Project No.: 285150

Project Acronym: SEEDS

Project Full Name: Self learning Energy Efficient builDings and open Spaces

PROJECT PERIODIC REPORT

Period covered: from 01/09/2013 to 28/02/2015

Period number: 3rd

Start date of project: 01/09/2011

Project coordinator name: Dr. NOEMI JIMÉNEZ-REDONDO

Project coordinator organisation name: Centro de Estudios de Materiales y Control de Obra S.A.

Version: 1

Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate)[1]:

  ☐ has fully achieved its objectives and technical goals for the period;

  ☒ has achieved most of its objectives and technical goals for the period with relatively minor deviations.

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable

  ☒ is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of the Coordinator: Dr. Noemi Jimenez-Redondo, CEMOSA

Date: 15th April 2015

Signature of coordinator:

[1] If either of these boxes below is ticked, the report should reflect these and any remedial actions taken.

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1 Publishable summary

1.1 Overview and project objectives

SEEDS is an FP7 project in the field of ICT technologies for Energy efficient Buildings. It started in September 2011 and ended in February 2015. It develops innovative technologies for optimizing building's performance in terms of energy, comfort, and life cycle costs. It is based on an innovative modelling methodology based on measurements, self-learning, optimization techniques and wireless technologies. SEEDS can be applied to buildings and surrounding open spaces. SEEDS is particularly attractive for the retrofitting of existing buildings.

SEEDS focuses on the operation stage of the building. It develops a *Building Energy Management Systems* (BEMS) to optimize energy behavior of the building over a time period. It performs detailed modeling of the HVAC and lighting equipment, energy sources and energy storages. The modeling of the energy equipment in the building is based on IFC – an Open BIM data exchange format. It applies a model-based control approach.

SEEDS implements an innovative model predictive control strategy based on sensor measurements and self-learning techniques. This methodology allows taking into account the properties of a building and its energy behavior without the need of having explicitly the architecture model of the building. If available, SEEDS uses BIM data about the building floorplan/layout and the building services structure. In any case, only very basic information of the architecture is required. The information about the energy equipment doesn't have either to be very comprehensive. In other words, SEEDS allows designing a BEMS using only the information available on the building and its facilities and the appropriate set of measurements that are captured by wireless sensor nodes which are also required to implement the most energy efficient control strategy. There is no need to have detailed architecture information (such as material parameters, thermal capacities etc.) and thus, SEEDS can be easily applied to the energy-aware upgrading/optimization of existing building services systems and to the retrofitting of old buildings which may lack constructional specification details necessary for traditional systems. Moreover, the use of wireless technologies allows an easier and faster deployment than in conventional and wired BMS.

The final goal of SEEDS is the development of a BEMS based on measurements, self-learning and wireless technologies. SEEDS' BEMS relies on the following objectives (O):

O1. *Development of innovative methodologies for the monitoring and control of energy consumption parameters inside buildings and surroundings or districts based on self-learning and optimization techniques*. This objective has been fully met.

O2. *Optimization of the building's (including surrounding space and district) performance in terms of comfort, functionality, energy efficiency, resource efficiency, economic return and lifecycle value*. SEEDS BEMS includes several components and systems whose joint performance allows optimizing the energy behaviour of the buildings. These components includes: the Controller, the Facility Model and the Energy Calculator, the Self-Learning, the Optimizer, the WISAN and GUI. These components were tested in a simulated prototype before their implementation for the two pilot buildings. After that, the joint performance and the communication of/among the different components were also tested for the original UiS scope and it worked well. However, during the very last stage of the project during the implementation in the Ferrovial pilot, some errors were found in the Optimizer code. These errors haven't been solved yet at the moment of submitting this report. The solution of these errors is being a difficult task because the researcher who developed the code in UiS (partner # 6) left the organization and the person to substitute him hasn't been able to solve the problem. Other software developers organizations in SEEDS (such as Fraunhofer, partner # 2, and USAL, partner # 5) have spent a lot of time trying to help UiS solving these errors but the Optimizer is not running yet. Therefore, this objective has been partly met because of the miss-functioning of the Optimizer code. However, the rest of the components properly perform their tasks and communicate well among themselves

O3. *Development, demonstration and validation of a methodology suitable for retrofitting and new construction including open spaces*. A methodology has been developed and validated for the SEEDS concept. A commissioning flow suitable for the application of SEEDS in any building has also been developed. Because of the errors in the Optimizer code references above, it hasn't been possible up to accomplish all the steps in the commissioning flow for the two pilots. Therefore the full demonstration (all components managing the building) in the two pilots hasn't been possible yet but the only inconvenience is the Optimizer. However, the developments were tested in a small size testbench and the integration of all software components was also tested for one of the pilots (UiS pilot) using WISAN mock up, prior to the commissioning of the nodes.

O4. *Integration with existing control systems (like safety, security, fire alarm or lifts)*. SEEDS' BEMS has been conceived so that it can easily be integrated with other control systems in the building. As SEEDS is only a prototype, the demonstration of SEEDS hasn't considered the integration with other control systems existing in the two pilots.

O5. *Exploitation and dissemination of the technologies developed and best practises learned*. Dissemination activities have been performed and an intital exploitation plan has been drafted.

O6. *Contribution to the reduction of greenhouse gas (GHG) emissions and, by hence, contribution to the fulfilment of the SET-Plan on energy efficiency*. The whole SEEDS concept is oriented towards energy optimization and GHG reduction while keeping comfort and health conditions.

To achieve the above list of goals, the following scientific/technical objectives (STO) are pursued:

STO	Objective Description	Related to WP	State
STO1	Development of a modelling methodology for a wide spectrum of building types and energy systems and subsystems.	WP1, WP2	Finished
STO2	Research and development of scalable implementations of global optimization algorithms.	WP5	Finished
STO3	Development of self-learning and optimization behavioural models for energy systems and subsystems in buildings.	WP1, WP2, WP5	Finished

STO	Objective Description	Related to WP	State
STO4	Development and adaptation of a network of Wireless Intelligent Sensors and Actuators (WISA) and design and implementation of communication middleware and configuration tools for the WISA.	WP3, WP4	Finished
STO5	Development and refinement of anytime self-learning and optimization algorithms able to cope with the requirements of energy management systems.	WP5	Mostly finished (1)
STO6	Validation and implementation in two pilot demonstrators.	WP1, WP7, WP8	Partially finished(2)

Table 1. Scientific/technical objectives (STOs)

(1) Some coding problems in the Optimizer code were encounter during the validation in Ferrvovial pilot. At the moment of the submission of this report these problems still remains (2): Because of the problems with the Optimizer the full validation in the pilots (SEEDS controlling the building) hasn't started yet.

The above STO are linked to the following technical achievements (TA)

TA#	Technical achievement description	Related to WP	State
TA1	Processes, systems and tools for the development of a BEMS based on self-learning and optimization techniques.	WP1, WP2, WP3, WP4, WP5, WP6	Mostly finished (1)
TA2	Holistic classification of building types and energy systems and subsystem and methodology for energy control systems modelling.	WP1, WP2	Finished
TA3	Design of energy systems and subsystem behavioural models and implementation into a library.	WP1, WP2	Finished
TA4	Design, development and implementation of a network of WISA and communication middleware and configuration tools.	WP3, WP4	Finished
TA5	Development of anytime self-learning and optimization algorithms tuned specifically for BEMS.	WP5	Finished (2)
TA6	Implementation of scalable global optimization algorithms with relevant computational infrastructure.	WP5	Mostly finished (1)
TA7	Validation and implementation of the technologies developed. Drafting of 'Best ICT practises for energy efficient buildings and surrounding spaces'.	WP1, WP7, WP8	Partially finished(3)

Table 2. Technical achievements (TAs)

(1): At the moment of the submission of this report some problems in the Optimizer coding remains. However, the rest of the tools work properly. The whole concept (process, systems and tools) was also validated before in other Testbenches. (2) The design of the SL and optimization algorithms was successfully tested in the Helicopter Garage testbench. (3): Because of the problems with the Optimizer the full implementation in the pilots hasn't started yet. Best practises has been draft and included in the corresponding deliverable (D8.6)

As explained in Section 2.3.2 'Problems encountered and solutions found', the validation of SEEDS was very much delayed and for that reason, in order to have enough time to allow SEEDS controlling the pilots during enough time to derive relevant conclusions in relation to energy validation, the consortium decided to ask on an extension of project duration which was accepted by the Commission and the end of the project was set in February 2015. In spite of that extension we haven't been able to fully validate in the two pilots due to some errors in the Optimizer code which remains unresolved at the time of drafting this report. The researcher from UiS in charge of the Optimizer and developing the code left the organization at a critical point and the replacement wasn't able to solve the problems. For those reasons, not all STO's and TA's have been successfully achieved in spite of the good results and challenges successfully tackle by the project.

Table 1 and Table 2 above include the status of STO and TA at the end of the project. As a summary, all STOs and TAs were fully met except for STO5, STO6 and TA1, TA6 and TA7. STO5, TA1 and TA6 have been mostly accomplished with the exception of the coding problems encountered in the Optimizer code during the validation in Ferrovial pilot in February 2015. However, the rest of the pieces in SEEDS concept perform properly. With respect to STA6 and TA7 which are related to the validation in the two pilots, they have only been partially met because of the impossibility to fully validate in the pilots as a consequence of the coding errors in Optimizer and also because of the delay in the two pilots.

Section 2.1*"Project objectives for the period M25-M42"* explains the goals and tasks accomplished during the finished period of the project (M25-M42).

1.2 Description of the work performed

During the third period (M25-M42) of the project activities has focused on:

1. Adjustments and tuning of the facility models and the control strategy tailored to the needs of the two pilot demonstrators (WP2).
2. Improvement in the optimization algorithms to reduce the computational time and adjustments and tuning for the application of the optimizer to the two pilot demonstrators (WP5).
3. Refinement on Self-learning algorithms and adjustments and tuning for the two pilot demonstrators (WP5).
4. Implementation and validation of the GUI for the two pilot demonstrators (WP6).
5. Deployment and commissioning of the WISAN in the two pilots (WP3-WP4).
6. Tasks for the implementation and commissioning of SEEDS in the two pilot demonstrators. These tasks are included in the internal documents (Road to pilots which is general for both pilots and Commissioning Flow for Ferrovial/UiS) and involved WP's 2-7.
7. Development of a methodology for the energy savings impact assessment to be applied to the two pilots (WP8).
8. Development of a methodology for Life Cycle Assessment and Life Cycle Cost analysis to be applied at SEEDS and its application in the two pilot demonstrators (WP8).
9. Drafting of Best practises for energy efficiency after the results and the experience in SEEDS (WP8).
10. Evaluation of project performance and deviation from original objectives and drafting of lessons learned (WP8).

