EMMON - EMbedded MOnitoring
ARTEMIS JU – FP7

D3.1 OPERATIONAL REQUIREMENTS

OPERATIONAL REQUIREMENTS CONSOLIDATED FROM END-USERS INPUT AND OPINIONS

EMMON

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D3.1 OPERATIONAL REQUIREMENTS

EMMON

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Chapter 3	Chapter 3	Chapter named "EMMON Project Overview" describing EMMON project scope is replaced by "Executive Summary" which describes the main common functionalities identified for the EMMON system	Chapter 3
Section 6.1	Section 6.1	State the consolidated scenarios. Water Pipelines sub-scenario is considered not feasible for the EMMON project.	Section 6.1
Section 6.1	Section 6.1	Figure 6 presents consolidated scenarios evolution throughout the versions of this document	Section 6.1
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REQ-EMMON-0020	REQ-EMMON-0020	Requirement traceability was changed	Page 28
REQ-EMMON-0030	REQ-EMMON-0030	Requirement traceability was changed	Page 28
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1. Introduction

1.1 Objective

The main purpose of this document is to present a consolidation of the operational requirements and constraints, derived from end-user needs for the various scenarios studied, and that will serve as input to the research teams.

1.2 Scope

This document was produced under the scope of Work-package 3 (WP3), Task 3.1 "Consolidation of operational scenario requirements" and is identified as D3.1 “Consolidated Operational Requirements”.

This document consolidates all the available operational requirements from the different scenarios. Some changes were introduced in the second version of this document, as some scenarios were found not feasible (such as the Marine Environments and the Water Quality scenarios) and new scenarios were identified (such as the Water Pipelines and the Ozone Spatial Representativeness scenarios). Since the second version of this deliverable, a more exhaustive study about the Water Pipelines scenario was carried out and this was considered not feasible.

As a result, this document consolidates requirements from all scenarios studied in the scope of the project, namely [AD-2], [AD-3], [AD-5] and [AD-6].

1.3 Audience

The target audiences of this document are:

- ARTEMIS JU and the Commission Services;
- WSN research groups;

1.4 Definitions and Acronyms

Table 1 presents the list of acronyms used throughout the present document.

Acronyms	Description
AD	Applicable Document
ANA	Brazilian National Water Agency ("*Agência Nacional de Águas*")
C&C	Command and Control
PDA	Personal Digital Assistant
RD	Reference Document
TBC	To Be Confirmed
TBD	To Be Defined
EYATh	Thessaloniki Water Supply and Sewerage Company

Table 1 - Table of acronyms

Definitions	Description
Real-time	This term is used in a broad sense in this document. It refers to when entities respond to events as they occur, having no significant delay in its timeliness.
Real-time data	Data that is provided immediately after collection or with no significant delay in its timeliness.
Sub-network	A subset of the entire network that is composed of several nodes, all logically connected between each other, and possibly having different hierarchical levels.

Table 2 - Table of definitions

1.5 Document Structure

Section 1, Introduction, presents a general description of the contents, pointing its goals, intended audience and document structure.

Section 2, Documents, presents the documents applicable to this document and referenced by this document.

Section 3, Executive Summary, presents an overview of EMMON project.

Section 4, System Overview, presents an overview of the EMMON system.

Section 5, Use Cases Catalogue, presents the Use Case Catalogue and the actors list.

Section 6, Requirements Consolidation Approach, presents the reasoning used for consolidating the operational scenario requirements from end-user input.

Section 7, Technical Requirements, presents the technical requirements catalogue, derived from the operational scenarios requirements.

Section 8, Conclusions, presents the consolidated operational requirements pending issues, if any.

Annex A, Traceability Matrix, presents the matrix that contains information regarding the traceability between the operational requirements for each scenario and the consolidated requirements.

2. Documents

This section presents the list of applicable and reference documents as well as the documentation hierarchy this document is part of.

2.1 Applicable Documents

This section presents the list of the documents that are applicable to the present document. A document is considered applicable if it contains provisions that through reference in this document incorporate additional provisions to this document.

[AD-1] "Technical Annex", EMMON Project, ARTEMIS Joint Undertaking Call for proposals ARTEMIS-2008-1, Grant agreement no. 100036, 2009-03-23.

[AD-2] "D3.4 Water quality scenario operational requirements", EMMON Project, Pedro Braga, Rui Mónica and Loukas Petrou, FP7-JU-EMMON-2009-DL-WP3-005, Version 2, 2010-02-26.

[AD-3] "D3.5 Urban quality of life scenario operational requirements", EMMON Project, Paul Bustamante, Karol Grandez and Manuel Santos, FP7-JU-EMMON-2009-DL-WP3-006, Version 2, 2010-02-26.

[AD-4] "D3.6 Marine environments scenario operational requirements", EMMON Project, Paul Mínguez-Olaondo and Nagore Guarretxena, FP7-JU-EMMON-2009-DL-WP3-007, Version 2, 2010-02-26.

[AD-5] "D3.7 Civil protection scenario operational requirements", EMMON Project, Rui Mónica and Loukas Petrou, FP7-JU-EMMON-2009-DL-WP3-008, Version 2, 2010-02-26.

[AD-6] "D3.8 Event propagation simulation operational requirements", EMMON Project, Lubo Jankovic, FP7-JU-EMMON-2009-DL-WP3-009, Version 2, 2010-02-26.

2.2 Reference Documents

[RD-1] "ESA PSS-05-03 Guide to the software requirements definition phase", ESA, ISSN 0379-4059, Issue 1, May 1995.

[RD-2] "Extensible Markup Language (XML)", http://www.w3.org/XML/, 2009-05-20.

[RD-3] "Hypertext Transfer Protocol -- HTTP/1.1", IETF, http://www.ietf.org/rfc/rfc2616.txt, June 1999.

[RD-4] "Simple Mail Transfer Protocol", IETF, http://tools.ietf.org/rfc/rfc5321.txt, October 2008.

[RD-5] "Real World Issues in Deploying a Wireless Sensor Network for Oceanography", Tateson, Jane and Roadknight, Christopher and Gonzalez, Antonio and Khan, Taimur and Fitz, Steve and Henning, Ian and Boyd, Nathan and Vincent, Chris and Marshall, Ian, Workshop on real-world wireless sensor networks REALWSN'05, Stockholm, Sweden, June 2005

[RD-6] "Acoustic methods for locating leaks in municipal water pipe networks", Hunaidi, O.; Wang, A.; Bracken, M.; Gambino, T.; Fricke, C., International Conference on Water Demand Management, Jordan Pages 1-14, 30 May – 3 June, 2004

3. Executive Summary

This document presents a consolidation of the operational requirements and constraints, derived from the end-user needs for the various scenarios studied and which suit the EMMON scope.

"WP3 - User environment requirements and needs" objective is to systematically identify the end-user needs and requirements that should be taken into account in the project for each application operational scenario. The WP is split into six (6) Tasks, five of these focus on a particular application scenario for the technology:

- "T3.2 - Water quality scenario";
- "T3.3 - Urban quality of life scenario";
- "T3.4 - Marine environments scenario";
- "T3.5 - Civil protection scenario";
- "T3.6 - Event propagation (Fire, pollution, etc) simulation".

The sixth task of this WP, T3.1, is to consolidate the operational scenarios requirements from the end-user input, "T3.1 - Consolidation of operational scenarios requirements".

Beyond of consolidation of operational requirements and constraints, this deliverable provides an input to the research teams in the work packages 4 to 7, and is to be considered for the LSWSN operation.

This deliverable also presents EMMON's main components, (C&C, Sensor Network and PDA, see Figure 1) and depicts the structure and relation between them. Thus, the consolidated requirements are related to each component.

4. System Overview

The EMMON system can be divided into two main components. One is the sensor network, composed by nodes that sense some natural parameters and communicate the results amongst them to collaborate in providing the overall results to some entity. The other component gets the information from the sensor network and produces services to end users. This entity can be further divided into a Command and Control (C&C) module and a PDA module.

The C&C module encompasses everything that is presented to the end user which is monitoring and controlling the measurement of physical parameters covered by the sensor network. This includes the Graphical User Interfaces (GUI) where the user can monitor the values in real-time and navigate through the historical data. The intrinsic characteristic of this module is that it allows monitoring the entire sensor network, from a high level perspective, using every sensing value, to produce a complete picture of the status of the parameters being read, to a single sensor perspective.

The PDA module represents the mobile device used by the operational user that will go into the field and that needs to connect to the sensor network to monitor local values or to perform diagnostic or maintenance activities. This mobile device presents a helpful tool in searching for specific geographical areas associated to some values that are seen on the top-level C&C monitoring that have triggered alarms, for example. It will also be helpful for detecting malfunctioning sensor nodes. The main distinction between PDA and C&C modules, and that makes the PDA not being considered also as a Command & Control system by itself, is that it is not a mandatory part of the overall system – and not feasible – that the user be able to monitor the whole sensor network just by accessing the nearest sub-network of sensors.

Figure 1 illustrates the relation between these three modules. This structure and module configuration is considered throughout this document, including in the requirements.

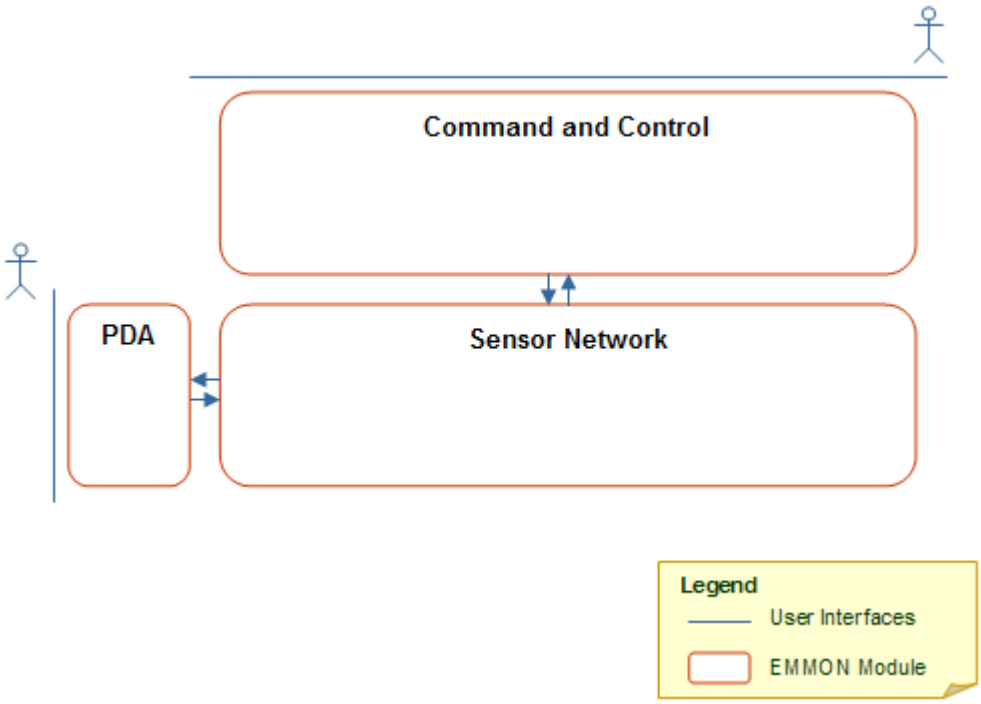

Figure 1 - EMMON modules

5. Use Cases Catalogue

This section presents the Use Case Catalogue and the actors list for the domain of the Scenario Requirements Specification.

5.1 Actors List

This section presents the Actors List for the domain of the Scenario Requirements Specification.

5.1.1 Physical Environment

The physical Environment is where the sensor network is deployed. It encompasses all environmental parameters to be measured, such as air temperature, for example.

5.1.2 C&C Operator

A human that interacts with the system receiving information and providing instructions through the C&C user interfaces.

5.1.3 PDA Operator

A human that interacts with the system receiving information and providing instructions through the PDA user interfaces.

5.1.4 External Information System

External information systems are other systems that interact with the EMMON system asking for and receiving information through machine-machine interfaces.

5.2 Use Cases

This section presents the Use Case Catalogue for the domain of the Scenario Requirements Specification.

