WP4 and WP5.

The final conclusions from the field results were that REFET and reference electrode is suffering degradation due to the leakage of the internal solution. This could be solved by incrementing the internal solution volume or by refilling it. This solution could be solved with a more complex microfluidic structure. Another alternative is the use of commercial reference electrodes that are sold as "free of leakage". This alternative will be tested in next months

Significant results

3 types of probes with sensors, electronics, communications fabricated
Field validation with results

Deviations

Validation has not been achieved completely as the measurements were not accurate few days after installation. The reference electrode must still be improved. Several solutions have been devised in D6.3. The duration of the battery is too short (15 days). The main cause is the radio module which in the first version was always on, in the last version an ON/OFF strategy has been implemented and the battery is expected to last much longer.

Nevertheless, within the consortium, milestones in the second period have been considered achieved and therefore have been accepted for payment

WP 7 Dissemination, exploitation and IPR´s

Summary of progress towards objectives and details for each task;

The work carried out in this WP during the first period has been presented in deliverable "**D7.3** Final Plan

for the Use and Dissemination of Knowledge".

T7.1 Project website

The project website is created and updated

www.widesens-project.eu

T7.2 Identify, capture and protect IP

Property Rights have been identified and properly addressed within the Consortium Agreement. The RTDs and SMEs, with the input of the Exploitation Manager and IP Specialists continually log and capture IP as it emerges from the research work. The consortium has engaged an IP lawyer during the development of the project to ensure that the work result in patentable results and that the work is not in breach of any existing patents.

The main lines that have been followed in the IPR management have included:

- **Licensing of pre-existing know-how (Background knowledge)**: the background knowledge will remain of property of each partner, nevertheless it has been already agreed that the background knowledge will be put at disposal of SMEs in the way that it will not undermine the full usability (with no costs) for the SMEs of the foreground knowledge. Background knowledge will be put at disposal of RTD performers royalty-free for implementing the project.
- **Knowledge gained within the WIDESENS project (Foreground knowledge)**: The foreground knowledge is ownership of the involved SMEs in an equal manner. The consortium has entered into an agreement regarding the ownership of foreground and access rights to be provided to any SME and RTD performer, for both use and dissemination purposes.

3 key foregrounds have been identified that may generate IP issues:

- [R1] Multiparameter probe based on semiconductor sensors
- [R2] Central station software
- [R3] Telecommunications module

		WTELECOM		TELLAB		HYDRELIS	
Project Result (No)	Project Result (Description)	Type of Exploitation (*)	Remuneration (€)	Type of Exploitation (*)	Remuneration (€)	Type of Exploitation (*)	Remuneration (€)
R1	Multiparametric Probe	ownership	262.813,89 €	ownership	262.813,89 €	ownership	262.813,89 €
R2	Central Station Software	ownership	17.422,22 €	ownership	17.422,22 €	ownership	17.422,22 €
R3	Telecommunications module	ownership	23.288,89 €	ownership	23.288,89 €	ownership	23.288,89 €
	Subtotal remuneration		303.525,00 €		303.525,00 €		303.525,00 €
Total remunerations	910.575,00 €						

The three SMEs are proprietary of the foreground generated equally:

	[R1]Multiparametric probe	[R2] Central station software	[R3] Communication module
Wellness Telecom	33%	33%	33%
Tellab	33%	33%	33%
Hydrelis	33%	33%	33%

Consortium Agreement establish the property of the results of the projet

Art.9.4 Access Rights for Use

Foreground is exclusive property of SMEs.

RTDs will be allowed to use the acquired knowledge in scientific publications or as a background for other researches, with the approval of SMEs, provided that they do not reveal inner aspects and confidential aspects.

A third party shall not be granted direct Access to Foreground generated by other Parties unless those Parties explicitly agree to it.

Access Rights to Background, specifically described on attachment 1, if needed for use of a Party's own Foreground, shall be granted on a royalty-free basis. Other type of background shall be granted on fair and reasonable conditions provided that the Party concerned is entitled to grant them.

A request for Access Rights may be made up to twelve months after the end of the Project or, in the case of Art. 9.6.2, after the termination of the requesting Party's participation in the Project.