11. Dissemination and clustering activities (WP9)
12. Elaboration of an exploitation plan (WP9)
13. Completion of management activities (WP10)

Other tasks that were foreseen but have not been fully achieved or accomplished at all are:

1. Migration of historical data from MySQL to OpenTSDB. This tasks was not included in the DoW but was considered a nice to have improvement for SEEDS. Unfortunately, we were delayed in the validation of the project and didn't have time to complete this task. In any case the data base MySQL can handle properly all the type and amount of data.
2. Validation and reporting of SEEDS performance over a long time period. As the errors in the optimizer code remains unsolved, the full validation (SEEDS controlling the pilots buildings) wasn't possible. Therefore the full completion of WP's 7 and 8 was not possible. See explanations in the description of the development in WP7 (Validation of the technologies) and . in the description of WP8 (Energy balance and environmental impact) in in Section 2.2.7 and Section 2.2.8

The main obstacle in SEEDS development was the lack of time to validate in the two pilots for the reasons already explained. On top of that, errors in the optimizer code were found at a very late stage and after the software developer in UiS left the organization. This has also been an obstacle as it has made impossible to fully run SEEDS in the two pilots. In spite of that, SEEDS has produced some relevant scientific and technological developments which are listed below:

1. Development of an open and flexible architecture suitable for all types of buildings and facilities, not requiring a detailed information on the architecture or the facilities and able to evolve and integrate new sensors/actuators, devices or equipment.
2. A reusable Facility Model Library based on BIM has been developed.
3. A modelling methodology which allows the automatic generation of the SEEDS software for any building based on the creation of an MS ACCESS schema which is also based on IFC (an open BIM standard) enhanced to gather all SEEDS requirements. The integration and/or update of new building facilities only required the actualization of the MS ACCESS data base and the new execution of the configuration process.
4. A low cost, scalable and building independent WISAN platform very appropriate for BAS and including configuration tools and data storage.
5. A wide range of self-learning methods that can be tune for particular building types and scalable SL methodology which allows parallelization and distributed processing.
6. A model based commissioning procedure to test and validate the integration of the different systems included in SEEDS.
7. The use of standards has been applied when possible within the project to enhance the replicability potential. The following standards were used: IFC (in the Facility Model Library, MS ACCESS creation and in a positioning developed within WISAN to facilitate nodes positioning) and OSGI (for the Controller development).
8. A methodology to calculate energy savings and reduction in CO2 emissions in a building when new Energy Conservation Measures are applied. The methodology is based on data from a previous baseline period and climatic conditions.

Because of the above achievement and because of the different types of buildings (different use and climate) and the wide range of facilities included, SEEDS' replicability potential is high.

However, some developments have still to be pursued to facilitate market penetration. Some of SEEDS partners have the intention to carry on working on this direction. In particular, it is sought the integration of SEEDS into commercial BAS software and integrated with other control systems in the building.

A detailed description by each work package is included in section 2.2 *"Work Progress and achievements during the period M25-M42"*.

1.3 Expected final results and potential impacts

As already mentioned in Section 1.2 above (when listing the main scientific/technological SEEDS' achievements), the main impact of SEEDS is related to its high potential for replicability and enhancement of market penetration of customized and cost-effective ICT solutions for energy efficient buildings.

One of the main advantages of SEEDS' concept is its feasibility to be applied to any building. The modelling methodology based on measurements and self-learning and structured into re-usable libraries makes SEEDS a very flexible approach which allows an easy integration of new and current energy devices and subsystems and an easy adaptation to different buildings. The automatic generation of SEEDS software is also one of its main properties.

SEEDS approach is oriented towards effective customizations of solutions that are more effective and can provide a competitive advantage. Moreover, the well-defined interfaces, libraries of different energy subsystems, and communication middleware will allow easy integration of products from different vendors. As a consequence, SEEDS means an important step forward towards the development and opening to the market of novel ICT customized solutions for building operation.

The main competitiveness, economic, environmental and sustainability benefits of the project are:

- Reduction of energy consumption, costs and CO_2 emissions due to an efficient management of the energy performance of the building.
- Improved health, quality of life and comfort.
- Reduction of first adjustment and maintenance costs.
- Maintenance of natural resources and reduction of generated waste.
- Reduction of the cost for the development and implementation of building energy control systems thanks to SEEDS' methodology aimed at an easy customization of Building Energy Management Systems
- Enhancement of market penetration of efficient control systems for building operation.

1.4 Consortium and Contact details

The SEEDS consortium includes an appropriate mix of practitioners and researchers from industry and academia, with a range of expertise that aims to ensure a successful outcome. The consortium is made up of the following organizations: CEMOSA (Project Coordinator, Spain), Fraunhofer (Germany), SOFTCRITS (Spain), Fundación CIDAUT (Spain), University of

Salford (United Kingdom), University of Stavanger (Norway), NSC (Germany), Ferrovial Agromán (Spain) and FASA (Germany).

The contacts details can be addressed to www.seeds-fp7.eu and www.seeds-fp7.com

2 Core of the report for the period: Project objectives, work progress and achievements, project management

2.1 Project objectives for the period M25-M42

During the first two years of the project, the main achievements of the project were:

- The definition and development of SEEDS architecture, the modeling methodology and the creation of the MS ACCESS schema
- The development of the Facility Model and the Controller components
- The development of a wide range of self-learning algorithms
- The development of the optimization algorithms
- The development of the WISAN and its configuration and communication tools
- The development of the GUI
- The analysis of the two validation pilots and implementation of a monitoring system to gather their behavior before SEEDS implementation

During the last period of the project, from M25 to M42, the focus has been in the commissioning and implementation of SEEDS in the two pilots. The main objectives for this period were:

1. The implementation and commissioning of SEEDS in both pilots
2. The validation of SEEDS including energy analysis and Life Cycle Assessment and Cost
3. The drafting of Best Practices
4. The evaluation of project performance and lessons learned
5. The elaboration of an exploitation plan
6. The completion of dissemination activities

All the above objectives were met except for numbers 1 and 2 above which were only partially met due to the delay in the validation stage and the errors in the optimizer code that were encountered at a very late stage of the project (February 2015) during the validation in Ferrovial pilot. .

Table 3 below shows the tasks developed during this period and its relationship with WP`s and Scientific and Technological Objective (STO) and/or Technical Achievement (TA).

Tasks developed within M25-M42	Into WP #	In relation to STO/TA #
The tailoring of the WISAN system to the particular scope of each pilot, the definition and design of the different types of nodes, the ordering to an external an manufacturer, the testing and the configuration of all the nodes	WP3-WP4	STO4, TA4

Tasks developed within M25-M42	Into WP #	In relation to STO/TA #
Reporting/summary of the adjustments of the building models (Task 2.4) and the control strategy (Task 2.6) required during the implementation and commissioning in the pilots	WP2, WP5	STO6, TA7
Improvements in optimization algorithms to reduce the computational time	WP5	STO2, TA5, TA6
Training and tuning of Self-Learning algorithms according to the characteristics of the two pilots and SEEDS is able to learn the characteristics of each particular	WP5	STO3, STO5, TA5, TA7
Implementation and validation of the GUI for the demonstrator pilots in Madrid and Stavanger	WP6	TA1
Development of all the tasks included in the internal documents Road to pilots (general document for both pilots) and Commissioning Flow (one document per pilot). These tasks include: • Preconditions: Creation and population of MS ACCESS data base for both pilots and configuration of a local PC to control the building • Development of test plans • Configuration of the different components: MySQL data base, Facility-Model, Optimizer, Self-Learning, Controller, GUI and WISAN • Deployment and installation of MySQL • Installation of the different components in the controller layer • Definition of local control algorithms and integration in the WISAN • Definition of a procedure to gather enough variety of data for the training of Self-Learning algorithms • Integration tests, functional tests and operational test	WP2-WP7	STO6, TA1, TA3, TA7
The integration and test of all SEEDS components using WISAN mock-up using as a test bench the original scope of UiS pilot (which includes 79 rooms of different types a a good variety of HVAC and lighting equipment	WP2-WP7	STO6, TA1, TA3, TA7
Methodology on Impact Assessment of energy efficiency and energy savings	WP8	STO6, TA7

Tasks developed within M25-M42	Into WP #	In relation to STO/TA #
Life cycle issues, environment and economic impact	WP8	STO6, TA7
Post-Occupancy study	WP8	STO6, TA7
Evaluation of project performance and analysis of lessons learned	WP8	Evaluation of the project
Dissemination, clustering and exploitation activities	WP9	
Coordination and management activities	WP10	

Table 3. Tasks developed within M25-M36 period

2.2 Work progress and achievements during the period M25-M42

During the third period of the project, activities have been carried out in the following Work Packages:

- WP2: System behaviour models and library generation.
- WP3: Wireless intelligent sensors and actuators network (WISAN)
- WP4: WISAN Communication infrastructure
- WP5: Self learning and global optimization
- WP6: Graphical User Interface (GUI)
- WP7: Validation of the technologies. Case studies
- WP8: Energy balance and environment impact. Best practises and lessons learned.
- WP9: Dissemination and Exploitation.

The following sections describe progress towards the objectives and achievements in these Work packages during the third period: from September 2013 to February 2015.

2.2.1 WP 1: Requirements analysis and buildings design methodology

This WP finished in M8 (first period).

2.2.2 WP2: System behavior models and library generation

<u>Summary of progress towards the objectives and details for each task</u>

The objectives of WP2 in the period are:

- Prove of concept of the SEEDS modelling methodology and the SEEDS control strategy,
- Evaluation and adjustment of the building facility models applied in the two SEEDS pilots,
- Evaluation and refinement of the building energy control strategy that was developed in the first two periods and applied in the pilots in the third period.

The work progress of each task is explained below.

Task 2.1 Analysis of the different energy consuming devices/appliances/ facilities, energy sources and energy storages

Start month: M4 (December 2011)

End month: M6 (February 2012)

This task is already finished.

Task 2.2 Analysis of different modelling approaches, platforms and standards

Start month: M1 (September 2011)

End month: M9 (May 2012)

This task is already finished.

Task 2.3 Definition of the modelling methodology for the subsystems and the whole system

Start month: M4 (December 2011)

End month: M18 (February 2013)

This task is already finished.

Task 2.4 Model creation for relevant systems and subsystems

Start month: M7 (March 2012)

End month: M42 (February 2015)

Deliverable 2.6 "*Optimized Models for the energy system and for sub-systems verified and optimised for the demonstrator*" (M36, Fraunhofer)

The concept of the SEEDS building model library was developed in the second SEEDS period (see Deliverable 2.4, 2.5 and 2.7). In the third period, the model library was implemented for the pilots, evaluated, validated and refined as far as necessary (see Deliverable 2.6).

All building models and the building model library are completely tested and validated for both the Ferrovial and the UiS demonstrator. The tests were carried out in January and February 2015. During the test phase and the pilot commissioning, the building model library could be finally adapted and adjusted by measurements of the real building energy system.

Task 2.5 Development of a library architecture

Start month: M7 (March 2012)

End month: M21 (May 2013)

This task is already finished.

Task 2.6 Development of energy control strategy

Start month: M15 (November 2012)

End month: M42 (February 2015)

Deliverable 2.9 "*Energy control strategy. Final release*" (M36, Fraunhofer)

The concept of the SEEDS control strategy was developed in the second SEEDS period (see Deliverable 2.8). In the third period, the control strategy was implemented in the pilots, evaluated, validated and refined as far as necessary (see Deliverable 2.9). In detail, following steps were carried out in the SEEDS project to implement the control strategy into the pilots:

(1) Integration of all kinds of energy conversion and transmission equipment
(2) Determination and grouping of all relevant variables and the multitude of their types and metrics
(3) Based on (1) and (2), development of configuration database (MS Access) containing all control relevant building data to be used for an semi-automatically controller configuration according to the needs of the controlled building
(4) Definition and configuration of the final BEMS architecture for the application in the pilots), definition of all required functions, interfaces and activities
(5) Adjustment and refinement of the energy calculation according to the real measurements
(6) Refinement of the self-learning and optimizer according to the required forecast horizon
(7) Demonstration of the automatically configuration using the SEEDS Energy Calculator as example
(8) Definition of realistic boundaries for the comfort
(9) Definition of an adjustable forecast horizon
(10) ICT organization allowing building energy management in real time
(11) Definition of commissioning plans for the controller and its components.