5.2.1 PDA Use Cases

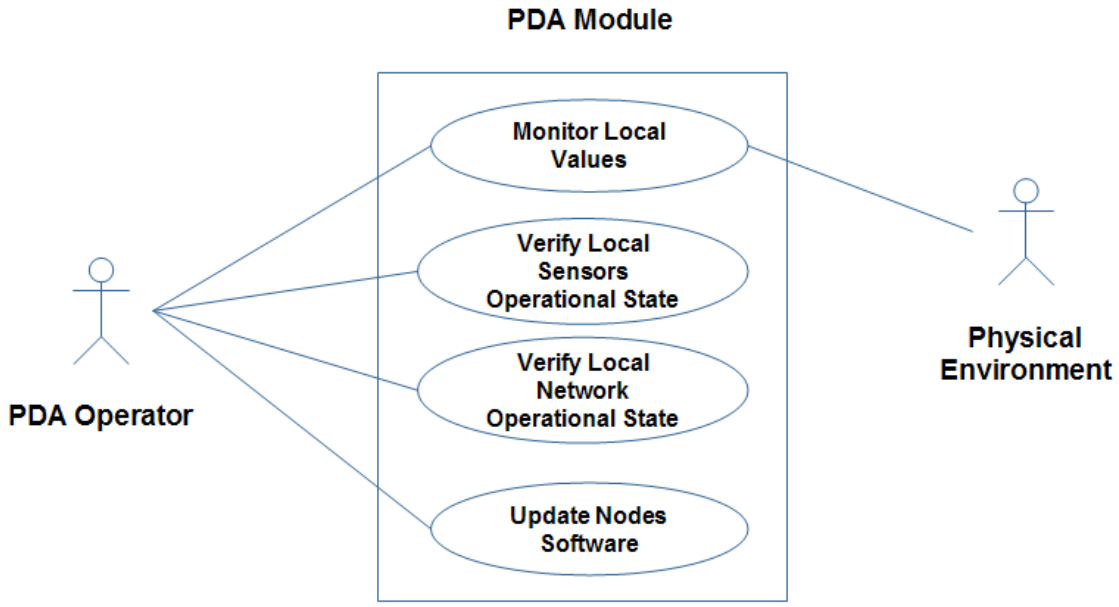

Figure 2 - PDA use cases

The PDA Operator can locally monitor values read by the WSN. The values start to appear on the PDA after a registration process in the network. The values appearing in the PDA will always be from a sub-set of sensors logically connected to the same sub-network where the PDA is connected to.

The PDA operator shall perform some diagnosis on the sensors and network where the PDA is connected to. The operator can verify the state of each sub-network attached sensor, the operator can:

- Verify corrected network initialisation and receiving and transmitting data status;
- Verify the consistent operational state;
- Confirm the status of the power supply (electrical batteries and generators).
- Verify the state of the sub-network: links' quality, lack of redundant links, detail the respective number of sensors dependent on each link, and verify the network nodes' power state.
- Perform some maintenance, for example upload new firmware for a set of sensors or network nodes or upload a new configuration setup.

5.2.2 C&C Data Navigation

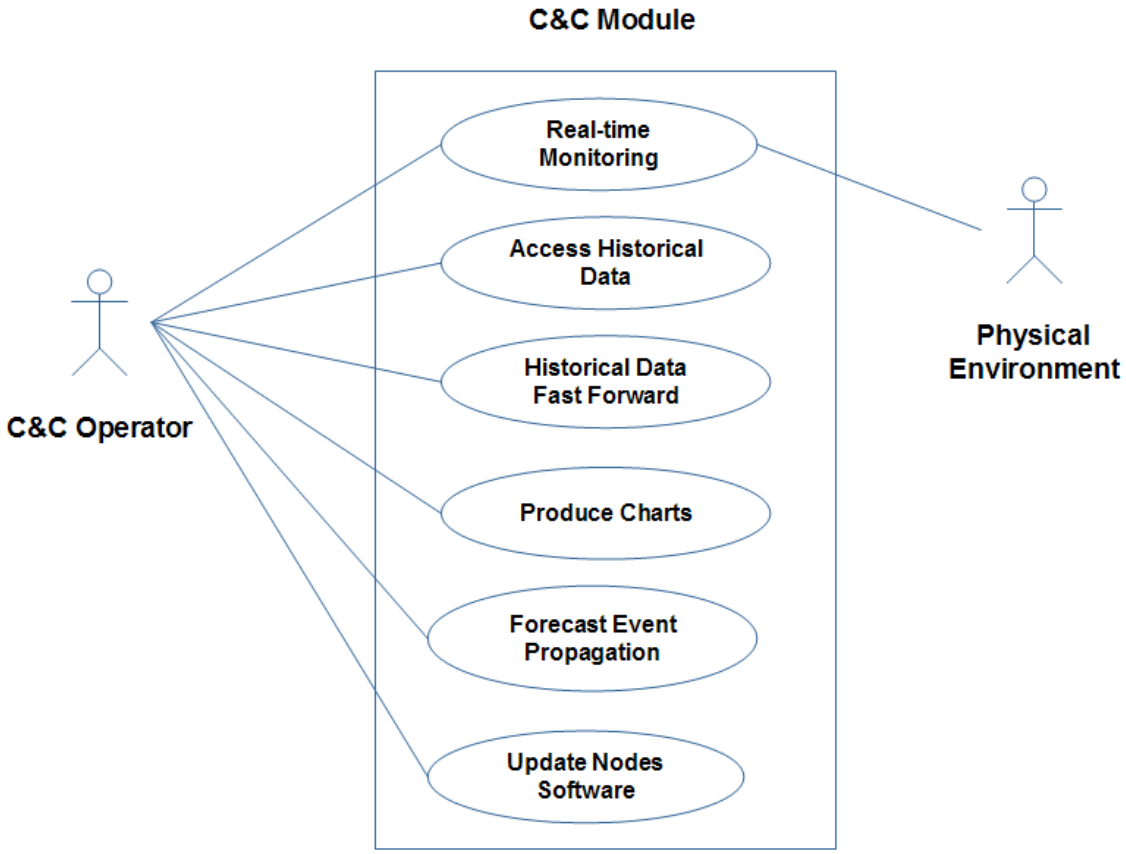

Figure 3 - C&C data navigation use cases

The C&C Operator can monitor the physical environment in real-time. The values that are being presented to the C&C Operator will be updated every time new data arrives to the C&C from the WSN.

The C&C Operator can access historical data in different ways: accessing snapshots at specified time, visualising the evolution of the values through time in fast forward for a specified time interval, or producing charts for a specified set of sensors with aggregated values (average, sum, max, min, etc…) within a specified time interval.

The C&C Operator can also ask for the system to forecast some event propagation into the near future. The system will compute this based on mathematical modules of the physical environment, historical data and current environment conditions (time of day, current wind, etc…).

5.2.3 C&C Alarm Use Cases

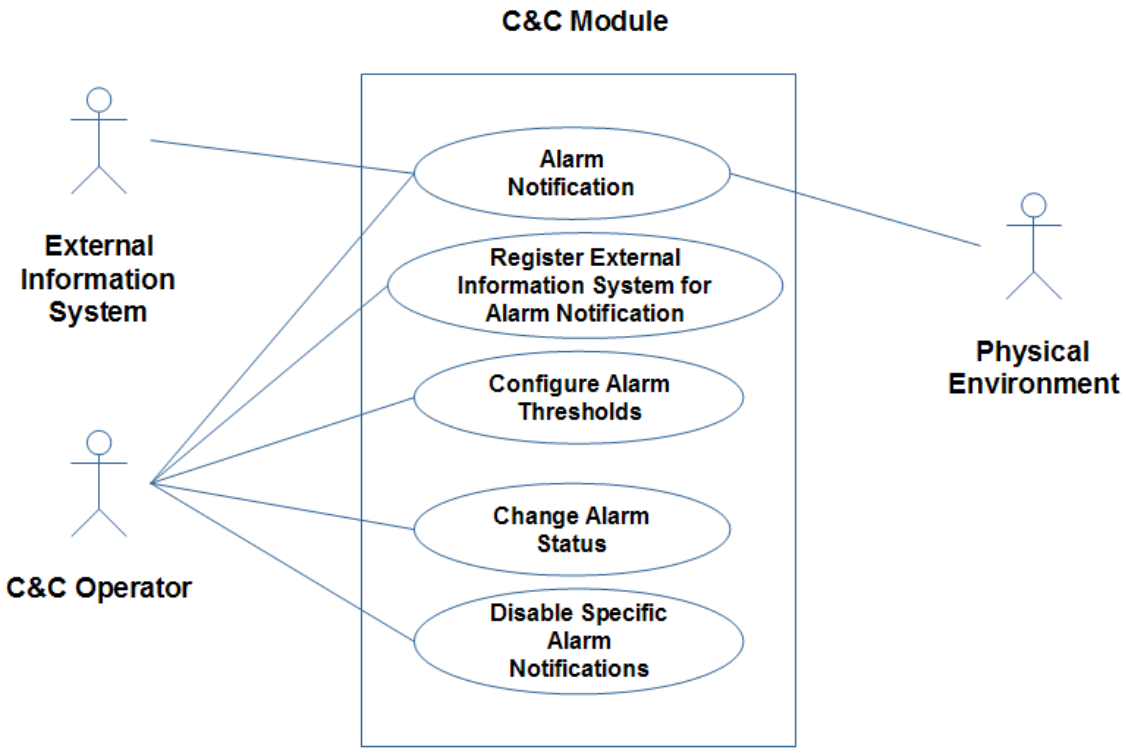

Figure 4 - C&C alarm use cases

The C&C Operator receives alarm notifications from the system when some predefined situations occur. Alarm situations might be values over predefined thresholds, a quick change of values over a small time interval or other anomalous situation that might be detected by the analysis of data measured by the sensors in the Physical Environment, and that needs attention by the C&C Operator. Some alarm notifications might also be sent to external Information Systems.

The C&C Operator can register external Information Systems for alarm notification. For each external system, sub-sets of alarm types can be specified. This way, each system only receives notifications of alarms of interest to them.

The C&C Operator can configure the situations that trigger alarms (absolute thresholds, variation thresholds, etc).

The C&C Operator can acknowledge an alarm by changing its status. While the alarm has not been acknowledged by the C&C Operator, the system will keep notifying of the alarm. There might be several alarm statuses predefined to allow for an adequate handling of the situation. The C&C Operator might also temporarily disable certain types of alarms for a certain sub-set of sensors (e.g.: geographical area). This might be useful when handling some situation on the field or in maintenance, to prevent from getting alarm notifications due to these actions.

5.2.4 C&C Readings Validation Use Cases

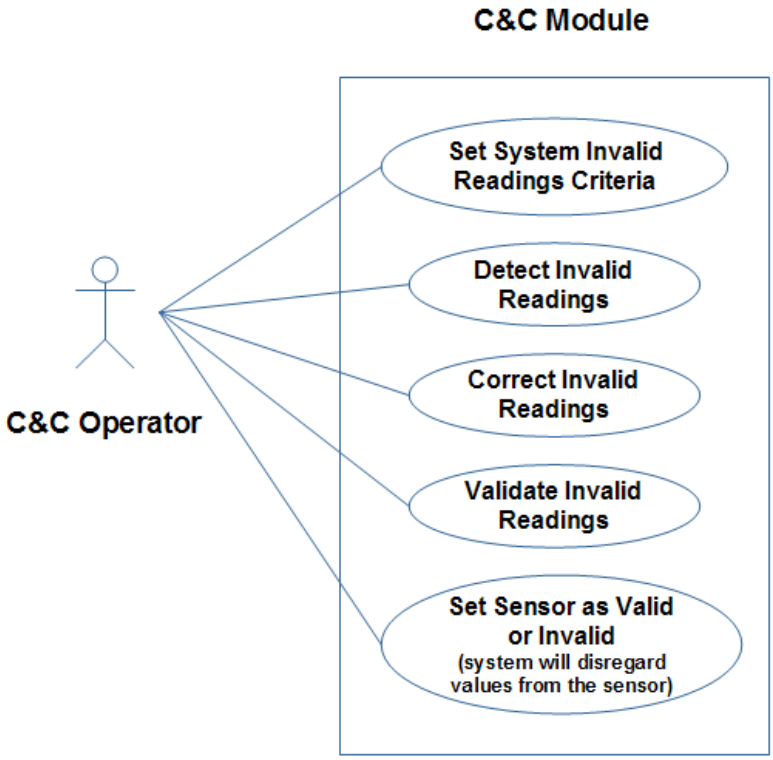

Figure 5 - C&C readings validation use cases

The C&C Operator can establish criteria to detect potentially invalid readings. After detecting a potentially invalid reading the C&C Operator can verify the potential error and correct or validate it. When confirming incorrect values from a sensor, the C&C Operator can mark the sensor as invalid, making the system disregard the values reported by the that sensor.

6. Requirements Consolidation Approach

In this section, the rationale used for consolidating the operational requirements from all the scenarios is presented.

6.1 Consolidated Scenarios

Before going into detail regarding the consolidation rules, it is important to clarify which scenarios were taken into consideration for this consolidation process. The previous version of this document (version 2) took into account the original scenarios identified in the Technical Annex [AD-1] (see Figure 6). The PDA module represents the mobile. For each scenario that was presented in the second version of this document extended research and analysis was performed for each scenario taking into account the end-user needs as well as the implementation technical details. As a result, all of the scenarios were reassessed. This version (version 3) presents a different reality covering a narrow range of scenarios and monitoring applications.