Patentability Study

We have contacted IP experts (www.clarkemodet.es) and they have concluded that WIDESENS is not in breach of any existing patent. (The patents of ISFET based sensors were published in the nineties (therefore they are expired) and currently the design and architecture related to ISFETs are published and publicly available.

CLARKE has stated that the probe is not patentable as it is a conjunction of several already existing devices with the aim to obtain a benefit that would be "expectable". CLARKE advises against patenting and advises for studying the route of Intelectual Property Right.

T7.3 Exploitation Plan

The Exploitation manager in cooperation with the Project Coordination Committee has worked on the Exploitation Plan which is in full accordance with the Grant and Consortium Agreement that has been signed by all partners before the project starts.

Specifically the CA establishes in sect. 8 that the (...)knowledge arising from work carried out under the Project shall be the joint property of the SME Partners alone (...)

The three SMEs have agreed to have freedom for commercializing the solution separately. It is understood that each SME will commence commercialization efforts in each of their countries of origin so, competition among SMEs should not appear at least during the introduction-to-market stage.

T7.4 Dissemination Plan

The **Dissemination Manager** has been responsible for the coordination of the dissemination stage of the project results and has elaborated the dissemination plan in cooperation with the Project Coordination Committe.

The information generated during the development of the project it is being disseminated by a wide range of channels and means, the most important are:

- Promotion of the Widesens project in all project partners´ web-sites.
- Creation and maintenance of the public Widesens website. http://www.widesens-project.eu/

- Dissemination materials. Leaflet. Poster.
- Promotional video in website
- Events and exhibitions detailed bellow

The project was disseminated in several international events included as part of the stands of WT, TELLAB and Hydrelis, leaflets were handed and discussions were sustained with attendants.

T7.5 Market Penetration Strategies [Leader: HYDRELIS; Participants: WTELECOM, TELLAB, CSIC, INCDMTM]

EM & DM have conducted a comprehensive **Exploitation Plan** with the collaboration of RTDs in D7.3. This survey provides market data on the competition, potential market and expected sales.

T7.6 Scale-up Plans for Product Manufacture

This task has been addressed in D6.3 that relates the components and details for product manufacture.

T7.7 Promotional Video

Done. Check website please.

T7.8 Transfer of Knowledge

This task has been addressed in D6.3 that relates the components and details for product manufacture.

Significant results

D7.1 Project webs site www.widesens-project.eu

D7.3 Final Plan for the Use and Dissemination of Knowledge

D7.4 Promotional Video

1.4. Potential impact (including the socio-economic impact and the wider societal implications of the project so far)

1.4.1. Potential impact as in the proposal document

The WIDESENS´potential impacts were defined in the proposal document as next:

- **Beneficiary SMEs** SMEs will receive revenue for the commercialization of the WIDESENS system and it will also complement their current services´ portfolio making it more appealing to City Councils, Water Authorities, Water Utilities and other possible clients.
- **Water Utilities & authorities**-WIDESENS will improve water management processes like the water chlorination, water leak detection, water quality management & assurance. In this way responsibles for the healthiness of water will have greater peace of mind as they will have a method for accurately ensuring the quality of the supply.
- **Users and citizens**- People will enjoy of safer water at home with improved chemical features.
- **The environment**- Less chlorine, better water preservation and leak detection.
- **EU legislation**- Legislation will have to adapt to include the new possibilities offered by the developed technology.

1.4.2. Impacts and wider societal implications of the project so far

The main impact so far has been the inclusion of a new product in the portfolio of the three SME companies Wellness Telecom, T.E. Laboratories and Hydrelis.

Market has been studied, the competition has been identified, market volume and sales projections have been calculated, a business plan has been forwarded.