Deliverable 2.9 has been submitted in-time.

<u>Major Results/Significant results obtained</u>

The major results and achievements are:

- SEEDS control strategy was implemented, validated, and evaluated of in the pilots. The SEEDS controller was proven; some minor bugs had to be fixed.
- Energy calculation and energy prediction are proven by measurements in real buildings. The energy calculation algorithms were adjusted.

- Due to the usage of the MS Access as configuration data base, the SEEDS components could be easily semi-automatically adapted to the specific pilot needs. The specific pilot needs are represented by different configurations of the MS Access database. During the commissioning phase, the MS Access configuration database was optimized and adjusted. For the semi-automatically pilot configuration the SEEDS configurator was successfully proven and tested.
- The PSO optimization and forecast algorithms were refined to increase both the forecast horizon and the run-time performance:
    a. Smart Initialisation of Particles
    b. Search Space Restrictions and Comfort Boundaries
    c. Cost Function
    d. Optimization with Multistep Forecasts and Dynamic OPT Call
    e. Feature vectors specification and configuration for NN

<u>Deviations from Annex I</u>

No deviations from the plan in this period.

<u>Use of resources</u>

The following table indicate the planned person months in comparison to the actual used person months in the third period (M25-M42).

WP2	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	**TOTAL**
Planned M25-M42	0.5	3	0	0	2.7	0	0	0	0	**6.2**
Actual M25-M42	0.52	3.71	0	0.3	2.5	0	0	0	0	**7.03**

Table 4. Use of resources in WP2

2.2.3 WP3: Wireless intelligent sensors and actuators network (WISAN)

<u>Summary of progress towards the objectives and details for each task</u>

The objectives of WP3 during the period were:

- Support the installation of the WISAN in the SEEDS demonstrators

- Fix the possible bugs detected during the installation phase

The work progress of each task is explained below.

Task 3.1: Evaluation of wireless technologies and sensor/actuator node hardware for building automation

Start month: M1 (September 2011)

End month: M3 (November 2011)

This task is already finished.

Task 3.2: WISA design and development

Start month: M3 (November 2011)

End month: M12 (August 2012)

This task is already finished.

Task 3.3: Implementation of local analysis algorithms

Start month: M15 (November 2012)

End month: M40 (December 2014)

The local analysis algorithms defined in the previous period were modified during the installation phase. These modifications made it necessary a major re-implementation of the algorithms previously implemented in the nodes. All these modifications have been carried out in this period in parallel to the final deployment in the demonstrators.

Task 3.4 Sensor/Actuator selection, evaluation and integration

Start month: M7 (March 2012)

End month: M40 (December 2014)

SOFTCRITS has been responsible of the manufacturing process and the support of the installation of the WISAN nodes at the SEEDS demonstrators. For the manufacturing, SOFTCRITS was in charge of the quality control for the nodes (by means of testing) and the configuration of each of the nodes according to the demonstrators specification. The configuration process included network interfaces configuration and the sensor and actuators associated to each of the nodes (93 nodes por Ferrovial and 54 nodes for Uis). This configuration was changed after the scope modifications in the demonstrators and the process had to be partially repeated.

During the installation SOFTCRITS was in charge of providing support to install and configure the WISAN nodes and for the final testing of the nodes in the installation (diagnosis of errors after connection, bug fixing, etc).

Task 3.5: Positioning systems evaluation and Network Design Framework

Start month: M1 (September 2011)

End month: M23 (July 2013)

This task is already finished.

Major Results/Significant results obtained

The major result of SOFCRITS is the installation of a large WSN with one hundred nodes. The manufacture of several kinds of nodes, have been an important result also, because it shown the flexibility of the hardware and software developed in the project.

Deviations from Annex I

Although the deliverables were submitted on time, several tasks related with the adaptation of the scope of the demonstrators have been appeared during the installation of the WISAN. According with this situation, SOFTCRITS have been working in the adaptation of the software and hardware of the WISAN nodes to accomplish the new requirements of the demos.

Use of resources

The following table indicate the planned person months in comparison to the actual used person months in the third period (M25-M42).

WP3	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	**TOTAL**
Planned M25-M42	0	0	0	0	0	0	0	0	0	**0**
Actual M25-M42	0.6	0	6	0	0	0	0	0	0	**6.6**

Table 5. Use of resources in WP3

2.2.4 WP4: WISAN Communication infrastructure

Summary of progress towards the objectives and details for each task

The objectives of WP4 during the period are:

- Support WISAN installation in SEEDS demonstrators.
- Fix bugs detected during the installation phase.

The work progress of each task is explained below.

Task 4.1: Mesh management and self configuration

Start month: M1 (September 2011)

End month: M40 (December 2014)

Supporting of the demo phase and bug fixing of the WISAN Server and WISAN Tool Support. Several tasks performed during this period related with data collection and WISAN integration with the rest of SEEDS components, for instance:

- Problems with MAC address in configuration files of WISAN Server.
- Reconfiguring of the network to fit with the new scope.
- Improvement of communications to solve network disconnection problems in gateways.

Task 4.2: Reliability and QoS management

Start month: M3 (November 2011)
End month: M12 (August 2012)

This task is already finished.

Task 4.3: Security support

Start month: M3 (November 2011)
End month: M12 (August 2012)

This task is already finished.

Major Results/Significant results obtained

The main significant result of this work package has been a set of tools that ease the installation of the WISAN and a software with good integration capabilities with external systems.

Deviations from Annex I

Although the deliverables were submitted on time, during the installation process have been appeared several tasks related with the change of the scope of the demonstrators. According with this situation, SOFTCRTIS have been worked in the adaptation of the WISAN Server configuration and the WISAN Tool Support to accomplish the requirements of the demos. During this period SOFTCRITS have been fixed bugs of the tools.

Use of resources

The following table indicate the planned person months in comparison to the actual used person months in the third period (M25-M42).

WP4	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	**TOTAL**
Planned M25-M42	0	0	0	0	0	0	0	0	0	**0**
Actual M25-M42	0.45	0	11.82	0	0	0	0	0	0	**12.27**

Table 6. Use of resources in WP4

2.2.5 WP5: Self learning and global optimization

<u>**Summary of progress towards the objectives and details for each task**</u>

The objective of WP5 during the third period is:

- To provide methods that can utilise the learned relationships and models to accurately predict the thermodynamics of buildings under various configurations and conditions.
- To develop scalable and effective methods for optimising the energy supply and utilisation of buildings subject to a range of hard and soft constraints that model user comfort, type of building and surrounding environment.
- To provide interfaces and integrate self-learning in an open architecture to facilitate continuous improvements in energy management for a range of scenarios.

The work progress of each task is explained below.

Task 5.1: Research on Self-learning and Optimization Methods for Efficient Energy Building Management

Start month: M3 (November 2011)

End month: M6 (February 2012)

This task is already finished.

Task 5.2: Development of Self-Learning Algorithms

Start month: M6 (February 2012)

End month: M18 (February 2013)

This task is already finished.

Task 5.3: Development of Optimisation Methods

Start month: M11 (July 2012)

End month: M20 (April 2013)

SEEDS has developed a novel approach to optimisation, using a multi-level look forward strategy and using Particle Swarm Optimisation (PSO).

The additional complexities of using multiple steps has resulted in greater complexity, particularly since the search space increases exponentially at each step, making the problem computationally expensive and challenging. The early attempts at addressing this challenge included consideration of what were termed "expert rules" and a review of draft of D5.3, together with discussions at the project meeting held in September 2013, suggested alternative ideas involving smart initialisations of the particle swarm population, which were described in the submitted deliverable D5.3. The ideas developed were implemented and tested for the Helicopter Garage testbench, with D5.3 concluding that:

- Use of Genetic Algorithms(GAs) and Particle Swarm Optimisation (PSO) producing similar performance.
- PSO was easier to understand and implement.
- The smart initialisation idea was effective in trimming the search space.
- The PSO converged more rapidly when using a cost function that included a penalty function when temperature was out of a reasonable comfort level; however it might not be straight forward to find an adequate penalty function for a more complex optimization problem
- Multi-level forecasting was more effective than single level forecasting in saving energy.

The conceptual ideas, specification and an evaluation on the Helicopter Garage testbench had been successfully conducted by the end of 2013 and the next stage was to integrate and interface them in the implementation of the SEEDS architecture (Task 5.4) and refine them so they apply successfully to the validation sites (Tasks 5.5).

Task 5.4: Interfacing and integration within SEEDS architecture

Start month: M17 (January 2013)

End month: M21 (May 2013)

The deliverable associated with task, namely Deliverable 5.4 "*Specification and implementation of interfaces that have been integrated and tested*" was submitted in June 2013, and as reported in the Periodic Report for M12 to M24, the following had been achieved:

- Conception, development, implementation, validation and documentation of a library of interfaces for the SEEDS controller internal components and external components. That includes the interfaces of the core components Building Model, Self-Learning, Optimizer, and the Controller itself and all interfaces outside the controller. This mainly concerns the communication between the Data Management Layer (SEEDS Cache) and the interface between Controller, and WISAN to transfer optimized control settings.
- The interfaces are implemented as abstract Java classes to be implemented in the SEEDS components. The interfaces are completely independent on a certain SEEDS application.

- The interfaces test as part of the SEEDS system was run with the test harness (Helicopter Garage) described in task 2.4.

- A test and commissioning plan for the commissioning of the interfaces in the pilots in Stavanger and Madrid was developed.

Although testing exercise was performed, it is important to note that this was on a test harness, and that installation in the validation pilots was the ultimate test and was expected to result in some additional challenges. Several issues arose as the implementation developed including:(i) the implementation did not take full account of the proposals to develop a multi-step look ahead forecasting process given these ideas were not fully formed until after this period and (ii) as commented during the second review meeting the concerns with lack of speed remained and (iii) new functionality for obtaining weather data was needed.

These issues were resolved by significant work on the self-learning and optimisation components including:

- (i) Self learning forecasting and training utilised a cache so that data base accesses, which can be time consuming, were minimised.

- (ii) Concurrency was introduced using multi-threading so that both self-learning forecasting and training can operate in parallel and self-learning training can update the models on the fly.

- (iii) An external weather agency module was implemented to fetch data from a third party weather web service.

- (iv) The self-learning training and forecasting components were redesigned to allow distributed processing.

- (v) The concept of anytime computation was introduced for optimisation to continuously improve its solutions with time and stopping within the required time span.

Although, some of issues belong properly to Task 5.2 on development of Self-learning algorithms, they arose during the period of integration and the solutions reported in deliverable D5.4 and D5.5.

Subsequently, integration testing was planned to take place in April 2014 at an event in Malaga. The integration test was performed on the original UiS pilot scope, based on the MS Access for UiS pilot which was available since 03/03/2014. It included testing the optimization, self-learning, facility model and controller. More specifically, it included:

1. Testing of database retrieval

   OPT, SL, facility model: all successfully tested querying necessary data from database.

2. Integration test of SL and OPT with the CONTROLLER

   This test consisted in executing the SEEDS bundles together. The aim was to check if the JAVA OSGI bundles are able to intercommunicate and successfully interface with each other. To check the status of the test, debugging checkpoints were strategically set in the code in a way that the values of the variables were controlled in run time.