The Water Quality Scenario [AD-2] is divided in two sub-scenarios: a Water Quality sub-scenario (the original scenario identified in the Technical Annex [AD-1]), and a Water Pipelines sub-scenario, these have been included in the second version of this deliverable.

For the Water Quality sub-scenario, it has become apparent that ANA does not require a large density sensor network. Although this scenario involves a huge area to monitor, ANA does not need to have it all covered by sensors. The Water Quality sub-scenario does not seem to be a viable application scenario for the EMMON project. The main reasons that support this conclusion are highlighted below:

- **Monitoring area** – the proposed area of 50 km2 to be monitored by the EMMON system is an excessively low value for ANA's needs, as they need to monitor a total of 969 rivers running over a distance of about 1.620.000 km. The São Francisco River alone has a basin area of about 641.000 km2.
- **Density** – the node density needed by ANA is far lower than anticipated (and envisaged by the EMMON system). ANA only requires sensing points on a few strategically chosen locations, mainly along rivers, with node distances in the range of hundreds to thousands of meters.
- **Proposed solution** – the proposed EMMON system (a large-scale WSN solution) does not fit ANA's needs. For their current monitoring purposes, a more beneficial solution might be to have smart meters placed in strategic locations along the monitored rivers and basins. No large density is needed, since the measurement points need to be distant from each other (for geographical reasons), and the number of sensing points is lower than EMMON expectations.

For the Water Pipelines sub-scenario, a great effort was made to explore the multiple methods for location leaks in water pipe, networks.

- **Proposed solution**: The parameters to be measured for this scenario are sound (through a microphone or an ultrasound detector) and Vibration (through an accelerometer). The sensors are required to be installed on top of the control valves that already exist in the pipeline network. Further information regarding Acoustic Methods for Locating Leaks in Municipal Water Pipe Networks is presented in [RD-6]. These methods requires high processing capabilities (execution time and accuracy) and this produces a significant amount of data, therefore a trade-off will exist between the transmission of a large amount of data (with subsequent remote processing) versus local processing and transmission of the leakage message only (leak characteristics).

- **Deployment and Density**: The sensors are placed inside already existing vertical chambers. These chambers are 1.5m deep, they are mainly located in the pavement and in the road and they are accessible through 10cm diameter lid. The distance between adjacent sensors depends on the pipe type. Usually, for plastic and metal pipes this distance is 70-80m and 120-140m respectively.
- **Communications**: The lids are typically metallic. All these constraints: sensors placement; distance between adjacent sensors; metallic lids and pipes compromise signal transmission.

  This scenario does not require a large density sensor network. Moreover, all the constraints stated above will significantly compromise signal transmission.

Another scenario that was found to be not feasible for the EMMON project is the Marine Environments [AD-4] scenario. However, for this particular scenario, the reasons are somewhat different. This is a viable and interesting scenario from the end user's point of view, but the problems arise from its problematic and complex practical realisation. The main issues regarding this scenario are highlighted below:

- **Equipment price** – the price of the hardware needed to monitor the specified physical parameters is prohibitive, especially when the large-scale objective is taken into consideration. To measure longitudinal and vertical wind velocity in the sea, for example, specific three-dimensional sonic anemometers would be needed, each with a cost varying from 2500€ to 3800€.
- **Lack of equipment** – for some of the specified physical parameters to monitor, there is currently no hardware that can provide those measurements. For example, no hardware was found that would allow the measurement of dissolved SO2 in the sea.
- **Deployment** – a typical marine sensor network will be composed of floating and diving sensor nodes. This scenario requires a floating structure. Generally, a buoy supporting sensor and radio package, cage, cables, ropes, machining, electronics housing, batteries, solar panels and a signalling light is used. Also, it is usually required by marine authorities to put a light on top of the buoy. To support all necessary sensors, these structures are large and heavy (not to mention very expensive).
- **Physical protection** – it would be very difficult (and expensive) to provide physical protection for the nodes, giving them appropriate protection from the harsh environmental conditions of operating in this scenario.
- **Maintenance** – an intervention to repair or adjust something in the station would be a very complicated, difficult and dangerous operation. Access to the sensor nodes is also highly difficult driven by the nature of this application scenario.
- **Communications** – early analysis indicates that sea-to-sea communication can produce tremendous stresses on network communication activities, which could lead to its collapse [RD-5].

As stated in the first version of this document, the Civil Protection scenario was left out of that version due to the lack of information provided by end-users at the time. This scenario has now been included in the second and subsequent versions.

Finally, the original Urban Quality of Life scenario [AD-3] was also divided in two sub-scenarios: an Urban Quality of Life sub-scenario (reflecting the original scenario identified in the Technical Annex [AD-1]), and an Ozone Spatial Representativeness sub-scenario. This latter sub-scenario appeared after some conversations with a Portuguese entity - the Steering Committee and Regional Development of the North (CCDR-N) – while trying to come up with alternative scenarios for the EMMON project, and consisting of Ozone (O3) measurement distribution and levels around existing end-user measurement stations to make the reading area broader. The objective is to provide an overall picture of O3 distribution for the targeted area (1km2 to 50km2).

Figure 6 summarises the above considerations, showing which scenarios were used for the consolidation process in each version of this document. Please note that scenarios highlighted in red were not used in the consolidation process (for the specified version of the consolidation), and scenarios highlighted in green represent new scenarios.

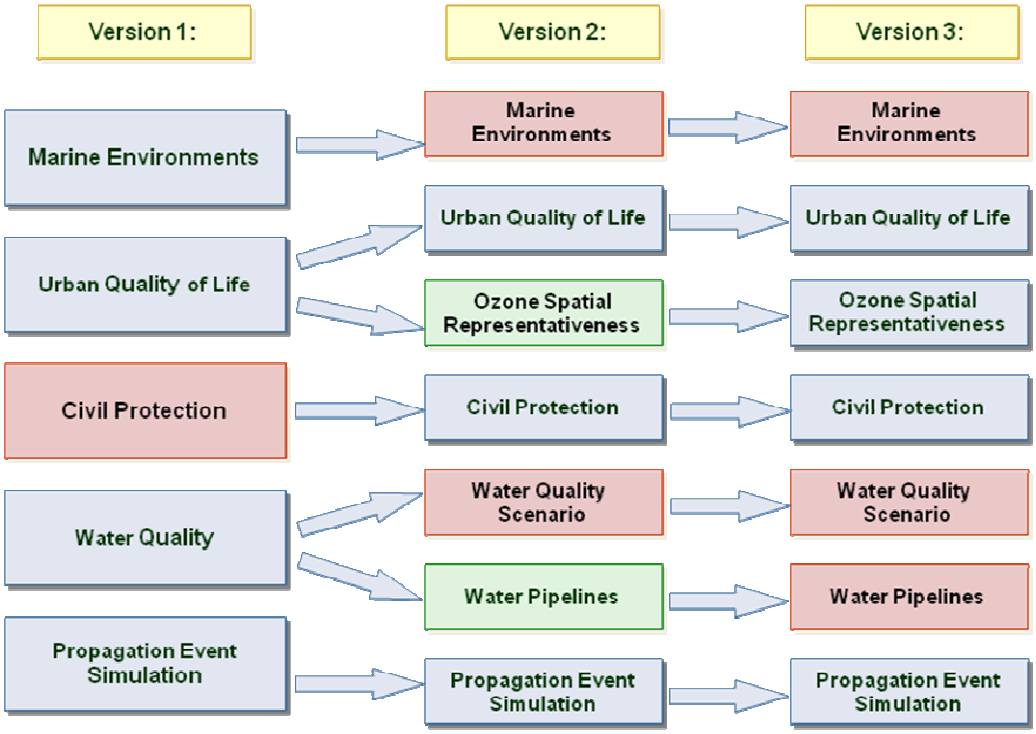

Figure 6 - Consolidated scenarios evolution throughout the versions of this document

6.2 Consolidation Rules

The EMMON system must provide a solution as generic as possible, in order to be able to be tuned to fit several applications (or application patterns). It is obvious that we cannot build a system that will serve as a solution to every single large-scale monitoring problem, but the goal is to provide a solution that can be easily adapted to various applications, with only small modifications.

With this premise in mind, and in order to consolidate the operational requirements, focus was given to the identification of the operational requirements that are common to as many scenarios as possible. Nevertheless, some operational requirements identified for a particular scenario were included in the requirements consolidation, even though they are not common to several scenarios. This was due to the fact that they were considered important to the system from a global point of view.

The following steps were used for the consolidation process:

- All of the scenarios were analysed to identify functional and non-functional requirements and to organise them by module (C&C, Sensor Network and PDA);
- Within each module, the requirements were organised by logical groups (first column of Table 4, Table 5 and Table 6);
- For each logical group, the operational requirement for each particular scenario was listed (see Table 4, Table 5 and Table 6);
- For each logical group, a consolidation rule was decided;

- Logical groups for which it was not possible to identify a common rule were handled individually.

The following table presents the description of the consolidation rules used on the consolidation process:

Consolidation Rule	Description	Example
RULE-1	Specific to each scenario. A generic consolidated requirement was created.	REQ-EMMON-0180: Each particular scenario has a set of physical parameters that need to be measured. To make the system as generic as possible, a generic requirement was specified.
RULE-2	The consolidated requirement reflects the most comprehensive case.	REQ-EMMON-0110: Some scenarios specify a single data set for the sensor readings, while another specifies two data sets (for raw data and data aggregation).
RULE-3	The consolidated requirement reflects the choice of one operational requirement in detriment of the other(s).	REQ-EMMON-1040: Though there was a scenario with a more demanding requirement for power autonomy (3 years), it was decided to set the consolidated requirement for 1 year, due to foreseen hardware limitations.
RULE-4	The consolidated requirement aggregates the most relevant features of the corresponding operational requirements.	REQ-EMMON-1540: Requirements of historical and real-time diagrams were joined with a fast-forward (future data simulation) requirement, to produce a consolidated requirement for diagrams with historical, real-time and future data.
RULE-5	Although not common to several scenarios, the requirement was considered important for the system, from a global point of view.	REQ-EMMON-6010: Although only raised in one of the scenarios, it was considered important for the overall system to allow over the air programming and configuring of any node through the C&C module.
RULE-6	The consolidated requirement aggregates the most relevant features of the corresponding operational requirements, and introduces some generalization.	REQ-EMMON-4030: This requirement takes into account features of secure transmission protocols and encryption found on the corresponding scenario requirements, but does not commit to a specific technology.
RULE-7	The operational requirements are identical. The consolidated requirement reflects this.	REQ-EMMON-0030: This requirement is simply a reflection of the corresponding scenario requirements.
RULE-8	The operational requirement reflects the most demanding case.	REQ-EMMON-2060: From the scenarios, we have 3 temperature ranges: -10º to 60º, -15º to 50º and -20º to 50º (all in degrees Celsius). The resulting consolidated range is: -20º to 60º.

Consolidation Rule	Description	Example
RULE-9	Specific to each scenario (not consolidated)	No example available as no consolidation took place.
RULE-10	Other cases were analysed case by case	REQ-EMMON-4040: This requirement comes from the decision to group most of the security issues related to the C&C module in a single requirement.

Table 3 - Consolidation rules description

Some new requirements were added to the catalogue, although they were not identified in any of the studied scenarios. These were raised by expert judgement and considered important for the system. They are marked with "New requirement" in the Consolidation rule field and have "Low" stability in the requirements catalogue, as they still need to be discussed, confirmed and validated with end-users.

The following sub-sections summarise the results obtained from the consolidation process, detailing the consolidation rule used for each logical group of operational requirements, within each EMMON module (C&C, Sensor Network and PDA).