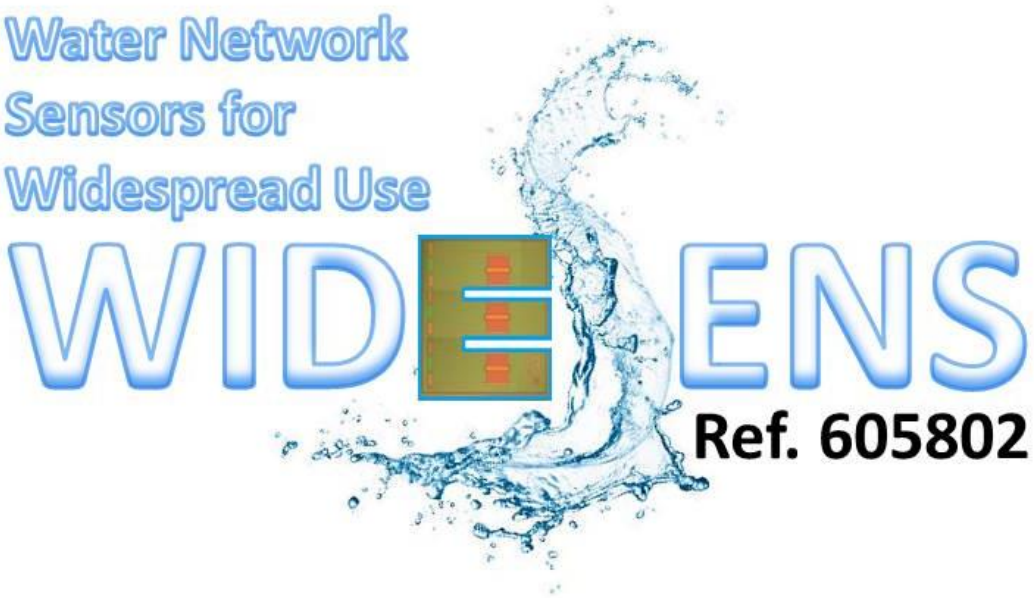
Sales have not been achieved as the product is not in a commercial stage, as we have mentioned, it needs further development to solve the life problems relating the reference electrode. Solutions to this problem have been suggested in D6.3.

The wider societal implications envisaged have not been possible to demonstrate as the pilot activity in "La Coruña" was too small and too short to notice any improvement on the water utilities´operational procedures. Nevertheless the potential effects are considered as "realistic" and "expectable" by the water utilities we have approached if we reached a true long-life sensor and a wide deployment is made over a water network.

1.5. Project website and video

Project Website is updated and in operation www.widesens-project.eu. Video can be found on the same website and youtube. https://youtu.be/HDFdZ6M3GUA

1.6. Project logo


Water Network
Sensors for
Widespread Use
WIDENS
Ref. 605802

1.7. Poster

WIDESENS

Water Network Sensors for Widespread Use

WIDESENS proposes the research and development of an innovative probe based on microelectronic sensors to achieve a feasible widespread use of sensors in water networks management.

WIDESENS measures:

- pH 4,5-10,5
- Conductivity 0-3000 µS/cm
- Redox-potential 100-400 mV
- Free Chlorine 0-1.2 mg/l
- Pressure 0-10 bars

2 extra body options:

Multi-Parametric Electronic Tongue

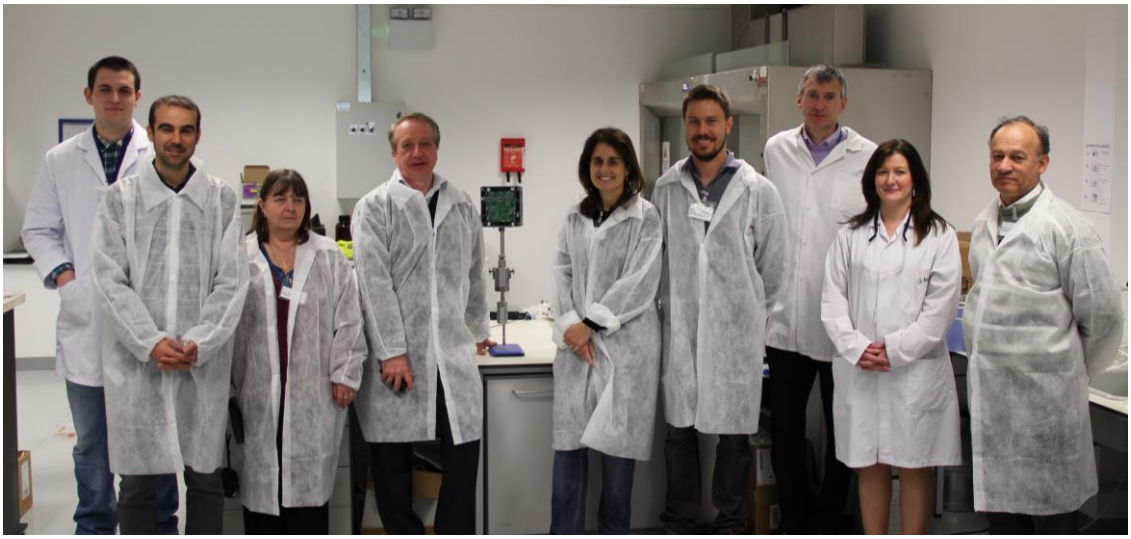
Mini Version for pipes < 45 mm

Bypass for analytical panels

Wellness Telecom | TelLab | INCDMTM | HYDRELIS WATER CONTROL | CSIC Consejo Superior de Investigaciones Científicas