After some minor debugging the Self-Learning, Building model and OPT were successfully integrated with the Controller.

It is important to note that at the time of the integration testing meeting in April 2014, the WISAN had yet to be installed, and hence testing was on dummy data and functional tests were not possible, and had to be deferred to Task 5.5.

Task 5.5: Implementation and refinement of self learning algorithms and global optimization into the two validation pilots

Start month: M21 (May 2013)

End month: M35 (July 2014)

Task 5.5 was to follow the interfacing and integrations task, with the aim of ensuring that implementations of the optimisation and self-learning methods were operational in the pilots and could be tuned as more live data became available in the pilots. This task has not been fully completed and it is therefore to review this task in stages, so the scientific, technical and project management challenges encountered are identified and lessons learned for future research projects. The key stages with respect to this task (see D2.3 on SEEDS methodology) are to (i) define the building characteristics together with scope of facilities (ii) populate the MS Access data base so it can be used for configuration (iii) collect suitable data from the sensors for initial training of self-learning models (iv) configure, trial and test optimisation (v) tune the models and optimisation as more data becomes available. The following reviews these stages and concludes with the lessons learned.

<u>Review of steps (i) to (iii): From configuration to initial training for the pilots</u>

Initial versions of the MS Access data base (see Task 5.x) were developed and then populated for the Madrid Pilot, with preliminary versions available by end of October 2014. Data for the self-learning was collected for the periods 3rd to 10th November and 17th to 19th November. Analysis of the data collected showed some malfunctioning sensors and nodes, and missing data which was only identified following poor results from the initial self-learning models. A data quality report was produced as part of Task 5.5 in December 2014 and some reconfiguration of the models necessary before retraining, leading to good results for variables such as temperature. Producing Energy data for training proved to be more challenging with some unexpected issues around missing data and how different types of energy could be unified. A strategy for missing data, which involved using interpolation was adopted and issues with the energy data were resolved the data was made available on the 19th January 2015. Training and refinement of the predictive models for energy were completed and the self-learning models made available on the 9th February 2015 ready for optimisation.

Neural network models were produced for:

- indoor room temperature (per room)
- indoor air quality (per room)
- electrical energy

- fuel energy
- thermal energy

Our trials showed that use of decision tree learning was more appropriate for predicting use and room command settings. The flexibility and generic nature of the SEEDS self-learning component meant that adoption of this different learning technology was possible in the same framework.

In total, for the Madrid site, 151 models were trained, taking approximately three hours. The following three tables summarises the accuracy of the models.

Variable Type	Average RAE
Indoor room temperature (per room)	4.22%
Indoor air quality (per room)	18.11%

Variable Type	Accuracy
Use (per room)	94.98%
Room command module (per room)	97.00%

Variable Type	Accuracy
Electirical energy (per building)	8.43%
Fuel energy (per building)	5.03%
Thermal energy (per building)	5.21%

Table 7. Accuracy of SL models

Similarly, data for the Stavanger pilot (final scope which as reduced with respect to the original one used in the integration test in April 2014) was collected from 9th February to the 19th February. Initial models were produced by the 27th March 2015 and following a revision of the energy data, revised models produced on the 30th March 2015. The results produced were similar to those for Ferrovial and show the validity of the self-learning approach and its implementation in SEEDS.

<u>Review of step (iv) Configure, Trial and Test Optimisation</u>

The models for this to commence for the Ferrovial site were made available on the 19th January 2015.

The project team was conscious that timescales would be tight given the start of this task 5.5 was delayed due to unforeseen issues with the validation sites. It has therefore adopted good practice in testing the interfaces in integration test event (based on the original UiS pilot scope) held in Malaga in April 2014. This was successful and also identified some issues around integration between the different components which were resolved. However, the successful operation of the optimization component is delayed. Reasons for the delay are varied but mainly due to the person developing the PSO component leaving the project at a critical point. The learning curve for a new person is steep and although partners from Salford and Fraunhoffer have provided support, there has been inevitable delay and a negative impact on completing this task. The primary issues that have arisen include:

- (i) coding errors due to assumptions around variable naming in multi-step optimisation that had previously been discussed and may have been due to change over of personnel and availability of resources in the extension period;

- (ii) issues with the data quality which were outlined in the data quality report submitted to partners in December 2014, leading to delays in producing models of sufficient accuracy. These issues were resolved following further data collection.

- (iii) changes to scope, which require re-configuration due to some failing nodes. These can, of course be resolved but the late start of this task towards the end of project makes this difficult.

In summary, Task 5.5 has not been fully completed at the time of writing this report. On reflection, the project team should have considered a number of milestones, such as the availability of the data from the pilot sites, to have a higher risk than assumed. Some mitigation strategies, such as the Helicopter Garage pilot, and integration testing were used to reduce impact.

However, although it is easy with hindsight, a strategy for mitigation against the impact of key staff leaving during an extension should also have been considered.

At the time of writing, the optimisation code had been configured for the Madrid pilot and unit testing had been completed. Operational tests were defined though not completed as some coding errors remain unsolved.

Task 5.x: Development of SEEDS' Data Management

DoW didn't include any task on Data Management which is essential for the completion of the SEEDS concept. This new Task was added to the DoW and the previous report provided the details of the progress made and work done in developing the MS Access database and the SEEDS cache and the historical archive.

All three have been successfully populated with information for the Madrid and Stavanger pilots. In populating the database for the pilots, some further refinements were made to naming conventions and tables. The few changes confirmed the robustness of the design and its suitability for different buildings and energy management systems. Thus, the populated data bases have been successfully used for configuring the self-learning component, optimisation and the user interface.

<u>Major Results/Significant results obtained</u>

- A novel, flexible and open architecture for providing a range self-learning methods has been developed and integrated into the SEEDS architecture

- A self-learning component that is scalable and reconfigurable for different buildings has been developed and demonstrated on two very different buildings

- Unit tests and integration tests demonstrate suitability of the self-learning architecture

- Models have been developed for the Madrid and Stavanger case studies and results obtained show very good accuracy for predicting temperature, air quality, usage, and types of energy.

- The efficacy of the data management systems has been demonstrated on both the validation sites.

- A new multi-step energy optimisation algorithm based on the adoption of Particle Swarm Optimisation (PSO) has been implemented.

- A new and flexible boundary checking algorithm has been implemented.

<u>Deviations from Annex I</u>

WP 5 tasks 5.1 and 5.2 and their associated deliverables were completed on time. The design of a multi-step forward looking Particle Swarm Optimisation algorithm is a novel idea that evolved during the project and reviews of the early versions of deliverable 5.3 revealed additional complexities and technical issues, such as the increasing requirements for computational power that had not been anticipated but identified as a result of the SEEDS internal quality review process. This led to refinements and revisions, and deliverable D5.3 was submitted in M26, with some delay with respect to the due date. Having agreed a specification as detailed in D5.3, some additional development, coding and interfacing was carried out as part of Task 5.4 was needed in this time period.

The start of Tasks 5.4 and Task 5.5 were delayed considerably and the plan required continual updating. As mentioned above, availability of data for the pilot sites is a pre-requisite for this task, and unfortunately, due to unforeseen challenges and complexities in installing sensors and actuators, led to major delays. The start date for integration testing (Task 5.4) was revised to be in April 2014, and was carried out on mock up data given delays in installations at the pilot sites.

Delays were managed by revising a commissioning plan, one for each validation site. The original project plan aimed to commence for Task 5.4 in M17 and conclude Task 5.5 in M35, which would have provided significant time for integration, resolving problems and tuning for the two validation sites. Given the delays, as much testing and configuration as possible was carried out in advance, for example with mock ups. This enabled to revise the commissioning plans and set a more ambitious target delivery time for the development self-learning models. Some initial data for the Madrid site was made available in November 2014, leading to detection of issues with data quality. Revised data was available on 19th January 2015 and self-learning models were made available on the 9th February 2015.

For Stavanger, the installation was very slow and the scope had to be reduced (see description of WP7). On the reduced scope, data was collected from 9th February to the 19th February. Initial models were produced by the 27th March 2015 and following a revision of the energy data, revised models produced on the 30th March 2015.

This, in turn had an impact on functional testing the of optimisation methods for the pilots which could not be done until the availability of the self-learning models. Changes to identifier names

OPT have also had an impact on the code for optimisation. Finally, there were also some late changes in scope leading to further issues deviation from the original plan. At the time of writing, optimisation was being tested.

Use of resources

The following table indicate the planned person months in comparison to the actual used person months in the third period (M25-M42).

WP5	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	**TOTAL**
Planned M25-M42	1.5	2	0	0	5.76	11	0	0	0	**20.26**
Actual M25-M42	4.28	2	0	0	21	9.5	1	0	0	**37.78**

Table 8. Use of resources in WP5

2.2.6 WP6: Graphical User Interface (GUI)

Summary of progress towards the objectives and details for each task

The objective of WP6 during the second period is:

- Implementation and validation of the GUI for the two pilot demonstrators.

The work progress of each task is explained below.

Task 6.1: Research on GUI strategies for Efficient Energy Building Management

Start month: M9 (May 2012)
End month: M12 (August 2012)

This task is already finished.

Task 6.2: Definition of GUI requirements for Efficients Energy Building Management

Start month: M10 (June 2012)
End month: M13 (September 2012)

This task is already finished.

Task 6.3: Specification of the hardware and software platform for the GUI

Start month: M12 (August 2012)
End month: M16 (December 2012)

This task is already finished.

Task 6.4: Implementation of the GUI for Efficient Energy Building Management

Start month: M14 (October 2012)

End month: M21 (May 2013)

The following activities were performed for the implementation of the GUIs for both demonstrators in Madrid and Stavanger:

- Definition of the GUI Design and Structure
- Configuration of the GUI from the MS Access Database
- Implementation of Data Interchange Component
- Implementation of the Visualization Component
- Implementation of different user access levels
- Deployment to the demonstrator location
- GUI online available

Task 6.5: Validation of the GUI

Start month: M18 (February 2013)

End month: M21 (May 2013)

The target of this task was to validate the GUI's in SEEDS. It includes two stages:

- In the first stage, a methodology to validate SEEDS' GUI was developed. This task was finished in August 2013 (2nd period of the project). The result of this task was reported in D6.4, submitted in August 2, 2013 (due date May 2013).
- In the second stage, the GUI implemented for each demo was validated using the methodology defined in the first stage and reported in D6.4. The results of the validation of the GUI in each demonstrator have been defined as Annexes A & B to D6.4 and submitted in February 2015.

<u>Major Results/Significant results obtained</u>

- It's now possible to display few thousand of information and interactive controls.
- Separation of Content (Sensor and Actuator information) from the graphical representation.
- Definition of GUI component description standard
- Identifying a SCADA solution which integrates applications and devices from different manufacturer.
- Reducing the implementation effort by a generic approach based on the GUI component description

- GUI system is not bound to specific sensor and actuator hardware; so it can be inserted in existing BEMS environments.
- Configuration changes only need to change the GUI system configuration (no work on design, imaging or representation are necessary).
- Integration of different kinds of user groups by ability of role based view and interaction.
- Web based visualization integrates the ability of mobile interaction
- Platform independence
- Remote control (usage with almost every graphic enabled internet device possible including PC, Smartphones, Tablets)
- Scalability and easy enhancement

Deviations from Annex I

Deviations are related to the delay in the development of demonstrators for the validation stage. The GUIs were directly affected by the changes of scopes in the demonstrators.