6.2.1 C&C Module

Table 4 summarises the results obtained from the consolidation process, for the C&C module of the EMMON system:

Req. Logic Group	Urban Quality of Life	Ozone Spatial Representativeness	Civil Protection	Event Propagation	Rule #
Access Restrictions	Access to GUI restricted to users with proper credentials GUI uses an encrypted authenticating and authorisation system	Configurable user and group accounts Authentication mechanism Restrict access to historical and real-time data to users with proper credentials	-	-	RULE-4
Alarm Actions	-	Configurable sets of actions to be executed in alarm situations Notification to specific entities	Alert users when thresholds are crossed Notify regional authorities	-	RULE-3
Alarm Interface	-	Pop-up alarm information, visual information with area status	-	-	RULE-7
Alarm Thresholds	-	Configurable thresholds by range and persistence	Endangerment levels Configurable thresholds by sudden change and big variance	-	RULE-4

Req. Logic Group	Urban Quality of Life	Ozone Spatial Representativeness	Civil Protection	Event Propagation	Rule #
Configurable Data	Sensor data range, set of variable to measure, alarm thresholds	Several levels of information customization Detailed information on demand	Several levels of information customization Detailed information on demand	-	RULE-4
Data Chronology	Historic and present data	Historic and present data	Historic and present data	-	RULE-2
Documentation	-	-	-	Technical and user manual	RULE-5
Services	-	GIS environment, operational conditions, sensors' operating parameters, schedule maintenance, enable/disable nodes	GIS environment, operational conditions, sensors' operating parameters, schedule maintenance, enable/disable nodes Provide information to authorities	-	RULE-6
GUI	Web-based	Search, selection, geographical visualization with zoom	2-D graphic representation of node positioning with zoom Map fire front and isothermal lines	2-D graphic representation of node positioning	RULE-6
Maintenance	Remote maintenance	Remote maintenance	-	-	RULE-7
Performance	30 sec maximum reading delay	Update information every minute	Update information every minute	Measure and transmit parameters in intervals no larger than 6mins	RULE-6
Prediction/Estimation	-	-	Estimate fire front	-	RULE-6
Sensor Data Set	-	1 data set identifying relevant fields	2 data sets: one for raw values and another for aggregated values	-	RULE-2
Validation of Sensor Readings	-	Range, Sudden change, Persistence	-	-	RULE-4
Others	-	-	-	-	RULE-10

Table 4 - Requirements consolidation approach for the C&C module

6.2.2 Sensor Network Module

Table 5 summarises the results obtained from the consolidation process, for the Sensor Network module of the EMMON system:

Req. Logic Group	Water Pipelines	Urban Quality of Life	Ozone Spatial Representativeness	Civil Protection	Event Propagation	Rule #
Physical measures	Sound, vibration	CO2, humidity, light intensity, amount of trash in containers, sound	Temperature, air relative humidity, ozone concentration	Temperature, air and ground humidity, wind speed, CO and CO2	Pollution, fire detection	RULE-1
Passive Sensors	-	-	Yes	Yes	-	RULE-7
Data Aggregation	-	-	Single reads and data aggregation	Single reads and data aggregation	-	RULE-2
Minimum Sensor Points	-	100,000	100,000	100,000	10,000	RULE-10
Power Autonomy	3 years	-	1 year	-	-	RULE-3
Performance	Collect readings every day or every other day	-	Provide readings at most every hour and transmit average data every hour	On normal operation, transmit 1 block of readings each day, on emergencies, transmit each 30s	Measure and transmit in intervals no larger than 6mins	RULE-6
Reading Range	CO2 : 0 to 10,000 ppm Humidity : 0 to 100% Light : 0 to 30,000 lx Sound : 40 to 110 dB	-	Ozone : 20 to 200 ppb Temperature : -10 to 50 ºC Humidity : 0 to 100%	-	-	RULE-1
Operational Temperature	-10 to 60ºC	-15 to 50ºC	-15 to 50ºC	-	-20 to 50ºC	RULE-8
Distance Between Points	70 to 80m for plastic pipes and 120 to 140 for metal ones	10 to 500m	<100m	-	TBD	RULE-6
Physical Protection	-	Rain, hail and water	Water, other hostile conditions	Water	-	RULE-6
Connectivity Verification	Yes	-	Yes	-	By simulation	RULE-3
Others	-	-	-	-	-	RULE-10

Table 5 - Requirements consolidation approach for the Sensor Network module

6.2.3 PDA Module

Table 6 summarises the results obtained from the consolidation process, for the C&C module of the EMMON system:

Req. Logic Group	Urban Quality of Life	Ozone Spatial Representativeness	Civil Protection	Event Propagation	Rule #
Monitoring	-	Local monitoring	Monitor sub-regions	-	RULE-2
Alerts	-	Alert regional PDA	Alert regional PDA	-	RULE-6
Interface	-	Local search, selection, geographical visualization	mapping of local sensor positions, as well as readings, through a GUI	-	RULE-4
Security	Communications use TLS encryption	Authentication mechanism	-	-	RULE-6
Services	-	Map local area, receive information from the nearest sensors, supervision of the operating conditions of local sensors, receive/transmit commands/reports from/to the C&C, provide instructions for the installation and maintenance of the sensors, field sensor programming	Map local area, receive information from the nearest sensors, supervision of the operating conditions of local sensors, receive/transmit commands/reports from/to the C&C, provide instructions for the installation and maintenance of the sensors, field sensor programming	-	RULE-7
Operational	-	Identify elements of interest by colours and different layers	-	-	RULE-7
Others	-	-	-	-	RULE-10

Table 6 - Requirements consolidation approach for the PDA module

7. Technical Requirements

Requirements will be organised by their type. The requirements types are presented in sub-section 7.1; sub-section 7.2 explains the requirements attributes and conventions; and finally on sub-section 7.3 the requirements catalogue presents all the requirements.

7.1 Requirements Types

The following requirements types were identified according to European Space Agency (ESA) "Guide to the software requirements definition phase" [RD-1].

7.1.1 Functional Requirements

A function is a "defined objective or characteristic action of a system or component" and a functional requirement "specifies a function that a system or system component must be able to perform".

7.1.2 Non-Functional Requirements

7.1.2.1 Performance Requirements

Performance Requirements specify numerical values for measurable variables used to define a function (e.g. rate, frequency, capacity, speed and accuracy). Performance requirements may be included in the quantitative statement of each function, or included as separate requirements.

7.1.2.2 Interface Requirements

Interface Requirements specify hardware, software or database elements that the system, or system component, must interact or communicate with. Interface requirements should also be classified into "internal" and "external" interface requirements, depending upon whether or not the interface coincides with the system boundary.

7.1.2.3 Operational Requirements

Operational Requirements specify how the system will run (i.e. when it is to be operated) and how it will communicate with human operators (e.g. screen and keyboards etc.). Operational requirements may describe physical aspects of the user interface. Descriptions of the dialogue, screen layouts, command language styles are all types of operational requirements.

7.1.2.4 Resource Requirements

Resource Requirements specify the upper limits on physical resources such as processing power, main memory, disk space etc. They may describe any requirements that the development or operational environment place upon the software. A resource requirement should state the facts about the resources, and not constrain how they are deployed.

7.1.2.5 Verification Requirements

Verification Requirements constrain the design of the product. They may do this by requiring features that facilitate verification of system functions or by saying how the product is to be verified.

7.1.2.6 Documentation Requirements

Documentation Requirements state project-specific requirements for documentation. The format and style of the Interface Control Documents may be described in the documentation requirements, for example. Documentation should be designed for the target readers (i.e. users and maintenance personnel).

7.1.2.7 Security Requirements

Security Requirements specify the requirements for securing the system against threats to confidentiality, integrity and availability. They should describe the level and frequency of access allowed to authorised users of the software. If prevention against unauthorised use is required, the type of unauthorised user should be described. The level of physical protection of the computer facilities may be stated (e.g. backups are to be kept in a fire-proof safe off-site).

7.1.2.8 Portability Requirements

Portability Requirements specify how easy it should be to move the software from one environment to another. Possible computer and operating systems, other than those of the target system, should be stated.

7.1.2.9 Quality Requirements

Quality Requirements specify the attributes of the software that make it fit for its purpose. The major quality attributes of reliability, maintainability and safety should always be stated separately. Where appropriate, software quality attributes should be specified in measurable terms (i.e. with the use of metrics).

Software **reliability** is “the ability of a system or component to perform its required functions under stated conditions for a specified period of time”. The reliability metric, “Mean Time Between Failure” (MTBF), measures reliability according to this definition.

Maintainability is ‘the ease with which a software system or component can be modified to correct faults, improve performance or other attributes, or adapt to a changed environment'. All aspects of maintainability should be covered in the specification of the maintainability requirements, and should be specified, where appropriate, in quantitative terms.

7.2 Requirements Definition Standard

All requirements are presented in tabular format using Table 7

<ID> - <Title>					
Type:	<Type>	**Priority:**	<Priority>	**Verification Method:**	<Verify-method>
Status:	<Status>	**Stability:**	<Stability>	**Version:**	<Version>
<Detail>					
Notes:	<Notes>				
Traceability:	<List of high-level user requirements, e.g. REQ1 ; REQ2; etc>				
Consolidation Rule:	<Consolidation Rule>				

Table 7 - Requirements presentation table

All the words enclosed by "<>" on Table 7 are keywords to be replaced by the real requirement information. Except for the <Notes>, every attribute is mandatory. These requirement attributes are explained next:

<**ID**>: This is the unique identifier of the requirement. This identifier will be used to reference the requirement (ex.: in traceability). The requirement follows the convention: "REQ-EMMON-<Number>", where:

REQ-EMMON: A prefix that indicates the item describes a requirement;

<**Number**>: A 4 digit number that starts with 0000 and is incremented by steps of 10. Example: 0000, 0010, 0020, 0030 (allowing insertions of new requirements without changing order).

<**Title**>: A concise description of the requirement

<**Type**>: This is the type of the requirement as defined on sub-section 7.1.

<**Priority**>: The priority of the requirement:

"**High**": Hard requirement

"**Low**": Nice to have

<**Verify-method**>: The method(s) that will be used to verify if the requirement was fulfilled

"**Analysis**": The processing of accumulated data obtained from other qualification methods. Examples are reduction, interpretation or extrapolation of test results. Analysis also includes any analogy claims by the production of evidence of previously accepted testing. In the case of compliance by existing evidence as defined by a Test Plan, the acceptability of the evidence will be established by review, prior to the next level of test.

"**Demonstration**": The operation of a system (hardware of software), or part of a system, that relies on observable functional operation not requiring the use of instrumentation, special test equipment, or subsequent analysis.

"**Inspection**": The visual examination of an item of hardware, software code, documentation, etc., without the need for any manipulation or operation.

"**Test**": The operation of a system (hardware or software), or part of a system, using instrumentation or other special test equipment to collect data for later analysis.

"**Simulation**": The proving of an aspect of a system by theoretical modelling or calculation.

<**Status**>: This is the status of the requirement. It defines the workflow of the requirement.

"**Proposed**": Requirement has been proposed.

"**Approved**": Requirement is approved after formal internal review.

"**Deleted**": Requirement was deleted (even when deleted the requirement identifier shall be maintained and not used by other requirements).

"**N/A**": This means "Not Applicable". The requirement is not applicable to the final solution, consequently it won't be fulfilled.

<**Stability**>: This is the stability. It defines the likelihood of changes on the requirement definition.

"**High**": The requirement is stable, understood by the project team, no open issues are associated to it, and is unlikely to be changed.

"**Medium**": The requirement could change but it's not expected.

"**Low**": The requirement most likely will change or there is high uncertainty associated to the realisation of specification of this requirement.

<**Version**>: This is the version of the requirement. It identifies the requirements document version where the requirement was created or last updated. In a new version of the requirements document, the requirements unchanged will keep the version number. New or updated requirements will have the new document's version as the requirement version. It will thus allow for traceability of changed requirements over different document versions. Versions are numbers starting with 1 and sequentially incremented by 1 unit. Example: 1, 2, 3, etc.

<**Detail**>: This is a multi-line text field that accepts carriage returns and presents detailed information about the requirement. This is where the requirement text is stated. This field is also known as the requirement body.

<**Notes**>: This is the only optional attribute and brings additional information about the requirement as for example: problems, issues, changes needed or traceability information from where the requirement was derived/originated.

<**Traceability**>: This field consists of one or more high-level user scenario requirements from which each particular consolidated requirement was derived.

<**Consolidation Rule**>: This field consists of the rule used to consolidate this requirement. It is of the form "RULE-X", where "X" is the consolidation rule number.

7.3 Catalogue

7.3.1 C&C

This section presents the consolidated requirements catalogue for the Command & Control (C&C) module of the EMMON system.