http://www.widesens-project.eu/

1.8. List of beneficiaries and contact names



Participant organisation name	Country	Contact name	Contact
Wellness Telecom	ES	Antonio Chaparro	achaparro@wtelecom.es
T.E Laboratories Ltd	IR	Mark Bowkett	mbowkett@tellab.ie
Hydrelis	FR	Dominique Gayraud	dominique.gayraud@hydrelis.com
CSIC- Consejo Superior de Investigaciones Científicas	ES	Cecilia Jimenez	cecilia.jimenez@csic.es
National Institute of Research and Development for Mechatronics and Measurement Techniques	RO	Diana Badea	dianammura@gmail.com

2. Plan for use and dissemination of foreground

The WIDESENS information generated during the development of the project has been disseminated by a wide range of channels and means, the most important are:

- Promotion of the Widesens project in all project partners´ web-sites.
- Creation and maintenance of the public Widesens website. www.widesens-project.eu Widesens website has been one of the most important tools for disseminating the outcome of the project. It has been regularly updated and has the following purposes:

    - Present the project and its structure.
    - Present the Consortium of the project.
    - Introduce the objectives, documents and public deliverables.
    - Make available electronically public documents and publications
    - Inform about relevant events.
    - Offer contact point.
    - Provide partners-protected-area, which provide further internal communication.

- **Dissemination materials**. Development of material for use in national/international follow-up presentations of project progress and results.
    - Leaflet. See D7.3
    - Poster. See above.
    - Promotional video https://youtu.be/HDFdZ6M3GUA

2.1. Dissemination events attended

- **Analytica 2014 Munich March 2014**. Tellab exhibited at this event and included a summary of Widesens on the stand. Information was gathered and is discussed below.
- **Water Research Council Innovation day April 2014**. This is a technology showcasing event and networking day. Tellab attended this event and gained valuable information relevant to this plan.
- **Arablab March 2014.** Tellab exhibited at this event and had some discussions regarding the Widesens project(see below)
- **Aquatech Amsterdam November 2013**. Tellab attended this event as a visitor and obtained valuable information relevant to this plan. Full details are below.
- **Pollutec Horizons December 2013 Paris**. Tellab attended this event and met with Hydrellis as well as reviewing similar technologies that were being exhibited.
- **ROMENVIROTEC 2014 - International trade fair for technology and environmental protection equipment, 26th and 29th March 2014**, at Romexpo Exhibition Centre, Bucharest.
- **South-East European Exhibition on Energy Efficiency and Renewable Energy 2014 05.03.2014 –07.03.2014** Bucharest, Romania
- **Brokerage event at ENREG ENERGIA REGENERABILA - international trade fair for renewable energy nd energy efficiency 9th-11th of April 2014,** Expo Arad International Romania
- **BUCHAREST RomExpo, TIB, ExpoEnergie, 15-18 October, 2014**. By INCDMTM.
- **BARCELONA International Matchmaking Event, EXPOQUIMIA. 2 October 2014**. CSIC team was doing networking with some companies and showing the last development related to sensors for water.