The validation of GUIs was delayed to the third period because the implementation of them was also delayed due to the delay in the demonstration stage.

Use of resources

The following table indicate the planned person months in comparison to the actual used person months in the third period (M25-M42).

WP6	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	TOTAL
Planned M25-M42	0	0	0	0	0	0	3.5	0	0	**3.5**
Actual M25-M42	2.15	0	0	0	0	0	3.5	0	0.5	**6.15**

Table 9. Use of resources in WP6

2.2.7 WP7: Validation of the technologies. Case studies

Summary of progress towards the objectives and details for each task

The objective of WP7 during the third period is:

1. To define the final scope (rooms and equipment) to be monitored and controlled by SEEDS in both pilots in order to complete the MS Access file to configure the SEEDS components,

2. To install the WISAN nodes in both demos and to carry out the commissioning of it,
3. To start the implementation of SEEDS in both pilots,
4. To validate the performing of SEEDS in both pilots.

Objectives 1 and 2 above have been accomplished. However, the full implementation and validation of SEEDS hasn't been possible because of the errors found in the Optimizer code at a very late stage during the validation in Ferrovial pilot. Those errors still remains at the moment of drafting of this report and have impede the full validation (SEEDS controlling the two pilots) so far. Besides, the Optimizer errors that have made impossible the full validation, the demonstration and validation was already delayed.

The organization and responsibilities in the demonstration is as follows. CEMOSA is responsible of the MS Access completion in UiS pilot. CEMOSA is also responsible for the test plans description, commissioning and overall running of SEEDS in Stavanger. All these responsibilities were defined in the internal document 'Road to pilots' and Commissioning Flow for Stavanger. UiS is the final responsible of this pilot as 'owner' of the building.

CIDAUT is responsible of MS Access completion of the pilot in Ferrovial pilot. CEMOSA supervise CIDAUT's work to make sure that the developments in both pilots are homogenous. CIDAUT is also responsible for the test plans description, commissioning and overall running of SEEDS in Ferrovial. Again, these responsibilities are defined in the Roadmap for Commissioning in Ferrovial (SEEDS' internal document). FERROVIAL is the final responsible of Ferrovial pilot as owner of the building.

Fraunhofer is responsible of the implantation of the Controller, SEEDS Archive and Facility Model in each pilot. USAL is responsible of the implementation of Self-Learning algorithms in both pilots. UiS is responsible of the implementation of optimization algorithms in each demo. SOFTCRITS has designed the WISAN component for each demo. They and CEMOSA provided nodes installation instructions and supported the installation and commissioning in both pilots. In Ferrovial demo, the commissioning of WISAN was carried out for CIDAUT also. NSC is responsible for the development of the GUI for each demo.

The work progress of each task is explained below.

Task 7.1: Initial state

Start month: M7 (March 2012)

End month: M19 (March 2013)

This task finalized in the second period of SEEDS project (M13-M24).

Task 7.2: Analysis of energy measures to be applied in each case study

Start month: M16 (December 2012)

End month: M19 (March 2013)

This task finalized in the second period of SEEDS project (M13-M24).

Task 7.3: Implementation and validation of the SEEDS' BEMS (Building Energy Management System)

Start month: M20 (April 2013)

End month: M42 (February 2015)

General tasks

The implementation of SEEDS in both pilots requires of a preliminary definition of the scope of SEEDS in both pilots where the scope is the selection of rooms/spaces and equipment to be monitored/controlled by SEEDS.

Once the scope is selected, the first step for the implementation of SEEDS in any building is the population of the MS ACCESS database as the MS ACCESS is the procedure that allows an automatic generation of SEEDS software. The MS Access database is the procedure to establish all the relationships among spaces, devices (energy equipment and also sensors/actuators), uses and users comfort requirements.

The second step for SEEDS deployment is the installation and commissioning of the WISAN system. After that, local control algorithms (installed in the WISAN) are used to control the building keeping user comfort. The goal of the application of the local control algorithms is the collection of data to allow for the training of SL algorithms. A set of procedures are prepared to gather enough variety of data for the training of Self-Learning algorithms. The procedures are managed by WISAN Support Tool storing the whole set of data (sensors and actuators) in SEEDS Cache. The period considered to carry out this collection of data is two weeks in both pilots.

Once SL is trained with the gathered data, operational and functional tests are applied and finally SEEDS is ready to control the building. All the steps for the validation of SEEDS are reported in the internal document Commissioning Flow (one per pilot).

Scope definition

The selection of the scope has been changing throughout project duration.

In the case of Ferrovial, due to the economic situation, part of the building was unoccupied. The building is owned by Ferrovial and is occupied by tenants. Only floors 3rd and 5th were occupied and so the scope was chosen within these floors and linked equipment.

The available budget and time has also determined the selection of the scope in both pilots.

After several iterations, both Ferrovial and UiS approved an initial scope in November 2013. This scope was the baseline to perform the order to the manufacturer company. The final scope in Ferrovial pilot was defined in February 2014. It was slightly modified with respect to that selected in November 2013. The validation in Ferrovial includes:

- The thermal comfort and air quality comfort will be also controlled in the rooms selected in the scope. Finally, the third and fifth floors (42 rooms) have been selected with different uses (meeting rooms, individual offices, collective offices and corridors).

- Control on heat pump, fuel boiler and air cooled chillers: SEEDS will control the switching On and Off of this equipment.
- Control on air handling unit of the third and fifth floors: SEEDS will control the performing of air handling units setting the position of air dampers (free-cooling dampers), hot water valve and cold water valve, based on sensors signals and decisions of SL and OPT. It also will set free-cooling position (dampers mentioned) when outside conditions are favourable.
- Control on 37 volumetric flow controllers installed in the two floors in order to manage the air quality comfort and thermal comfort.

In the case of Ferrovial pilot, the installation of WISAN lasted 6 month due to the size of scope, the amount of nodes and the restriction of access time because the building was occupied for tenants during the installation. The installation started in May 2014 and finalized in October 2014.

In the case of Stavanger, all the tasks for the validation of SEEDS were performed according to the scope selected in November 2013 (which covers 79 rooms/spaces of different uses and characteristics and a large variety of HVAC and lighting systems). However due to a sequence of events, in November 2014 very few nodes were installed.

First, after the nodes were already manufactured and ready to be delivered, it was found that some of the nodes didn't meet some requirements which made them unsuitable for public buildings. Because of this, some re-design was made with the limitation of being able to use the already manufactured nodes. After the re-design, the nodes arrived in UiS in the 3rd week of May.

UiS tested the nodes prior to the installation and this process took an extraordinary long time. This task was not included in the Commissioning Flow but was a condition for UiS to accept the deployment in its building despite the fact that the manufacturer and Softcrits had tested the nodes. During this testing performed by UiS new problems were found in the performance of some types of nodes. SOFTCRITS, CEMOSA and UiS looked for solutions and reached the agreement.

As a result of this long process, very few nodes were installed in November 2014 and it was suggested by the former Project Officer (Ms. Mariana Stantcheva) to reduce the scope to be able to validate and have some data. For this reason the final scope in UiS dated from November 2014 and is reduced with respect to the original scope (which was used for the integration tests in April 2014). After this reduction, the WISAN nodes were installed and commissioned in three months. The installation finished in second week of February 2015.

The final scope in UiS includes:

- The thermal comfort and air quality comfort will be controlled in the rooms selected in the scope. Finally, 24 rooms have been selected with different uses (auditoriums, classrooms, conference rooms, offices and corridors.
- Control on air handling units 2 and 3: SEEDS will control the set points of supply temperature according to sensors signals and decisions of SL and OPT.

- Control on 15 volumetric flow controllers installed in auditoriums and classrooms. This equipment is in charged to control de air quality comfort.
- Control on electric radiators installed in the 24 rooms included in the scope.
- Although the diffusion elements are not controlled by SEEDS, the energy provided by them are considered in the energy computation of FM.

In spite of the reduction of the scope in November 2014, UiS pilot remains with a large variety of rooms types/uses and equipment.

<u>Current state</u>

At the moment of the finalization of the project (28/2/2015), the system was not fully applied in any of the pilots. One important reason hindering the final validation of SEEDS is the problems encountered in the Optimizer code (see task 5.5). These problems were shown during the Final Meeting that took place 24th And 25th February 2015. These problems weren't identified at the submission of D5.5 in September 2014. The problems in the Optimizer code (developed by partner UiS) are still to be solved at the moment of drafting this report.

All SEEDS components, except Optimizer, are implemented in both pilots.

The remaining steps to complete the validation in Ferrovial (after the problems in the Optimizer code are solved) are:

a) the testing of the performance of the pair SL/OPT (SL already performs well),
b) the development of the operational tests (all SEEDS components working together but in open loop i.e. commands are not send to actuators) and
c) the launching of SEEDS.

The tests which haven't been performed because of the errors in the Optimizer are listed below. These tests are defined in the Annex I 'Additional document. Validation of the technologies, energy balance and environment impact' which is linked to D7.2 on the validation in Ferrovial.

- Test 46. OPT-MySQL-CONT. Optimizing writes data on MySQL
- Test 50. OPT-MySQL-SL-CONT. PSO loop. Off-line
- Test 62. OPT-MySQL-SL-CONT. PSO loop.
- Test 63. OPT-MySQL-SL-CONT. OPTIMIZING Computation performance
- Test 64. CONTROLLER execution 1. On-line
- Test 65. CONTROLLER execution 2. On-line
- Test 66. CONTROLLER execution 3. On-line
- Test 67. OPT-MySQL-SL-CONT. Optimizing tuning

In relation to the demonstration in UiS, again, the full implementation hasn't been possible because of the problems in the optimizer code are:

a) perform the functional tests of the pair SL/OPT (SL is already trained),
b) perform the operational tests (open loop) and

c) the launching of SEEDS

The tests which haven't been performed because of the errors in the Optimizer are listed below. These tests are defined in the Annex I 'Additional document. Validation of the technologies, energy balance and environment impact' which is linked to D7.1 on the validation in UiS

- Test 37. OPT-MySQL-CONT. Optimizing reads data from MySQL
- Test 38. OPT-MySQL-CONT. Optimizing writes data on MySQL
- Test 42. OPT-MySQL-SL-CONT. PSO loop. Off-line
- Test 54. OPT-MySQL-SL-CONT. PSO loop.
- Test 55. OPT-MySQL-SL-CONT. OPTIMIZING Computation performance
- Test 56. CONTROLLER execution 1. On-line
- Test 57. CONTROLLER execution 2. On-line
- Test 58. CONTROLLER execution 3. On-line
- Test 59. OPT-MySQL-SL-CONT. Optimizing tuning

Major Results/Significant results obtained

The major results during this period are:

- The integration and validation of main components of SEEDS (Controller, Facility Model, Self-Learning, Optimizer and WISAN) using WISAN mock-up for the original scope of UiS pilot. These tests were performed in April 2014 during a meeting hosted by SOFTCRITS,
- Population of MS Access for both pilots and configuration of all SEEDS components,
- The installation and commissioning of WISAN nodes was faster than with conventional control systems,
- The deployment and implementation of all components (FM, OPT, SL, WISAN, GUI, MySQL) in both pilots,
- The completion of majority the tasks included in the internal document Commissioning Flow (one for each pilot).