7.3.1.1 Functional Requirements

REQ-EMMON-0010 - Historical and Real-time Data					
Type:	Functional	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall provide both historical and real-time data regarding the measured values. All data from previous sensor readings and validated by the C&C module shall be stored by the C&C module.					
Notes:					
Traceability:	REQ-UQL-0060; REQ-UQLO-0010; REQ-CIV-0010				
Consolidation rule:	RULE-2				

REQ-EMMON-0020 - Validation of Sensor Readings					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall classify each sensor reading as “Good”, “Suspicious” and “Invalid”, according to the following rules: - if the sensor reading is outside a configurable range (maximum and minimum allowed values), the reading shall be classified as “Invalid”; - if the first derivative between the current reading and the previous reading is higher than a configurable threshold, the sensor reading shall be classified as “Invalid”; - if the first derivative over a configurable period of time is bellow a configurable threshold, the sensor reading shall be classified as “Suspicious”; - if none of the previous rules applies, the sensor reading shall be classified as “Good”.					
Notes:	This classification of sensor readings is not related to the detection of an emergency situation, but rather with the correctness of the sensor data.				
Traceability:	REQ-UQLO-0090; REQ-UQLO-0100; REQ-UQLO-0110; REQ-UQLO-0120; REQ-UQLO-0150				
Consolidation rule:	RULE-4				

REQ-EMMON-0030 - Report Potential Malfunctions					
Type:	Functional	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall report potential sensor malfunctions when the reading is "Suspicious" or "Invalid".					
Notes:	This requirement is related to REQ-EMMON-0020 - Validation of Sensor Readings.				
Traceability:	REQ-UQLO-0130				
Consolidation rule:	RULE-7				

REQ-EMMON-0040 - Validation of Reported Potentially Invalid Readings					
Type:	Functional	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall allow for certified users to validate readings that were qualified as "Invalid" or "Suspicious".					
Notes:	This requirement is related to REQ-EMMON-0020 - Validation of Sensor Readings.				
Traceability:	REQ-UQLO-0140				
Consolidation rule:	RULE-7				

REQ-EMMON-0050 – Manual Data Correction					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall allow the manual correction of values originated from sensor readings, by C&C Operators. The manual modifications shall be saved by the C&C module with original value, new value, date of change and operator identification. Whenever the C&C module presents data sets and/or results, it shall notify if there are manually modified values in them.					
Notes:					

Traceability:	REQ-UQLO-0080
Consolidation rule:	RULE-7

REQ-EMMON-0060 - Configurable Alarm Thresholds					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall allow the manual configuration (create, modify, delete and view) of alarm thresholds for the monitored physical variables, by C&C Operators.					
Notes:					
Traceability:	REQ-UQLO-0160; REQ-UQLO-0170; REQ-CIV-0130; REQ-CIV-0140				
Consolidation rule:	RULE-4				

REQ-EMMON-0070 - Endangerment Levels					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall define the endangerment levels: "normal", "non-critical" and "critical". It shall be possible for the user to define sets of actions for the system to execute for each of these endangerment levels, to deal with emerging situations.					
Notes:	The sets of actions defined for each endangerment level can consist of defining and sending alerts, displaying visual information, sending commands to the sensors, sensor reconfiguration, etc...				
Traceability:	REQ-UQLO-0180; REQ-CIV-0120				
Consolidation rule:	RULE-2				

REQ-EMMON-0080 – Node Enabling and Disabling					
Type:	Functional	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Low	**Version:**	1
The C&C module shall allow a C&C Operator to configure individual nodes as “enabled” or “disabled”. A node which is set as “disabled” shall be regarded by the C&C module as not being part of it (and its sensor readings disregarded in terms of processing).					
Notes:	This requirement will allow the C&C module to ignore erroneous data from faulty (or not calibrated) sensor nodes so that the data does not taint the overall results. It can also allow for particular nodes to be disregarded, while being subject to maintenance activities.				
Traceability:	N/A				
Consolidation rule:	New requirement				

REQ-EMMON-0090 – User Accounts					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall allow creating, deleting, configuring and managing different account types, according to the type of user, each with its own access privileges. It shall also be possible to associate these accounts with the group account referred in requirement “REQ-EMMON-0100 – Group Accounts”.					
Notes:					

Traceability:	REQ-UQLO-0340; REQ-UQLO-0370
Consolidation rule:	RULE-4; RULE-5

REQ-EMMON-0100 – Group Accounts					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall allow creating, deleting, configuring and managing different group accounts types, each with its own access privileges. It shall also be possible to associate these accounts with the user accounts referred in requirement "REQ-EMMON-0090 – User Accounts".					
Notes:					
Traceability:	REQ-UQLO-0350; REQ-UQLO-0370				
Consolidation rule:	RULE-4; RULE-5				

REQ-EMMON-0110 – Sensor Data Sets					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	2
The C&C module shall define 2 (two) different data sets for the sensor readings: one for raw data and another for data aggregation. The data set for raw data shall consist of the following fields: - node location; - measurement parameter; - measurement type; - measurement value; - node operating condition; - node power status. The data set for data aggregation shall consist of the following fields: - cluster location; - activated nodes; - estimated situation; - nodes' operating condition; - nodes' power status.					
Notes:	Node location: information about the position (latitude, longitude and elevation) will be stored in a database in the C&C. Measurement parameter: defines what will be measured (temperature, wind speed, humidity, etc.) Measurement type: single measurement, RMS value, average, etc. Estimated situation: information regarding the situation (normal situation, emergency, etc.) Node operating condition: normal operation, critical operation, manual operation, etc. Information such as signal strength and sink location can be included in this field. Node power status: level of the battery.				
Traceability:	REQ-UQLO-0060; REQ-UQLO-0070; REQ-CIV-0180				
Consolidation rule:	RULE-2				

REQ-EMMON-0120 – C&C Services					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall provide the following services: - sensor readings linked to a GIS environment; - information regarding operational condition; - setup of sensors' operating parameters; - temporal and/or spatial search for recorded data and events; - scheduling of node maintenance procedures;					
Notes:					
Traceability:	REQ-UQL-0020; REQ-UQLO-0040; REQ-CIV-0090				
Consolidation rule:	RULE-6				

REQ-EMMON-0130 – Inform Authorities					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall distribute relevant data to the authorities, through web pages and/or web services.					
Notes:	This is a passive service, i.e., data is sent to the services on request. The information is available for the services to access it.				
Traceability:	REQ-UQLO-0190; REQ-UQLO-0200; REQ-UQLO-0230; REQ-CIV-0160; REQ-CIV-0260				
Consolidation rule:	RULE-3				

REQ-EMMON-0140 – Customizable Information On Demand					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall provide on demand and customizable information, according to user needs, at the following levels: - strategic; - management; - modelling; -training; - operational.					
Notes:	This means that, according to the level chosen by the user, the system will present different information.				
Traceability:	REQ-UQLO-0030; REQ-UQLO-0050; REQ-CIV-0040; REQ-CIV-0060				
Consolidation rule:	RULE-4				

REQ-EMMON-0150 – Alert Conditions					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall alert users if the monitored parameters are outside of the specified thresholds.					
Notes:					
Traceability:	REQ-UQLO-0220; REQ-CIV-0110				

Consolidation rule:	RULE-7

REQ-EMMON-0160 – Event Propagation Model					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall provide an event propagation model. This propagation model shall use past and present sensor data to predict future events.					
Notes:					
Traceability:	REQ-CIV-0070				
Consolidation rule:	RULE-6				

7.3.1.2 Performance Requirements

REQ-EMMON-1010 – Maximum Sensor Reading Delay					
Type:	Performance	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall provide the values of parameters at most 30 seconds after the reading was ordered by the user, or after the due time in time-triggered situations.					
Notes:					
Traceability:	REQ-UQL-1020				
Consolidation rule:	RULE-5				

REQ-EMMON-1020 – Information Update Frequency					
Type:	Performance	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall update the information available to the users every minute.					
Notes:	This means that the information presented to the user through the C&C is updated every minute. It does not imply that sensors take readings every minute too.				
Traceability:	REQ-UQLO-1010; REQ-CIV-1020				
Consolidation rule:	RULE-7				

7.3.1.3 Interface Requirements

REQ-EMMON-1510 – Graphical User Interface					
Type:	Interface	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall have a generic Windows-based Graphical User Interface (GUI). This GUI shall provide search, selection and geographical visualization (with zoom capabilities) of all areas being monitored by the system, using a Geographical Information System (GIS). The GUI shall also represent all sensor nodes in the system as two-dimensional sets of dots in a rectangular panel.					
Notes:					
Traceability:	REQ-UQLO-0020; REQ-UQLO-1510; REQ-UQL-1510; REQ-UQLO-1520; REQ-UQLO-1530;				

	REQ-UQLO-1550; REQ-CIV-0080; REQ-CIV-1510; REQ-CIV-1520; REQ-CIV-1530
Consolidation rule:	RULE-6

REQ-EMMON-1520 – Interactive Display of Sensor Readings					
Type:	Interface	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall provide a visual display of sensor readings to the C&C Operator, in a separate panel, by clicking on each sensor node representation.					
Notes:					
Traceability:	REQ-PRP-1520				
Consolidation rule:	RULE-5				

REQ-EMMON-1530 – Alarm User Interface					
Type:	Interface	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall visually notify the user of any alarm and/or alert situation that might occur, independently of the display available to the C&C Operator. Alarm and/or alert information shall be visible on the display at least until the C&C Operator acknowledges the alarm/alert. The C&C module shall provide a geographical visualization of all areas in alarm and/or alert status.					
Notes:					
Traceability:	REQ-UQLO-1570				
Consolidation rule:	RULE-7				

REQ-EMMON-1535 - Disable Alarm Notification					
Type:	Interface	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall allow for disabling an alarm for a set of sensors, for a set of parameters and for a time interval. The C&C module shall only allow this operation to a C&C Operator with proper credentials. The time interval shall be limited to a system -wide configurable duration.					
Notes:					
Traceability:	REQ-UQLO-1600				
Consolidation rule:	RULE-7				

REQ-EMMON-1540 – Historical, Present and Future Comparative Diagrams					
Type:	Interface	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall provide the following graphical information regarding historical, present, and future data measures: - comparative diagrams; - animations showing the evolution of sensor readings in a specific area, within a specific period (using the event					

propagation model). The future data shall be provided by the event propagation simulation.	
Notes:	
Traceability:	REQ-UQLO-1560; REQ-PRP-1530
Consolidation rule:	RULE-4

REQ-EMMON-1550 – Propagation Model Interface					
Type:	Interface	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall provide a GUI to the event propagation model, representing sensor nodes as two-dimensional sets of dots in a rectangular panel and providing a fast forward capability regarding the propagation event, to establish its impact before the impact occurs in the real time/world.					
Notes:					
Traceability:	REQ-PRP-1510; REQ-PRP-1530				
Consolidation rule:	RULE-5				

REQ-EMMON-1560 – Generic Alarm Interface					
Type:	Interface	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall represent an alarm using XML. The system shall provide alarm reports through HTTP and SMTP. The system shall allow for external entities to register for alarms.					
Notes:	The system shall use generic and well known formats; and generic and well known protocols; so it will be easily integrated with other existing modules or future ones. XML - Extensible Markup Language (from W3C) [RD-2] HTTP - Hypertext Transfer Protocol [RD-3] SMTP - Simple Mail Transfer Protocol [RD-4]				
Traceability:	REQ-UQLO-1580				
Consolidation rule:	RULE-7				

7.3.1.4 Operational Requirements

REQ-EMMON-2010 – Data Correctness					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	1
The C&C module shall collect all sensor readings. Any compression algorithm applied to the sensor data shall not result in any loss of information.					
Notes:					
Traceability:	N/A				
Consolidation rule:	New requirement				

REQ-EMMON-2020 – Identification of Elements of Interest on the C&C

Type:	Operational	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall identify each element of interest mentioned in requirement "REQ-EMMON-1510 – Graphical User Interface", by a unique code and/or name.					
Notes:					
Traceability:	REQ-UQLO-2010				
Consolidation rule:	RULE-7				

REQ-EMMON-2030 – Selection of Elements of Interest Using Layers on the C&C					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall allow for the visual selection of elements of interest by using layers of information.					
Notes:	Each layer will be associated with a particular type of element of interest.				
Traceability:	REQ-UQLO-2020				
Consolidation rule:	RULE-7				

REQ-EMMON-2040 – Set Endangerment Level					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall set the appropriate endangerment level, according to the sensor readings.					
Notes:	This requirement is related with requirement "REQ-EMMON-0070 - Endangerment Levels".				
Traceability:	REQ-UQLO-2030; REQ-CIV-2050				
Consolidation rule:	RULE-7				

REQ-EMMON-2050 – Automatic Evaluation Of Sensor Readings					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall compare the current sensor readings with historical data to make a primary automatic evaluation, classifying them as: "normal", "non-critical" or "critical". If a non-critical or critical reading is identified, the system shall execute the following actions: - increase the sensors' sampling frequency for the specific cluster where the reading was identified by a user-configurable amount, as well as nearby clusters; - provide additional data from nearby regions to the user.					
Notes:	This classification is related to the endangerment levels defined in requirement "REQ-EMMON-0070 - Endangerment Levels".				
Traceability:	REQ-CIV-2020				
Consolidation rule:	RULE-5				

7.3.1.5 Resource Requirements

Not applicable.

7.3.1.6 Verification Requirements

Not applicable.