- **Environ 2015, Institute of Technology, Sligo, Ireland 8th - 10th Apr 2015**: The 25th Irish Environmental Researchers Colloquium (Environ 2015) was held at Institute of Technology Sligo, Ireland where a wonderful platform is provided for researchers to present their research in relation to tackling societal challenges. Mark Bowkett, MD, TE Laboratories attended and a poster was presented at this event.
- **BUCHAREST- METAL SHOW 13 May 2015**. By INCDMTM
- **H2020 Environmental Networking Event, Dublin, Ireland 25th Jun 2015**. TelLab had a stand at this networking event held in Enterprise Ireland offices. They presented a Widesens poster on the stand and discussed the project with companies and researchers.
- I**ndustry Research and Development Group Lean Innovation Summit, Dublin, Ireland 15th Sept 2015**: Irish based SMEs and international companies who are interested in research, attended this event. TelLab had a stand with a Widesens poster displayed.
- **EPA National Information Day on H2020 Societal Challenge 5, Dublin, Ireland 21st Oct 2015**. Irish based researchers, SMEs and international companies attended this event. TelLab had a stand with a Widesens poster displayed and also presented a short overview of the project.
- **LES ULIS, FRANCE**. Premier Salon Innovations et energies. 21,22 October 2015. By Hydrelis.
- **BARCELONA SMART CITY EXPO 16-18 Nov 2015**. Wellness Telecom has presented a poster of the project as part of the stand of "Wellness Smart Cities", the division of the company born in 2014 and dedicated exclusively to smart city products.
- **DCU Water Institute / Agilent Symposium 28 Jan 2016**: Advanced Analytical Methods for Environmental Analysis of Water. This symposium brought experts from Ireland, Europe and the United States to show applications of advanced analytical methodologies for the field of water monitoring. Breda Moore, Technical Director, TE Laboratories Ltd attended this event, where she spoke to experts about the Widesens technology.

Feedback obtained from events attended

A number of key points are summarised as follows

1. The probe attracted great interest from attendants to the different events, we met several potential clients especially water utilities and also possible industrial partners, competitors demonstrated also great interest and possibilities of collaboration were discussed.
2. Feedback from the Water industry suggests a very significant market for the Widesens technology. A number of water utilities have requested to be updated with information on when it might be commercially available. A network of contacts is being compiled with an interest in the technology when it reaches the commercialisation stage.
3. The sensors may have an application in other related areas in water analysis. For example a self-calibrating conductivity sensor would be very relevant to surface water and pollution analysis, swimming pool and spas water control, legionella prevention and others.
4. There were no technologies present at any of the trade shows or events attended that had the same unique functionality that the Widesens technology contains.
5. Information has been gained on the Environmental technology validation programme. (ETV). This program has been designed to give emerging technologies creditably in the market place especially when being launched by SME's or companies new to this market. This will be a major advantage when commercialising the technology.

Figure 14 Barcelona Smart City Expo Nov 2015 by WT

Figure 15 Premier Salon Innovation et Energies Oct 2015 by Hydrelis

2.2. List of scientific publications

In WIDESENS we have not done any scientific publication.

During the project we had to deal with the dilemma of disseminating the project but not revealing too much in order to protect the project idea and results. The truth is that there exist a great number of competitors, sensors manufacturing companies that have a lot of advantage from us in terms of market holding and the consortium must treat with great care all the information that is released.

Especially we have had to be cautious in the dissemination as the technical validation results have not been as good as we expected (the sensors were only able to provide accurate measurements for 10 days), and although the problems have been identified (relate to reference electrode) and we have a plan for solving the technical issues (use of commercial reference electrodes and new design of own reference electrode), this may take still a while to complete, at least one year.

Therefore the activities of IP right protection, dissemination, market study and exploitation plans have been carried out seeking the correct balance among each other and taking into account the level of maturity of the solution.

2.3. Applications for patents – CONFIDENTIAL

We have contacted IP experts (www.clarkemodet.es) and they have concluded that WIDESENS is not in breach of any existing patent. (The patents of ISFET based sensors were published in the nineties (therefore they are expired) and currently the design and architecture related to ISFETs are published and publicly available.

CLARKE has stated that the probe is not patentable as it is a conjunction of several already existing devices with the aim to obtain a benefit that would be "expectable". CLARKE advises against patenting and advises for studying the route of Intelectual Property Right.

2.4. Exploitation plan - CONFIDENTIAL

This activity is carried out within task T7.3 Exploitation Plan [Leader: HYDRELIS; Participants: WTELECOM, TELLAB, CSIC, INCDMTM]

The Exploitation manager in cooperation with the Project Coordination Committee has worked on the Exploitation Plan which is in full accordance with the Grant and Consortium Agreement that has been signed by all partners before the project starts.

Specifically the CA establishes in sect. 8 that the (…)knowledge arising from work carried out under the Project shall be the joint property of the SME Partners alone (…)

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