Deviations from Annex I

The main deviation in this WP is the delay in the validation of SEEDS in the two pilots and the validation of Optimizer. See amendment section 2.3.2 focused in problems encountered).

Use of resources

The following table indicates the planned person months in comparison to the actual used person months in the third period (M25-M42).

WP7	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	**TOTAL**
Planned M25-M42	2,6	3	1	2	3,95	5	1	7.20	0	**25,75**
Actual M25-M42	7,85	1,41	1	8.14	3	5	1	7.20	0	**34,6**

Table 10. Use of resources in WP7

2.2.8 WP8: Energy balance and environment impact. Best practises and lessons learned

Summary of progress towards the objectives and details for each task

The objective of WP8 during the third period is:

- To calculate energy savings and reduction of CO_2 emissions of SEEDS system applied to the two specific case studies (demo buildings in Stavanger and Madrid).
- To evaluate the environmental and economic impact of SEEDS in the two specific cases.
- To identify best practises in Energy Efficient Buildings related to the different stages of the project development.
- To collect the perception and acceptance of the users regarding the performance of this new BEMS technology.
- To identify possible deviations from the intended scope of the project.
- To establish a set of lessons learned for being used by partners on similar situations.

The work progress of each task is explained below.

Task 8.1: Development of the Validation Methodology

Start month: M4 (December 2011)

End month: M6 (February 2012)

This task is already finished.

Task 8.2: Application of the Validation Methodology. Assessment of energy consumption before SEEDS developments in the two validation pilots

Start month: M6 (February 2012)

End month: M21 (May 2013)

This task is already finished.

Task 8.3: Application of the Validation Methodology. Assessment of energy efficiency and energy savings

Start month: M20 (April 2013)

End month: M42 (February 2015)

The assessment of energy efficiency and energy savings of SEEDS system in the two validation pilots should cover one whole year of energy measurement after a proper and optimized operation of SEEDS system (reporting period).

For this purpose, the methodology with equations and tables for calculating energy savings (based on measurements during the baseline period) and equivalent CO_2 reductions has been developed.

This methodology has been collected in Deliverable D8.3 “Report on the final situation of each case study (validation outcomes)”.

Unfortunately, up to the end of the project (February 28th 2015) none of the two demonstrators is working with SEEDS system and therefore the period to collect measures with SEEDS’ BEMS has not started yet.

The big delay of the project, joined to the last minute malfunctions in OPT make it really very difficult to have any reliable energy measurement in both pilots before the Final Review Meeting.

In any case, saving estimations have been made in order to complete other project deliverables.

Task 8.4: Development of a guide for ‘Best practises for Energy Efficient Buildings and Open Spaces’

Start month: M30 (February 2014)

End month: M42 (February 2015)

This tasks aims at describing the best practices identified during the different stages of the project development, especially in terms of economic and environmental impacts. This task and its linked report (D8.6) includes the analysis of the regulation in Europe and some suggestions to stimulate a more efficient building performance with the help of ICT solutions such as SEEDS, the best practises and procedures for the implementation of SEEDS in any building and the best practises for facility managers.

Task 8.5: Impact Assessment Methodology. Life cycle issues, environment and economic impact

Start month: M20 (April 2013)

End month: M42 (February 2015)

The first part of this task, the development of a general Impact Assessment Methodology, was made during the second year period and it was reported in the corresponding periodic report and in deliverable D8.4, whose last version was submitted in May 2014. In a parallel way, a Life Cycle Cost Analysis Methodology was developed and presented in D8.4.

During this last project period, the Impact Assessment Methodology has been applied to the specific cases of Demonstrators in Stavanger and Madrid.

Since there has not been finally data of energy savings, a reliable estimation of these has been used in order to calculate the environmental and economic impact of SEEDS system. The applied software was OpenLCA and it has been based on free available environmental databases as they are ELCD and NREL. Because of limitations in the software and environmental databases a complete LCIA has not been able to be obtained, but only partial results.

The LCA diagram only considers the additional elements in the new system that is different from conventional systems (Hard Disk Drives and WISAN components). Within this LCA diagram, energy saved in the building is expected to be the most relevant contributor to environmental impact, in return to the rest of small control elements that have to be manufactured.

Demo 1 only uses electrical energy, while Demo 2 uses electrical and natural gas energies. In order to have a unified functional unit, NG energy has been transformed into equivalent electrical energy with the help of a conversion factor. This has been obtained based on the structure of electrical and NG production and distribution in Spain.

A cost study of SEEDS has been made in parallel to Life Cycle Impact study. Previously, the developed Life Cycle was used for that purpose.

Thereby the study not only validates the energy and environmental performance but also the economic impact of this kind of Building Automation and Control Systems. A tool has been properly developed in order to identify the economic improvement potential of this new control system. In the same way as in the case of LCA, the new SEEDS system is being compared in the study with the conventional system.

The results of the study have been collected in Deliverable D8.5 *“Methodology on Impact Assessment and cost/benefit applied to SEEDS case studies”*.

Once, the main environmental impacts of SEEDs technologies have bee identified. SEEDs Projects have extracted a Roadmap or new innovation and development necessary to reduce the environmental impact over Building Sector. The work has been collected in the Deliverable D8.7 *“Report on Roadmap on Environmental Impact of the SEEDS”* . Some Roadmaps of from the Building and ICT Sectors have been used as background for the deliverable.

Task 8.6: Post-Occupancy Study

Start month: M31 (March 2014)

End month: M41 (January 2015)

The purpose of the survey data was to establish a pre-state to allow the assessment of the BEMS system proposed under the SEEDS Project. However, due to delays in the establishment of the system, the proposed follow up study cannot be undertaken in a valid way within the timeframe.

The results do suggest in both cases that there is the potential for a reasonable level of impact in terms of both comfort and energy efficiency in both buildings.

Task 8.7: Evaluate R&D project performance and deviation from original objectives

Start month: M1 (September 2011)

End month: M42 (February 2015)

This task has included the evaluation of the project, the determination of possible deviations from objectives, and the analysis of the major problems encountered during the full duration of the project.

This task has determined the deviation from the original objectives defined in the Description of Work (Annex I of the Grant Agreement) regarding results obtained at the end of the project, and whether all the deliverables have been produced.

The detailed evaluation of the SEEDS Project has been presented in the deliverable *D8.9 Report on project performance and lessons learned.*

Task 8.8: Analyse Lessons Learned

Start month: M1 (September 2011)

End month: M42 (February 2015)

The main goal of this task has been to capture information about the work done in the project in order to establish lessons learned, what has been a success and what has not been working well. This task has included the preparation of forms for gathering the inputs from the Partners (feedback, opinion, thoughts and suggestions), as well as the methodology for processing and drawing out the lessons learned. The questionnaire (checklist) was designed for addressing relevant topics in the project at different working levels (project planning, project execution, human factors, financial and overall). The email was the channel to gather the requested feedback. The rating was based upon a four-point scale from strongly disagree (1) to strongly agree satisfied (4). All collected inputs were analysed and, after evaluating of the general impressions of the Partners, the principal lessons learned have been presented in the deliverable *D8.9 Report on project performance and lessons learned.*

<u>Major Results/Significant results obtained</u>

- Developed methodology to calculate energy savings in two demo buildings.
- Evaluated environmental and economic impact of the SEEDS system in two specific case studies.
- Identified best practises in BEM Systems implementation.
- Identified best practises associated to energy equipment in buildings.

- Identified policy documents and roadmaps that have significant impact on the development of technologies applied in SEEDS system.
- Evaluated deviations from original objectives and project lessons learned.

Deviations from Annex I

Deviations are related to the delay in WP7, which prevented to the SEEDS system from a proper working before the end of the project. Thus resulting in:

- Real measurement energy consumption during the reporting period (one year) was not possible as there was no reporting period.
- Feed-back about perception and acceptability of SEEDS system by occupants failed to be obtained.

Use of resources

The following table indicate the planned person months in comparison to the actual used person months in the third period (M25-M42).

WP8	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	TOTAL
Planned M25-M42	2.5	0	0	2	0.48	2	0	3.35	0.5	10,83
Actual M25-M42	3.09	0	0	4.1	0.48	2	0	3.35	0.75	13,77

Table 11. Use of resources in WP8

2.2.9 WP9: Dissemination and Exploitation

Efficient dissemination and exploitation are fundamental aspects in any research project, since the success of related activities contributes decisively to the short and long term success of the project. This WP has been responsible for ensuring that all these activities have been appropriately developed and managed throughout the project duration.

The objectives of WP9 during M25-M42 are:

- Participation at relevant conferences, workshops, seminaries or related events.
- Cooperation with other projects.
- Development of the exploitation plan.

The work progress of each task is explained below. Only new results produced during period M25-M42 are detailed.

Task 9.1: Dissemination strategy

Start month: M1 (September 2011)

End month: M42 (February 2015)

During this period, the consortium has participated in 8 events to present the results of the research and development related to SEEDS project. Table 12 shows events to which partners have participated:

Event name	Type (*)	Role	Date and Venue	Partner/s
International Conference for Sustainable Places (ICT4SP) *Note: Four SEEDS' presentations (on preliminary results, wireless sensors, KPI and Data Models) were made during the conference.*	Conference	Speaker	9 to 11 September, 2013 in Nice, France	CEMOSA, SOFTCRITS, EAS, CIDAUT
4th Greencities. Smart Solutions to Urban Sustainability	Conference	Speaker	2 to 3 October, 2013, in Málaga, Spain	SOFTCRITS
4th Workshop on Impact of the Energy-efficient Buildings PPP	Workshop	Speaker	1 to 2 April, 2014 in Brussels, Belgium	CEMOSA
PTEC GT ciudad del Futuro	Meeting	Speaker	8 April 2014, in Madrid, Spain	CEMOSA
DG CONNECT & ETSI Workshop on M2M Smart Appliances	Workshop	Speaker	27 to 28 May 2014, in Brussels, Belgium	SOFTCRITS
International work-conference On Time Series (ITISE 2014)	Conference	Poster	25 to 27 June 2014, in Granada, Spain	UiS
European Conference on Product and Process Modelling (ECPPM 2014). 5th Workshop on eeBuilding Data Models	Conference	Speaker	17 to 19 September, 2014, in Vienna, Austria	EAS
World Sustainable Building 2014	Conference	Speaker	28 to 30 October, 2014, in Barcelona, Spain	CEMOSA

(*) C: Conference; W: Workshop; TM: Technical Meeting; F: Fair

Table 12. List of contributions to conferences/events

On the other hand, the third newsletter has been published and sent to the mailing list of the project.

Moreover, the consortium has established liaison with other FP7 projects (see Section 2.3.7).

The detailed description of the dissemination activities has been presented in the deliverable *D9.3 Dissemination and Exploitation Activities.*

Task 9.2: Contribution to eeSemantics wiki

Start month: M4 (December 2011)

End month: M42 (February 2015)

The SEEDS project contributed to eeSemantics wiki during the first periods, with the submission of the deliverable D2.2 *"SEEDS Modelling Ontology"* in October 2012 and participation in two VoCamps: "2nd Vocamp on Using and enriching open BIM ontologies for enhanced energy performance analysis and simulation during design phase" and "3rd VoCamp - Energy using and producing Products Management (EupP)".

During the third period, the SEEDS project has not collaborated in this wiki.