7.3.1.7 Documentation Requirements

REQ-EMMON-3510 – Event Propagation Model Technical Manual					
Type:	Documentation	**Priority:**	High	**Verification Method:**	Inspection
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall provide a technical manual for the event propagation model.					
Notes:					
Traceability:	REQ-PRP-3510				
Consolidation rule:	RULE-5				

REQ-EMMON-3520 – Event Propagation Model User Manual					
Type:	Documentation	**Priority:**	High	**Verification Method:**	Inspection
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall provide a user manual for the event propagation model.					
Notes:					
Traceability:	REQ-PRP-3520				
Consolidation rule:	RULE-5				

7.3.1.8 Security Requirements

REQ-EMMON-4010 – Access to the Graphical User Interface					
Type:	Security	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall restrict access to the GUI to C&C Operators with the proper credentials. The C&C module shall use an encrypted authentication and authorisation system to access the GUI.					
Notes:					
Traceability:	REQ-UQL-4010; REQ-UQL-4030; REQ-UQLO-0390; REQ-UQLO-0400				
Consolidation rule:	RULE-4				

REQ-EMMON-4020 – Access to Historical and Real-Time Data					
Type:	Security	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall restrict access to historical and real-time data to C&C Operators with the proper credentials. The C&C module shall use an encrypted authentication and authorisation system to access this information.					
Notes:					
Traceability:	REQ-UQLO-4010				
Consolidation rule:	RULE-5				

REQ-EMMON-4030 – C&C Secure Data Transmission					
Type:	Security	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall be designed to work with secure, generic and well known communication protocols. The C&C module shall also be designed to work with encryption.					
Notes:	The Hypertext Transfer Protocol Secure (HTTPS) is a possibility for a secure communication protocol. TLS encryption might be used, as it is currently one of the most secure encryption methods known.				
Traceability:	REQ-UQL-4020				
Consolidation rule:	RULE-6				

REQ-EMMON-4040 – C&C Access Restrictions					
Type:	Security	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall restrict access to the following features to C&C users with proper credentials: - configuration of the validation rules, as specified in requirement "REQ-EMMON-0020 - Validation of Sensor Readings"; - manual correction of values originated from sensor readings, as specified in requirement "REQ-EMMON-0050 – Manual Data Correction"; - manual configuration (create, modify, delete and view) of alarm thresholds for the measured parameters, as specified in requirement "REQ-EMMON-0060 - Configurable Alarm Thresholds"; - configuration of individual nodes as "enabled" or "disabled", as specified in requirement "REQ-EMMON-0080 – Node Enabling and Disabling".					
Notes:	The system can have different types of credentials, one for each feature. This requirement does not intend to imply that if a user has access to one of these features, it should have access to all of them. Nor does it intend to imply the opposite.				
Traceability:	REQ-UQLO-0140; REQ-UQLO-0150				
Consolidation rule:	RULE-10				

7.3.1.9 Portability Requirements

REQ-EMMON-4510 – Event Propagation Model Portability					
Type:	Portability	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	2
The C&C module shall guarantee that the event propagation model is portable between different event domains in the EMMON project, so that it can also model all the other scenarios identified for this project, in addition to fire and pollution for which it was initially considered.					
Notes:					
Traceability:	REQ-PRP-4510				
Consolidation rule:	RULE-5				

7.3.1.10 Quality Requirements

REQ-EMMON-5010 – Event Propagation Model Integrity					
Type:	Quality	**Priority:**	High	**Verification Method:**	Test

Status:	Approved	**Stability:**	Medium	**Version:**	1
The event propagation model shall maintain its integrity and functionality in the event of failure of up to 5% of the sensors.					
Notes:					
Traceability:	REQ-PRP-5010				
Consolidation rule:	RULE-5				

REQ-EMMON-5020 – Event Propagation Model Availability					
Type:	Quality	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The event propagation model shall be available continuously, in the event of failure of up to 5% of the sensors.					
Notes:					
Traceability:	REQ-PRP-5020				
Consolidation rule:	RULE-5				

7.3.1.11 Reliability Requirements

Not applicable.

7.3.1.12 Maintainability Requirements

REQ-EMMON-6010 – Over the Air Programming/Configuring Through the C&C module					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The C&C module shall provide a means to perform over the air programming of any node connected to the Sensor Network, including the ability to upgrade its firmware.					
Notes:	"Over the air programming" here refers to making changes to the firmware. Changing a node's configuration parameters is considered "over the air configuring".				
Traceability:	REQ-UQLO-6020				
Consolidation rule:	RULE-5				

REQ-EMMON-6020 – Remote Maintenance					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The C&C module shall provide remote maintenance through the graphical user interface (GUI): authorized end-users shall be allowed to change system parameters and configuration options.					
Notes:					
Traceability:	REQ-UQL-6010; REQ-UQLO-6010				
Consolidation rule:	RULE-7				

7.3.1.13 Safety Requirements

Not applicable.

7.3.2 Sensor Network

This section presents the consolidated requirements catalogue for the sensor network module of the EMMON system.

7.3.2.1 Functional Requirements

REQ-EMMON-0170 – Passive Sensors					
Type:	Functional	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall only have passive sensors. This means that sensors shall not perform functions as actuators, acting upon the environment.					
Notes:	Just for clarification, actuators are devices that take energy and turn it into some kind of physical action. Optical sensors, for example, might need some actuation in order to rotate them on a 360º angle (although this is not exactly acting upon the environment, and therefore not considered actuation for the sake of this requirement).				
Traceability:	REQ-UQLO-0250; REQ-CIV-0020				
Consolidation rule:	RULE-7				

REQ-EMMON-0180 - Sense Physical Quantities					
Type:	Functional	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	1
The Sensor Network shall measure physical quantities from the environment, and convert those measures to digital data.					
Notes:	The type of physical quantity to measure will depend on the particular scenario of application.				
Traceability:	REQ-UQL-0010; REQ-UQL-0020; REQ-UQL-0030; REQ-UQL-0040; REQ-UQL-0070; REQ-UQLO-0270; REQ-UQLO-0280; REQ-UQLO-0290; REQ-CIV-0200; REQ-CIV-0210; REQ-CIV-0220; REQ-CIV-0230; REQ-CIV-0240; REQ-CIV-0250; REQ-PRP-0030; REQ-PRP-0040; REQ-PRP-0050				
Consolidation rule:	RULE-1				

REQ-EMMON-0190 – Node Local Connectivity					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The Sensor Network shall have its nodes communicating with each other to a distance up to 100 meters.					
Notes:	These nodes can be sensor nodes or other types of nodes (such as routing nodes).				
Traceability:	REQ-PRP-0010; REQ-UQL-2040; REQ-UQLO-2050				
Consolidation rule:	RULE-3				

REQ-EMMON-0200 – Single Reads Vs Data Aggregation					
Type:	Functional	**Priority:**	High	**Verification**	Test

				Method:	
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall alternate between using every single sensor read or perform data aggregation. According to how critical the situation is, the most energy efficient solution shall be selected.					
Notes:	Typically, data aggregation will be applied to normal situations (as identified by the endangerment level). If a critical situation is detected, the system can then start using every single sensor reading, to get further details regarding the situation. Since the system will spend most of its time dealing with normal readings, this strategy is probably the most energy efficient approach.				
Traceability:	REQ-UQLO-0260; REQ-CIV-0190				
Consolidation rule:	RULE-2				

7.3.2.2 Performance Requirements

REQ-EMMON-1030 – Minimum Number of Nodes					
Type:	Performance	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	1
The Sensor Network shall be scalable up to 10000 (ten thousand) nodes.					
Notes:	These nodes can be sensor nodes, routing nodes, or any other type of node.				
Traceability:	REQ-UQL-1010; REQ-UQLO-2510; REQ-CIV-1010; REQ-PRP-1010				
Consolidation rule:	RULE-10				

REQ-EMMON-1040 – Power Autonomy					
Type:	Performance	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The Sensor Network shall have a power autonomy of no less than 3 (three) months. This means that the Sensor Network as a whole shall have a power autonomy of at least 3 (three) months.					
Notes:	This means that some nodes might die out due to lack of power autonomy, as long as the Sensor Network still remains operational. Exactly what percentage of nodes that are allowed to die out will the system accept, before considering that the Sensor Network is no longer operational, is something that will need to be defined by the end user.				
Traceability:	REQ-UQLO-1080				
Consolidation rule:	RULE-3				

REQ-EMMON-1050 – Sensor Data Transmission Frequency					
Type:	Performance	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The Sensor Network shall support a range of data transmission frequencies from 1 (one) per day up to 60 (sixty) per hour. It shall be also possible to vary this transmission frequency, within this range, to deal with emergency situations.					
Notes:	60 readings per hour is the same as 1 reading per minute.				
Traceability:	REQ-UQLO-1040; REQ-CIV-1040; REQ-CIV-1050; REQ-PRP-1020				
Consolidation rule:	RULE-6				

REQ-EMMON-1060 – Maximum Sensor Reading Interval					
Type:	Performance	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall have its sensor nodes perform measurements of physical parameters at a frequency up to 6 readings per hour (1 reading every 10 minutes).					
Notes:					
Traceability:	REQ-UQLO-1020; REQ-UQLO-1030; REQ-CIV-1030; REQ-PRP-1020				
Consolidation rule:	RULE-6				

REQ-EMMON-1070 – Readings Resolution and Range					
Type:	Performance	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The Sensor Network shall guarantee that the sensors have the needed resolution and range, for each of the measured physical parameters. Relating to requirement "REQ-EMMON-0180 - Sense Physical Quantities", the Sensor Network shall also guarantee that enough bits are used to convert these physical measures into digital values.					
Notes:	The resolution and range will depend on the particular physical parameter to measure, which in turn will depend on the scenario of application.				
Traceability:	REQ-UQL-1030; REQ-UQL-1040; REQ-UQL-1050; REQ-UQL-1060; REQ-UQL-1070; REQ-UQLO-1050; REQ-UQLO-1060; REQ-UQLO-1070				
Consolidation rule:	RULE-1				

7.3.2.3 Interface Requirements

REQ-EMMON-1570 – PDA Hardware Interface					
Type:	Interface	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	1
The Sensor Network shall provide a hardware interface to allow a user with a PDA to communicate with and access it.					
Notes:	The access to the system with a PDA is for diagnostic, local monitoring and maintenance activities.				
Traceability:	N/A				
Consolidation rule:	New requirement				

REQ-EMMON-1580 – PDA Software Interface					
Type:	Interface	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	1
The Sensor Network shall provide a software interface to allow a user with a PDA to access and use it.					
Notes:	The access to the system with a PDA is for diagnostic, local monitoring and maintenance activities.				
Traceability:	N/A				
Consolidation rule:	New requirement				

7.3.2.4 Operational Requirements

REQ-EMMON-2060 – Operational Temperature					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The Sensor Network shall provide correct readings for all measured parameters when exposed to temperatures ranging from -20 to 60 degree Celsius. This also means that the sensors will not loose calibration with temperature variation, within this range.					
Notes:	Current hardware might not support this requirement.				
Traceability:	REQ-UQL-2020; REQ-UQLO-2070; REQ-PRP-2010				
Consolidation rule:	RULE-8				

REQ-EMMON-2070 – Distance Between Sensing Points					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The Sensor Network shall have its sensing points distanced from each other no less than 30 meters and no more than 100 meters.					
Notes:					
Traceability:	REQ-UQL-2040; REQ-UQLO-2050				
Consolidation rule:	RULE-6				

REQ-EMMON-2080 – Data Correctness					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall collect all sensor readings. Any compression algorithm applied to the sensor data shall not result in loss of information.					
Notes:					
Traceability:	REQ-UQLO-2040				
Consolidation rule:	RULE-7				

REQ-EMMON-2090 – Protection Against Harsh Environmental Conditions					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall have all of its nodes protected against hostile environmental conditions. This applies to sensor nodes and any other node types that might be subject to harsh environmental conditions.					
Notes:	Hostile environmental conditions can be rain, hail, water, extreme temperatures, etc….				
Traceability:	REQ-UQL-2030; REQ-UQLO-2090; REQ-UQLO-2100; REQ-UQLO-2110; REQ-CIV-2070				
Consolidation rule:	RULE-6				

REQ-EMMON-2100 – Time Synchronisation					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test

Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall have all of its nodes synchronised. The maximum admissible difference between the clocks of any two nodes shall be 1 minute.					
Notes:					
Traceability:	REQ-UQLO-2120				
Consolidation rule:	RULE-5				

REQ-EMMON-2120 – Sleep Mode					
Type:	Operational	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall have all of its nodes in sleep mode, only waking up when they need to take readings of the monitored parameters, store the readings or transmit them.					
Notes:					
Traceability:	REQ-CIV-2040				
Consolidation rule:	RULE-5				

7.3.2.5 Resource Requirements

REQ-EMMON-2510 – Sensor Node Storage Capacity					
Type:	Resource	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall have all of its sensor nodes possess enough data storage capacity to store sensor readings before they are transmitted through the network.					
Notes:					
Traceability:	REQ-UQLO-1030; REQ-UQLO-2530; REQ-CIV-1030; REQ-CIV-2510				
Consolidation rule:	RULE-6				

REQ-EMMON-2520 – Over the Air Programming/Configuring					
Type:	Resource	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall have all of its nodes programmable and configurable over the air.					
Notes:					
Traceability:	REQ-UQLO-2520				
Consolidation rule:	RULE-5				

7.3.2.6 Verification Requirements

REQ-EMMON-3010 – Sensor Hourly Connectivity Verification					
Type:	Verification	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall make hourly verifications that each sensor has not lost its connectivity.					