Task 9.3: Contribution to Validation and eeMeasurement Methodologies (ValMet) wiki

Start month: M4 (December 2011)

End month: M42 (February 2015)

The SEEDS project contributed to ValMet wiki during the first periods, with the submission of the deliverable D8.1 *"Validation Methodology for BEMS"*.

During the third period, the SEEDS project has not collaborated in this wiki.

Task 9.4: Exploitation planning

Start month: M1 (September 2011)

End month: M42 (February 2015)

The SEEDS project performed an Exploitation Plan on April 2014. The aim is to facilitate the exploitation and deployment of the energy efficient technologies and methods investigated and demonstrated in SEEDS.

<u>Major Results/Significant results obtained</u>

The main achievements of WP9 in the third period are:

- Update of the website continuously: upload the public deliverables, newsletter,…
- 10 oral presentations in 7 events (conferences/workshops).
- 6 papers published in conference proceedings.
- Development of the Exploitation Plan

<u>Deviations from Annex I</u>

No deviations from the plan in this period.

Use of resources

The following table indicate the planned person months in comparison to the actual used person months in the third period (M25-M42).

WP9	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	**TOTAL**
Planned M25-M42	1.7	0	0	0.5	5.89	1	0	3	0	12.09
Actual M25-M42	2.3	0	0	0.3	3	1	0	3	0	9.6

Table 13. Use of resources in WP9

2.2.10 Overview of the effort (Use of Resources)

The following table indicate the summary of the actual vs. planned effort in the third period per participant and per work package.

	CEMOSA	FRAUNHOFER	SOFTCRITS	CIDAUT	SALFORD	UiS	NSC	FERROVIAL	FASA	TOTAL
WP1										
Planned M25-M42	0	0	0	0	0	0	0	0	0	**0**
Actual M25-M42	0	0	0	0	0	0	0	0	0	**0**
WP2										
Planned M25-M42	0.5	3	0	0	2.7	0	0	0	0	**6.2**
Actual M25-M42	0.52	3.71	0	0.3	2.5	0	0	0	0	**7.03**
WP3										
Planned M25-M42	0	0	0	0	0	0	0	0	0	**0**
Actual M25-M42	0.6	0	6	0	0	0	0	0	0	**6.6**
WP4										
Planned M25-M42	0	0	0	0	0	0	0	0	0	**0**
Actual M25-M42	0.45	0	11.82	0	0	0	0	0	0	**12.27**
WP5										
Planned M25-M42	1.5	2	0	0	5.76	11	0	0	0	**20.26**
Actual M25-M42	4.28	2	0	0	21	9.5	1	0	0	**37.78**
WP6										
Planned M25-M42	0	0	0	0	0	0	3.5	0	0	**3.5**
Actual M25-M42	2.15	0	0	0	0	0	3.5	0	0.5	**6.15**
WP7										
Planned M25-M42	2.6	3	1	2	3.95	5	1	7.20	0	**25.75**

Actual M25-M42	7.85	1.41	1	8.14	3	5	1	7.20	0	**34.6**
WP8										
Planned M25-M42	2.5	0	0	2	0.48	2	0	3.35	0.5	**10.83**
Actual M25-M42	3.09	0	0	4.1	0.48	2	0	3.35	0.75	**13.77**
WP9										
Planned M25-M42	1.7	0	0	0.5	5.89	1	0	3	0	**12.09**
Actual M25-M42	2.3	0	0	0.3	3	1	0	3	0	**9.6**
WP10										
Planned M25-M42	7	0	0.75	0	0	0.5	0	0.34	0	**8.59**
Actual M25-M42	9.11	0	1	0	0	0.5	0	0.34	0	**10.95**
Total planned PMs	**15.8**	**8**	**1.75**	**4.5**	**18.78**	**19.5**	**4.5**	**13.89**	**0.5**	**87.22**
Total actual PMs	**30.35**	**7.12**	**19.82**	**12.84**	**29.98**	**18**	**5.5**	**13.89**	**1.25**	**137.75**

Table 14. Use of resources in the project

2.3 Project management during the period M25-M42

This section provides an overview of the project management structure and activities to enable the achievement of the project goals.

2.3.1 SEEDS management structure

SEEDS consortium was developed to include all the capabilities to achieve successful results. The management structure of the consortium was divided into 2 levels:

- **Project level**, steered by the management board (chaired by Project Coordinator). The management board is organized as follows:
    - Project Coordinator, to run the day to day administration of the Project.
    - General Assembly, addressing the overall management of the project and the consortium as well as dealing with the communication between partners.
- **Work Package level**, driven by the WP leaders (WPL). The WPL are responsible for the quality of the work on their WP and are in charge of the internal scheduling and planning. Each WP has task leaders and deliverable leaders (person responsible for the production of the document).

This structure has performed well during the whole project duration. The consortium has had periodic Project Meetings where all technical developments were reviewed and analysed, progress was discussed, problems were identified and solutions were sought. Besides, dissemination and exploitation activities were also presented and encouraged in progress meetings and help was provided in relation to management and periodic reporting activities, if applicable.

A General Assembly was always included in the Progress Meetings.

Besides the periodic progress meetings other technical meetings has been necessary to achieve the project goals. Many of them were face to face meetings, others were by skype, phone or some other tool.

2.3.2 Problems encountered and solutions found

The project has found some problems during the last period. On the one hand, the validation of SEEDS was very much delayed. On top of that, at the very end of the project during the validation in Ferrovial pilot (which was in a more advance stage that the validation in UiS), errors in Optimizer code were found. Because of these coding errors, the full implementation and validation haven't been possible yet at the moment of drafting this report.

<u>Problem 1: Delay in the demonstration</u>

The demonstration of SEEDS was already delayed with respect to the planning. The delay was partly due to the complexity of the project and the challenges, not originally considered, that were assumed in order to increase the interoperability and the replicability of SEEDS but mostly due to the delays linked to the validation itself.

With respect to the extra challenges that were successfully tackle and increased the scientific and technological quality of the work produced during the project, it is remarkable the efforts to integrate BIM in the modelling in the model based control approach and in the development of the methodology to allow for an automatic creation of SEEDS software for any building. Such methodology is based on the definition of a MS ACCESS schema whose structure is taken form IFC with enhancements to cope with SEEDS requirements. It represent an own ontology of a BIM.

Other causes, very much related to the validation itself, of the delay were: i) the documentation available about the pilots was poor and incomplete and therefore several inspections and visits were required in order to identify the real state of the demonstrators; ii) the selection of the scope (rooms and devices monitored/controlled) was complex and needed several iterations with the buildings' owners and, iii) there were some delays in the manufacturing of the sensors/actuators nodes (which was performed by an external organization and was out of the control of SEEDS) because of some lack of stock of some of the components included in them at the time they were ordered, iv) the commissioning in occupied buildings took also longer than expected.

Besides the above general causes of the delay in both pilots, the validation in UiS was at an important risk in March 2014. At that time, during a project meeting and once the nodes were already manufactured and some prototypes brought to UiS taking the advantage of the project meeting, UiS found that the nodes didn't meet all the safety specifications to be deployed in public buildings. The discussion with UiS was difficult and slow. The nodes were redesigned to meet the requirements. However, because of this extra delay, it was considered very risky to end the project in August because the time to install in UiS was very short. Therefore the Consortium agreed on requesting an extension of project duration which was accepted by the Commission and the end of the project was set in February 2015. This extra time would also benefited Ferrovial pilot which would have more time to run controlling the building.

Finally, the installation and commissioning in both pilots took, again, longer than expected. The validation in Ferrrovial pilot would have been possible if we would have had errors in the Optimizer code. The plan was to validate in Ferrovial up to one week before the Final Review Meeting so that we had 1 week to compile the data and present results. Unfortunately, it hasn't been possible. This would have allowed to validate SEEDS in Ferrovial during 6 weeks approximately, since the end of February until mid April 2015.

In relation to UiS, as explained in Section 2.2.7, in November 2014, very few nodes were installed and the scope in UiS was reduced to have the chance to validate. The installation of the nodes finished in second week of February 2015 and initial models were produced by the 27th March 2015 and following a revision of the energy data revised models produced on the 30th March 2015. If the optimizer had run correctly, we would had been running SEEDS, collecting results until one week before the Final Review Meeting, around 10 days or two weeks of data. Unfortunately, the full validation hasn't been possible due to errors in Optimizer code.

<u>Solutions adopted to mitigate the effects of the delay in the demonstration</u>

The risk of the delays that could happen in the demonstration was already identified since the beginning of the project. The following solutions were adopted to mitigate the effects. First, a testbench was provided by CEMOSA to validate the SEEDS concept: the Helicopter Garage (HG). It was a good testbench because it included a large variety of HVAC equipment. The HG was used to proof the SEEDS concept and the performance of the different components. The HG was used since the 2nd period. Results of the performance of the different components in this testbench were reported in many deliverables. The last component to be tested was precisely the Optimizer (D5.3 which was due in the 2nd period but had some delay and was submitted in the 3rd period).

Secondly, after the new delays in the validation identified in March 2014, it was decided to organize a workshop to integrate all SEEDS components before the actual implementation in the pilots. This workshop was held in Malaga in April 2014, hosted by SOFTCRITS. For the integration of all components, the WISAN mockup was used. After this workshop, it was validated the integration and communication of the different SEEDS components.

Finally, to overcome the problem of the little time that was foreseen for running SEEDS (controlling the pilots) in UiS pilot after the problems found in March 2014, the consortium agreed to request an extension of project duration. The Project Coordinator submitted an amendment of the Grant Agreement on May 2014. On behalf of the whole consortium, the coordinator requested an amendment for the enlargement of the project duration. The European Commission approved this change (extension of the project duration) on 19th June 2014.

The reason of an enlargement of project duration of 6 months was to allow for the chance of taking measurements and demonstrate SEEDS capabilities during a longer time. The original reason motivating the request for the enlargement was to the important delay in the demonstration in Stavanger at that time (May 2014). There were no chances to demonstrate in this pilot is the project ended in August 2014 (which was the original ending time).

At that time, because of a sequence of events including the delayed in the delivery of the sensors/actuators nodes by the selected manufacturer due to the lack of supply of some components and some legal barriers, never mentioned before, that impeded the installation of one of the types of the already designed and manufactured nodes in the pilot in Stavanger, the delivery of the nodes to Stavanger has been delayed (on top of a previous delay). The remaining time, after the installation and commissioning of the SEEDS system in the pilot in Stavanger is too short to allow gathering enough measurements that can prove the properties of the SEEDS System.

This extension of the duration of the project would also allowed gathering more measurements in the pilot in Madrid under the responsibility of FERROVIAL.

Problem 2: Errors in the Optimizer code

As already explained, at a very late stage some problems in the Optimizer code had been found. Although the Optimization was a bit delayed during the project performance, this problem wasn't foreseen as Optimizer performed well as was reported in Deliverables D5.3 and D5.5.

The main cause of this problem was the fact that the researcher developing the code for Optimizer left UiS at a critical point of the project and the person taking the replacement was not very familiar with the project. Although UiS mentioned that the researcher developing the code would leave organization in August 2014, it assured that it would provide resources to end successfully the project. However, UiS hasn't managed properly the replacement and the new person in charge hasn't been able to solve the errors in the code. Other software developers in SEEDS (Fraunhofer and USAL) together with the organizations in charge of the validation in the pilots (CEMOSA and CIDAUT) have provided a lot of support to the new software developer in UiS but, at the moment of drafting of this report the errors remain.