In case of loss of connectivity, the system shall notify the users (through the C&C).	
Notes:	
Traceability:	REQ-UQLO-0300
Consolidation rule:	RULE-5

REQ-EMMON-3020 – Sensor Connectivity Verification					
Type:	Verification	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall provide means to verify if some sensor or group of sensors are connected and reachable.					
Notes:					
Traceability:	REQ-UQLO-3010; REQ-PRP-3010				
Consolidation rule:	RULE-3				

7.3.2.7 Documentation Requirements

Not applicable.

7.3.2.8 Security Requirements

REQ-EMMON-4050 – Sensor Network Secure Data Transmission					
Type:	Security	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall be designed to work with secure, generic and well known communication protocols. The Sensor Network shall also be designed to work with encryption.					
Notes:					
Traceability:	REQ-UQL-4040; REQ-CIV-4010				
Consolidation rule:	RULE-6				

REQ-EMMON-4060 – Node Level Security					
Type:	Security	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall provide data security at node level. Changing the measured values shall not be allowed.					
Notes:					
Traceability:	REQ-UQLO-4030				
Consolidation rule:	RULE-5				

REQ-EMMON-4070 – Sensor Readings Security					
Type:	Security	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The Sensor Network shall not allow changing the values of sensor readings. This shall only be allowed at the C&C level (see requirement “REQ-EMMON-0050 – Manual Data Correction”).					

Notes:	
Traceability:	REQ-UQLO-4030
Consolidation rule:	RULE-5

7.3.2.9 Portability Requirements

Not applicable.

7.3.2.10 Quality Requirements

Not applicable.

7.3.2.11 Reliability Requirements

REQ-EMMON-5510 – Loss of Node(s)					
Type:	Reliability	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	1
The Sensor Network shall be reliable, such that, degradation of monitoring capabilities by loss of one or several nodes shall be restricted to the node's radio range or region, and shall not affect the whole system.					
Notes:					
Traceability:	N/A				
Consolidation rule:	New requirement				

7.3.2.12 Maintainability Requirements

REQ-EMMON-6030 – Sensor Network Autonomy					
Type:	Maintainability	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	1
After deployment, the Sensor Network shall operate normally, requiring no human intervention or maintenance for a period of at least 3 (three) months.					
Notes:					
Traceability:	N/A				
Consolidation rule:	New requirement				

7.3.2.13 Safety Requirements

Not applicable.

7.3.3 PDA

This section presents the consolidated requirements catalogue for the PDA module of the EMMON system.

7.3.3.1 Functional Requirements

REQ-EMMON-0210 – PDA Services					
Type:	Functional	**Priority:**	High	**Verification**	Demonstration

				Method:	
Status:	Approved	**Stability:**	Medium	**Version:**	1
The PDA shall provide the following services: - map the area covered by the specific PDA indicating the sensors' positions; - receive information from the nearest sensors; - supervision of the operating conditions of the nearest sensors; - receive commands from the C&C; - transmit reports to the C&C; - transmit GPS positioning information to the C&C during the installation process; - provide instructions for the installation and maintenance of the sensors; - field sensor configuring.					
Notes:	Field sensor configuring can be with regards to position, thresholds, sampling frequency or communication requirements. What exactly is considered as "nearest sensors" is left to the user to define. It might be the nearest cluster or the neighbouring clusters.				
Traceability:	REQ-UQLO-0320; REQ-CIV-0100				
Consolidation rule:	RULE-7				

REQ-EMMON-0220 – Firmware Upgrade through the PDA module					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	1
The PDA shall provide a means to upgrade the firmware of any node connected to it.					
Notes:					
Traceability:	N/A				
Consolidation rule:	New requirement				

REQ-EMMON-0230 – Local Monitoring					
Type:	Functional	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The PDA shall provide real-time data regarding the values measured by sensor nodes to which the PDA device is locally connected to.					
Notes:					
Traceability:	REQ-UQLO-0310; REQ-CIV-0030				
Consolidation rule:	RULE-2				

REQ-EMMON-0240 – Alert Regional PDA					
Type:	Functional	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The PDA shall receive alerts when an emergency situation occurs in the region where it is connected to.					
Notes:					
Traceability:	REQ-UQLO-0330; REQ-CIV-0150				
Consolidation rule:	RULE-6				

7.3.3.2 Performance Requirements

Not applicable.

7.3.3.3 Interface Requirements

REQ-EMMON-1590 – Visualization of Node Status					
Type:	Interface	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Low	**Version:**	1
The PDA shall provide a visualization of the status of the sensors, using a colour code to identify: - operation status; - data availability.					
Notes:					
Traceability:	N/A				
Consolidation rule:	New requirement				

REQ-EMMON-1600 – Local Search, Selection and Geographical Visualization					
Type:	Interface	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The PDA shall provide search, selection and geographical visualization of all local geographical items, such as specific areas or neighbourhood, through a GUI, providing its corresponding sensor data. It shall also allow searching by name or ID for local geographical items and shall allow for selection for geographical visualization.					
Notes:					
Traceability:	REQ-UQLO-1610; REQ-CIV-1550				
Consolidation rule:	RULE-4				

7.3.3.4 Operational Requirements

REQ-EMMON-2130 – Identification of Elements of Interest on the PDA					
Type:	Operational	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The PDA shall identify each element of interest mentioned in requirement “REQ-EMMON-1600 – Local Search, Selection and Geographical Visualization” by a unique code and/or name.					
Notes:					
Traceability:	REQ-UQLO-2130				
Consolidation rule:	RULE-7				

REQ-EMMON-2140 – Selection of Elements of Interest Using Layers on the PDA					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	2
The PDA shall allow for the visual selection of elements of interest by using layers of information.					
Notes:	Each layer will be associated with a particular type of element of interest.				

Traceability:	REQ-UQLO-2140
Consolidation rule:	RULE-7

REQ-EMMON-2150 – PDA To Process Local Readings In Emergency Situations					
Type:	Operational	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Low	**Version:**	2
The PDA shall be commanded to receive and process locally incoming readings, when in the presence of a critical situation.					
Notes:	This allows the system to take advantage of the PDA's processing capabilities in an emergency, since sensor readings are likely to be more frequent.				
Traceability:	REQ-CIV-2030				
Consolidation rule:	RULE-5				

7.3.3.5 Resource Requirements

Not applicable.

7.3.3.6 Verification Requirements

REQ-EMMON-3030 – Sensor Connectivity Verification					
Type:	Verification	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Low	**Version:**	1
The PDA module shall provide means of verification if all sensors are connected and reachable.					
Notes:					
Traceability:	N/A				
Consolidation rule:	New requirement				

7.3.3.7 Documentation Requirements

Not applicable.

7.3.3.8 Security Requirements

REQ-EMMON-4080 – PDA Access Restriction					
Type:	Security	**Priority:**	High	**Verification Method:**	Test
Status:	Approved	**Stability:**	Medium	**Version:**	1
The PDA shall restrict access to the GUI to PDA Operators with the proper credentials. Authorized PDA Operators shall be allowed to change system parameters and configuration options. The PDA shall use an encrypted authentication and authorisation system to access the GUI.					
Notes:	This requirement comes from the need to guarantee that only specific users can access the system through the PDA module.				
Traceability:	REQ-UQL-4050; REQ-UQLO-0410; REQ-UQLO-0420				
Consolidation rule:	RULE-6				

Not applicable.

7.3.3.9 Portability Requirements

Not applicable.

7.3.3.10 Quality Requirements

Not applicable.

7.3.3.11 Reliability Requirements

Not applicable.

7.3.3.12 Maintainability Requirements

REQ-EMMON-6040 – Remote Maintenance					
Type:	Maintainability	**Priority:**	High	**Verification Method:**	Demonstration
Status:	Approved	**Stability:**	Medium	**Version:**	2
The PDA module shall provide remote maintenance through a Graphical User Interface (GUI).					
Notes:					
Traceability:	REQ-UQL-6010				
Consolidation rule:	RULE-5				

7.3.3.13 Safety Requirements

Not applicable.

8. Conclusions

Since the second version of this deliverable, a more exhaustive study concerning all scenarios was carried out. This section states some general conclusions regarding the work to consolidate the operational requirements from the end-user needs and requirements identified, taken into account each application operational scenario.

Having identified EMMON´s main components, the relation between them and their role into the system, these consolidated requirements can provide a solution that can be easily adapted to various applications, with only small modifications.

This deliverable also identifies the actors list and their action regarding each module. They can be applied to a generic scenario requirements specification, in this case, derived from the consolidated requirements.

Annex A

Annex A. Traceability Matrix Scenario Requirements Vs Consolidated Requirements

Table 8 presents the traceability matrix between the scenario requirements and the consolidated requirements.

Requirements REQ-EMMON-0080, REQ-EMMON-0220, REQ-EMMON-1570, REQ-EMMON-1580, REQ-EMMON-1590, REQ-EMMON-2010, REQ-EMMON-3030, REQ-EMMON-5510 and REQ-EMMON-6030, which are at the bottom of the traceability matrix, do not trace back to any scenario requirement. These are new requirements that were created by expert judgement because they were considered important for the overall EMMON system.

Scenario Requirements	Consolidated Requirements
REQ-UQL-0020 - Configurable Data &Alarm	REQ-EMMON-0120, REQ-EMMON-0060
REQ-UQL-0060 - Historical Data	REQ-EMMON-0010
REQ-UQL-1020 - Maximum Sensor Reading Delay of 30 sec	REQ-EMMON-1010
REQ-UQL-1510 - Graphical User Interface	REQ-EMMON-1510
REQ-UQL-4010 - Restricted Access	REQ-EMMON-4010
REQ-UQL-4020 - C&C Secure Data Transmission	REQ-EMMON-4030
REQ-UQL-4030 - Graphical User Interface Security	REQ-EMMON-4010
REQ-UQL-6010 - Remote Maintenance	REQ-EMMON-6020, REQ-EMMON-6040
REQ-UQL-0010 – CO2 Measurement	REQ-EMMON-0180
REQ-UQL-0020 – Humidity Measurement	REQ-EMMON-0180
REQ-UQL-0030 – Trash Measurement	REQ-EMMON-0180
REQ-UQL-0040 – Light Measurement	REQ-EMMON-0180
REQ-UQL-0070 - Noise Measurement	REQ-EMMON-0180
REQ-UQL-1010 - Minimum Number of Sensor Points	REQ-EMMON-1030
REQ-UQL-1030 - CO2 Readings Range	REQ-EMMON-1070
REQ-UQL-1040 - Humidity Readings Range	REQ-EMMON-1070
REQ-UQL-1050 - Trash Readings in Containers	REQ-EMMON-1070
REQ-UQL-1060 - Light intensity Readings Range	REQ-EMMON-1070
REQ-UQL-1070 - Noise Readings Range	REQ-EMMON-1070
REQ-UQL-2010 - Rechargeable Battery	-
REQ-UQL-2020 - Operational Temperature	REQ-EMMON-2060
REQ-UQL-2030 - Operational Outdoor Environment	REQ-EMMON-2090
REQ-UQL-2040 - Distance Between Sensing Points	REQ-EMMON-2070
REQ-UQL-4040 - Sensor Network Secure Data Transmission	REQ-EMMON-4050
REQ-UQL-4050 - PDA Secure Data Transmission	REQ-EMMON-4080
REQ-UQLO-0010 - Historical and Real-Time Data	REQ-EMMON-0010
REQ-UQLO-0020 - Incorporation Of GIS Database	REQ-EMMON-1510
REQ-UQLO-0030 - Information Customization In The C&C	REQ-EMMON-0140
REQ-UQLO-0040 - C&C Services	REQ-EMMON-0120
REQ-UQLO-0050 - Detailed Information On Demand In The C&C	REQ-EMMON-0140
REQ-UQLO-0060 - Sensor Data Set	REQ-EMMON-0110

Scenario Requirements	Consolidated Requirements
REQ-UQLO-0070 - Node Data	REQ-EMMON-0110
REQ-UQLO-0080 - Manual Correction of Sensor Values	REQ-EMMON-0050
REQ-UQLO-0090 - Validation of Sensor Readings by Range	REQ-EMMON-0020
REQ-UQLO-0100 - Validation of Sensor Readings by Sudden Change	REQ-EMMON-0020
REQ-UQLO-0110 - Validation of Sensor Readings by Persistence	REQ-EMMON-0020
REQ-UQLO-0120 - Final Validation of Sensor Readings	REQ-EMMON-0020
REQ-UQLO-0130 - Report Potential Malfunctions	REQ-EMMON-0030
REQ-UQLO-0140 - Validation of Reported Potentially Invalid Readings	REQ-EMMON-0040, REQ-EMMON-4040
REQ-UQLO-0150 - Configuration of Suspicious Thresholds	REQ-EMMON-0020, REQ-EMMON-4040
REQ-UQLO-0160 - Alarm Thresholds	REQ-EMMON-0060
REQ-UQLO-0170 - Alarm Thresholds - User Configurable Alarm Thresholds	REQ-EMMON-0060
REQ-UQLO-0180 - Alarm Actions	REQ-EMMON-0070
REQ-UQLO-0190 - Entities Configuration	REQ-EMMON-0130
REQ-UQLO-0200 - Entities Automatic Notification	REQ-EMMON-0130
REQ-UQLO-0210 - Measurements Comparison	-
REQ-UQLO-0220 - Alert Conditions	REQ-EMMON-0150
REQ-UQLO-0230 - Data Presentation Through Web Services	REQ-EMMON-0130
REQ-UQLO-0240 - Request for Sensor Readings Update	-
REQ-UQLO-0340 - Configure and Manage User Accounts	REQ-EMMON-0090
REQ-UQLO-0350 - Configure and Manage Group Accounts	REQ-EMMON-0100
REQ-UQLO-0360 - Associate User Accounts	-
REQ-UQLO-0370 - Configure Access Privileges	REQ-EMMON-0090, REQ-EMMON-0100
REQ-UQLO-0390 - Access Authentication Mechanism	REQ-EMMON-4010
REQ-UQLO-0400 - User Operations in The System	REQ-EMMON-4010
REQ-UQLO-1010 - Information Update Frequency	REQ-EMMON-1020
REQ-UQLO-1510 - HMI Interface For The C&C	REQ-EMMON-1510
REQ-UQLO-1520 - Zoom In The C&C	REQ-EMMON-1510
REQ-UQLO-1530 - Mapping Of Sensors' Position	REQ-EMMON-1510
REQ-UQLO-1540 - Geographical Visualization of Telemetric Station Status	-
REQ-UQLO-1550 - Search, Selection and Geographical Visualization	REQ-EMMON-1510
REQ-UQLO-1560 - Historical and Present Comparative Diagrams	REQ-EMMON-1540
REQ-UQLO-1570 - Alarm User Interface	REQ-EMMON-1530
REQ-UQLO-1580 - Generic Alarm Interface	REQ-EMMON-1560
REQ-UQLO-1590 - Alarm User States	-
REQ-UQLO-1600 - Disable Alarm Notification	REQ-EMMON-1535
REQ-UQLO-2010 - Identification of Elements of Interest	REQ-EMMON-2020
REQ-UQLO-2020 - Selection of Elements of Interest Using Layers	REQ-EMMON-2030
REQ-UQLO-2030 - Set Alarms and Execute Associated Actions	REQ-EMMON-2040
REQ-UQLO-4010 - Access to Historical and Real-Time Data	REQ-EMMON-4020
REQ-UQLO-4020 - Availability of Sensor Readings	-
REQ-UQLO-6010 - Remote Maintenance	REQ-EMMON-6020
REQ-UQLO-6020 - Over the air programming	REQ-EMMON-6010
REQ-UQLO-0250 - Passive Sensors	REQ-EMMON-0170
REQ-UQLO-0260 - Single Reads Vs Data Aggregation	REQ-EMMON-0200
REQ-UQLO-0270 - Sense Temperature	REQ-EMMON-0180
REQ-UQLO-0280 - Sense Air Relative Humidity	REQ-EMMON-0180
REQ-UQLO-0290 - Sense Ozone Concentration- O3	REQ-EMMON-0180
REQ-UQLO-0300 - Sensor Connectivity Verification	REQ-EMMON-3010

Scenario Requirements	Consolidated Requirements
REQ-UQLO-1020 - Maximum Sensor Reading Delay	REQ-EMMON-1060
REQ-UQLO-1030 - Frequency Of The Sensor Readings And Storage	REQ-EMMON-1060, REQ-EMMON-2510
REQ-UQLO-1040 - Frequency Of The Transmission To A Sink Node	REQ-EMMON-1050
REQ-UQLO-1050 - Ozone Readings Range from 20 to 200 ppb	REQ-EMMON-1070
REQ-UQLO-1060 - Air Temperature Readings Range from -10 to 50 degrees Celsius	REQ-EMMON-1070
REQ-UQLO-1070 - Air Relative Humidity Readings Range from -0 to 100%	REQ-EMMON-1070
REQ-UQLO-1080 - Power Autonomy	REQ-EMMON-1040
REQ-UQLO-2040 - Data Correctness	REQ-EMMON-2080
REQ-UQLO-2050 - Distance Between Sensing Points	REQ-EMMON-2070
REQ-UQLO-2060 - Sensor Placement Minimum Height For Ozone Measurements	-
REQ-UQLO-2070 - Operational Temperature	REQ-EMMON-2060
REQ-UQLO-2090 - Protection for Hostile Environment	REQ-EMMON-2090
REQ-UQLO-2100 - Protection Against Harsh Environmental Conditions	REQ-EMMON-2090
REQ-UQLO-2110 - Gas Sensors Protection	REQ-EMMON-2090
REQ-UQLO-2120 - Node Synchronization	REQ-EMMON-2100
REQ-UQLO-2510 - Minimum Number Of Sensor Points	REQ-EMMON-1030
REQ-UQLO-2520 - Node Support for Over the Air Programming	REQ-EMMON-2520
REQ-UQLO-2530 - Sensor Data Storage Capacity	REQ-EMMON-2510
REQ-UQLO-3010 - Sensors Connectivity Verification	REQ-EMMON-3020
REQ-UQLO-4030 - Sensor Network Security	REQ-EMMON-4060, REQ-EMMON-4070
REQ-UQLO-0310 - Local Real-Time Data	REQ-EMMON-0230
REQ-UQLO-0320 - PDA Services	REQ-EMMON-0210
REQ-UQLO-0330 - Alert Regional PDA	REQ-EMMON-0240
REQ-UQLO-0410 - PDA Access Authentication Mechanism	REQ-EMMON-4080
REQ-UQLO-0420 - PDA User Operations	REQ-EMMON-4080
REQ-UQLO-1610 - Local Search, Selection and Geographical Visualization	REQ-EMMON-1600
REQ-UQLO-1620 - Local Geographical Visualization of Telemetric Station Status	-
REQ-UQLO-2130 - Identification of Elements of Interest on the PDA	REQ-EMMON-2130
REQ-UQLO-2140 - Selection of Elements of Interest Using Layers on the PDA	REQ-EMMON-2140
REQ-CIV-0010 - Keep History Of Read Data	REQ-EMMON-0010
REQ-CIV-0040 - Information Customization In The C&C	REQ-EMMON-0140
REQ-CIV-0050 - Decision Support In The C&C	-
REQ-CIV-0060 - Detailed Information On Demand In The C&C	REQ-EMMON-0140
REQ-CIV-0070 - Model Based Prediction In The C&C	REQ-EMMON-0160
REQ-CIV-0080 - Incorporation Of GIS Database	REQ-EMMON-1510
REQ-CIV-0090 - C&C Services	REQ-EMMON-0120
REQ-CIV-0110 - Alert Conditions	REQ-EMMON-0150
REQ-CIV-0120 - Endangerment Levels	REQ-EMMON-0050
REQ-CIV-0130 - Threshold Definition	REQ-EMMON-0060
REQ-CIV-0140 - Threshold Configuration	REQ-EMMON-0060
REQ-CIV-0160 - Automatic Notification To The Regional Services	REQ-EMMON-0130
REQ-CIV-0170 - Scale, Intensity And Fire Front Estimation	-
REQ-CIV-0180 - Sensor Data Sets	REQ-EMMON-0110
REQ-CIV-0260 - Inform Authorities	REQ-EMMON-0130
REQ-CIV-1020 - Information Update Frequency	REQ-EMMON-1020
REQ-CIV-1510 - HMI Interface For The C&C	REQ-EMMON-1510
REQ-CIV-1520 - Zoom In The C&C	REQ-EMMON-1510
REQ-CIV-1530 - Mapping Of Sensors' Position	REQ-EMMON-1510
REQ-CIV-1540 - Map Fire Front And Isothermal Contour Lines	-

Scenario Requirements	Consolidated Requirements
REQ-CIV-2020 - Automatic Evaluation Of Sensor Readings	REQ-EMMON-2050
REQ-CIV-2050 - Set Endangerment Level	REQ-EMMON-2040
REQ-CIV-0020 - Passive Sensors	REQ-EMMON-0170
REQ-CIV-0190 - Single Reads Vs Data Fusion	REQ-EMMON-0200
REQ-CIV-0200 - Sense Temperature	REQ-EMMON-0180
REQ-CIV-0210 - Sense Air Humidity	REQ-EMMON-0180
REQ-CIV-0220 - Sense Ground Humidity	REQ-EMMON-0180
REQ-CIV-0230 - Sense Wind Speed	REQ-EMMON-0180
REQ-CIV-0240 - Sense CO	REQ-EMMON-0180
REQ-CIV-0250 - Sense CO2	REQ-EMMON-0180
REQ-CIV-0270 - Real-time Monitoring	-
REQ-CIV-1010 - Minimum Number Of Sensor Points	REQ-EMMON-1030
REQ-CIV-1030 - Frequency Of The Sensor Readings And Storage	REQ-EMMON-1060, REQ-EMMON-2510
REQ-CIV-1040 - Frequency Of The Transmission To A Sink Node	REQ-EMMON-1050
REQ-CIV-1050 - Maximum Sensor Reading Delay During Emergencies	REQ-EMMON-1050
REQ-CIV-2010 - Biodegradable Sensors	-
REQ-CIV-2040 - Sleep Mode	REQ-EMMON-2120
REQ-CIV-2060 - Temperature And Humidity Sensor Placement	-
REQ-CIV-2070 - Protection Against Harsh Environmental Conditions	REQ-EMMON-2090
REQ-CIV-2510 - Sensor Data Storage Capacity	REQ-EMMON-2510
REQ-CIV-4010 - Data Encryption	REQ-EMMON-4050
REQ-CIV-6010 - Adaptive Parameters	-
REQ-CIV-0030 - Monitoring Sub-regions With PDA	REQ-EMMON-0230
REQ-CIV-0100 - PDA Services	REQ-EMMON-0210
REQ-CIV-0150 - Alert Regional PDA	REQ-EMMON-0240
REQ-CIV-1550 - Mapping Of Local Sensors' Position	REQ-EMMON-1600
REQ-CIV-2030 - PDA To Process Local Readings In Emergency Situations	REQ-EMMON-2150
REQ-PRP-0010 - Local Connectivity Between Sensor Nodes	REQ-EMMON-0190
REQ-PRP-0020 - Sensor Grid Pattern	-
REQ-PRP-0030 - Sense Air Temperature	REQ-EMMON-0180
REQ-PRP-0040 - Sense air CO2 Concentration	REQ-EMMON-0180
REQ-PRP-0050 - Sense air CO Concentration	REQ-EMMON-0180
REQ-PRP-1010 - Minimum Sensor Points	REQ-EMMON-1030
REQ-PRP-1020 - Maximum Sensor Sampling Interval	REQ-EMMON-1050, REQ-EMMON-1060
REQ-PRP-1510 - Propagation Model Interface	REQ-EMMON-1550
REQ-PRP-1520 - User Interaction	REQ-EMMON-1520
REQ-PRP-1530 - Fast Forward Capability	REQ-EMMON-1550, REQ-EMMON-1540
REQ-PRP-2010 - Operational Temperature Range	REQ-EMMON-2060
REQ-PRP-3010 - Sensor Connectivity Verification	REQ-EMMON-3020
REQ-PRP-3510 - Event Propagation Model Technical Manual	REQ-EMMON-3510
REQ-PRP-3520 - Event Propagation Model User Manual	REQ-EMMON-3520
REQ-PRP-4010 - Event Propagation Model Security	-
REQ-PRP-4510 - Event Propagation Model Portability	REQ-EMMON-4510
REQ-PRP-5010 - Event Propagation Model Integrity	REQ-EMMON-5010
REQ-PRP-5020 - Event Propagation Model Availability	REQ-EMMON-5020
-	REQ-EMMON-0080
-	REQ-EMMON-0220
-	REQ-EMMON-1570

Scenario Requirements	Consolidated Requirements
-	REQ-EMMON-1580
-	REQ-EMMON-1590
-	REQ-EMMON-2010
-	REQ-EMMON-3030
-	REQ-EMMON-5510
-	REQ-EMMON-6030

Table 8 - Traceability matrix