Concluding, the problems found in the Optimizer code weren't foreseen as UiS committed to put the human resources to finish the project and Optimizer performed well in previous stages. The only solution that was possible was to provide help to the new developer in UiS mainly by Fraunhofer, USAL, CIDAUT and CEMOSA.

2.3.3 Deviation from original plan and risk analysis

During the last period of the project M25-M42, D8.2 and D8.4 which were due during the 2nd year of the project were submitted. In any case, the delay in these deliverables hasn't produced any delay in other parts of the projects.

In relation to WP5, the delivery of D5.3 was also delayed. It was due on M20 (April 2013) during the 2nd year of the project and was submitted in M26 (October 2013) during the 3rd period of the project. The delay in the development of Optimization algorithms has contributed to the delay of the project and was already identified as a risk in the 2nd Project Periodic Report (see section 2.3.4 and Table 6). The original submission delivery date for D5.5 was M24 (August 2013). However, as the development of the optimization algorithms was very much delayed, the delivery date was changed to M35 taking the advantage of the amendment requested in May 2014.

After the amendment approved in June 2014, the Gant chart was updated (Figure 1). With respect to the new Gant Chart, D5.5 has a delay of 1 month and few days.

The major deviation of the project, as already mentioned, is related to the impossibility of full validation in the pilots because of the errors in the Optimizer code.

Besides, if the Optimizer hadn't had any errors, the validation would have been delayed and very short time of SEEDS managing the pilots before the Final Review Meeting would have been possible.

2.3.4 Use of resources for project management

In terms of resources, a total of 83person-months were planned for Project Management (WP10) during the project entire lifespan. As shown in the table below, a total of 10.95 person-months was used by the coordinating partner during the third reporting period (M25-M42).

WP10	CEMOSA	Fraunhofer	SOFTCRITS	CIDAUT	Salford	UiS	NSC	FERROVIAL	FASA	**TOTAL**
Planned M25-M42	7	0	0.75	0	0	0.5	0	0.34	0	**8.59**
Actual M25-M42	9.11	0	1	0	0	0.5	0	0.34	0	**10.95**

Table 15. Use of resources in WP10

2.3.5 Project planning and status

The SEEDS project started on September 2011 and its current status is finished.

There was an important delay regarding the demonstration phase and for this reason the Consortium requested an extension of 6 months in the project duration, as explained above.

Figure 1 shows the new Gantt chart of the SEEDS project.

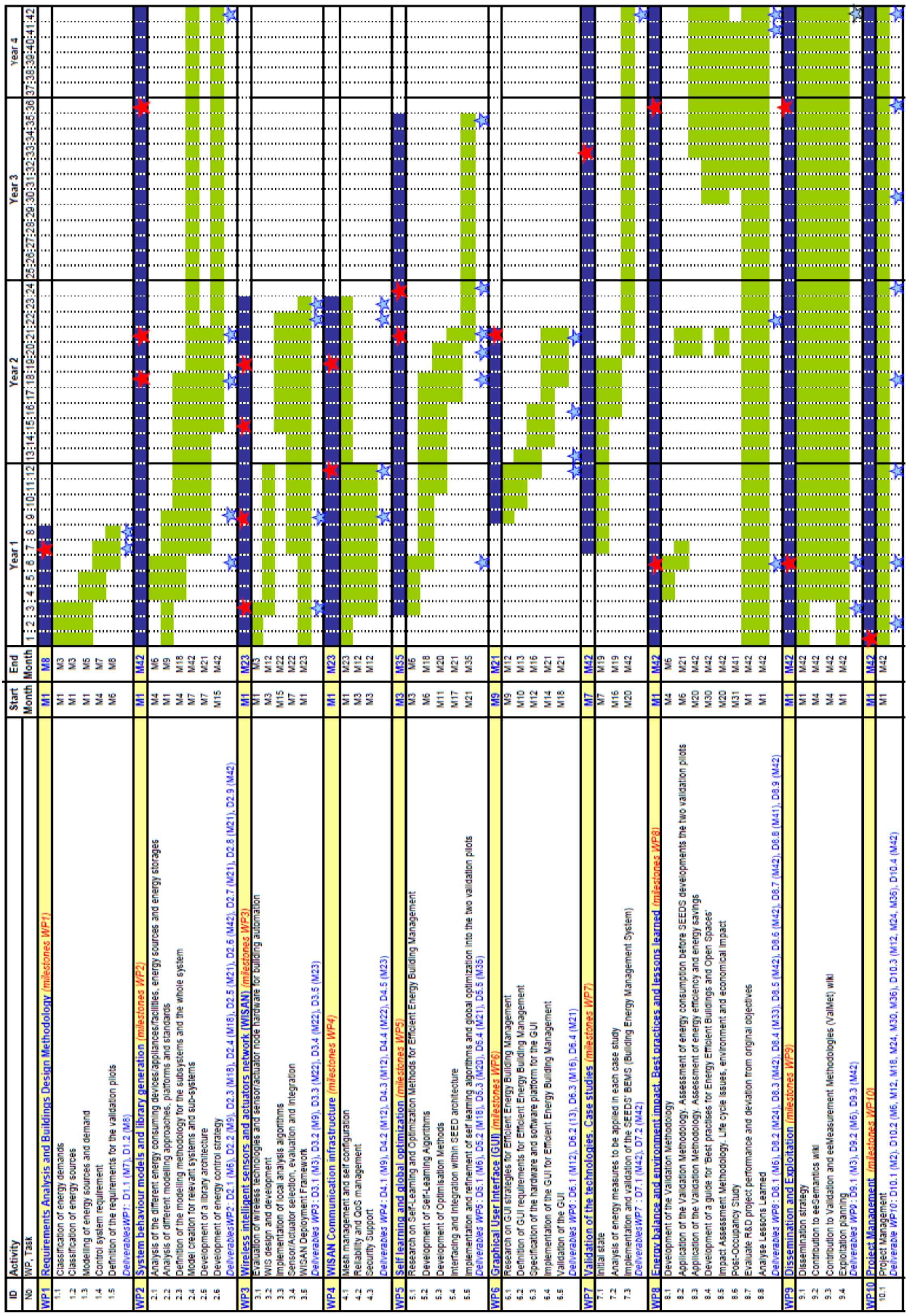

Figure 1. Gantt chart of the project

During the third period (M25-M42), the project has had some obstacles and counteraction, which have been presented in this Periodic Report. Section 2.3.2 describes the problems encountered and the solution proposed.

2.3.6 Meetings & cooperation between partners

During the reporting period M25-M42 project meetings were organized and executed. The list of meetings executed during the third period is shown in Table 16 and Table 17.

Progress meetings (including General Assembly meetings)

The progress meeting consists of at least one representative per consortium partner, and is chaired by the Project Coordinator.

Meeting	Date	Venue	Hosted by partner	Participants
Final Meeting	24-25 February 2015	Malaga, Spain	CEMOSA	All partners
Progress Meeting	25-26 March 2014	Stavanger, Norway	UiS	All partners
2nd Review Meeting (plus previous rehearsal)	4-5 December 2013	Brussels, Belgium	EC	All partners
Progress Meeting	18-19 September 2013	Salford, UK	USAL	All partners

Table 16. List of Project Team meetings

The Final Review Meeting will take place on 23rd April 2015, in Brussels (Belgium).

Technical meetings/conference calls

The technical/internal meetings (including conference calls) are planned when considered necessary.

Meeting	Date	Location	Meeting content	Participants
DEM Meeting	28-29 October 2014	Madrid, Spain	Monitoring of SL Training	CIDAUT, FERROVIAL
DEM Meeting	22-23 October 2014	Madrid, Spain	Nodes commissioning	CIDAUT, FERROVIAL
DEM Meeting	13-16 October 2014	Stavanger, Norway	Supervise nodes installation in some rooms and test the performance of local control algorithms	CEMOSA, SOFTCRITS, UiS
DEM Meeting	2-3 October 2014	Madrid, Spain	Nodes commissioning	CEMOSA, CIDAUT, FERROVIAL

DEM Meeting	30 September and 1 October 2014	Madrid, Spain	Nodes commissioning	CEMOSA, CIDAUT, SOFTCRITS, FERROVIAL
DEM Meeting	24 September 2014	Madrid, Spain	Nodes commissioning	CEMOSA, CIDAUT, FERROVIAL
DEM Meeting	23 September 2014	Madrid, Spain	Nodes commissioning	CIDAUT, FERROVIAL
DEM Meeting	18-19 September 2014	Madrid, Spain	Nodes installation	CIDAUT, FERROVIAL
DEM Meeting	3-4 September 2014	Madrid, Spain	Nodes installation	CEMOSA, CIDAUT, SOFTCRITS, FERROVIAL
DEM Meeting	26-27 June 2014	Madrid, Spain	Nodes installation	CEMOSA, CIDAUT, SOFTCRITS, FERROVIAL
DEM Meeting	25 June 2014	Madrid, Spain	Nodes installation	CIDAUT, FERROVIAL
Amendment Meeting	20 May 2014	Phone call	Discussion in relation to the extension of project duration	CEMOSA, FhG EAS, SOFTCRITS, CIDAUT, USALF and NSC (*)
DEM Meeting	19 May 2014	Madrid, Spain	Solve some problems identified during the installation	CIDAUT, FERROVIAL and nodes installers
DEM Meeting	12-14 May 2014	Madrid, Spain	Nodes installation	CEMOSA, CIDAUT, SOFTCRITS, FERROVIAL
DEM Meeting	8 May 2014	Madrid, Spain	Nodes installation	CIDAUT, FERROVIAL
DEM Meeting	7 May 2014	Phone Call	Discussion about problems identified by UiS after the reception of the the nodes	CEMOSA, UiS and SOFTCRITS
RTD Meeting	23-24 April 2014	Malaga, Spain	Integration Meeting in order to coordinate the work among Facility Model, Optimizer, Self-Learning and Controller. WISAN mockups were used	CEMOSA, FhG EAS, SOFTCRITS, CIDAUT, USAL and UiS
RTD Meeting	26 February 2014	Phone call	Discussion about the set point predictions per room.	CEMOSA and USAL
DEM Meeting	20 February 2014	Madrid, Spain	Training for the connection and installation of the nodes to the staff in charge of the installation	CIDAUT and FERROVIAL
Technical meeting	13 February 2014	Malaga, Spain	Meeting in order to evaluate the state of nodes manufacturing and clarify on their connections schemes	CEMOSA, SOFTCRITS and CIDAUT

DEM Meeting	11 February 2014	Madrid, Spain	Previous meeting in order to identify the real state of the demonstrator before starting the installation of the nodes	CIDAUT and FERROVIAL (and installers)
RTD Meeting	25 November 2013	Phone Call	Commissioning Process	All partners
RTD Meeting	12 November 2013	Phone Call	Predicted comfort values	CEMOSA, FhG EAS, USAL, UiS and NSC.
RTD Meeting	16 October 2013	Madrid, Spain	Installation Plan	CIDAUT, FERROVIAL and installers

Table 17. List of technical meeting and conference calls

(*): Ferrovial and FASA didn't attend the meeting but agreed previously on the extension of project duration

2.3.7 Cooperation with other projects

The SEEDS Project has made an effort to cooperate with other projects. The consortium initially identified some EU projects having a degree of synergy with SEEDS, as Pebble, EnRima, HESMOS, ICT4E2Forum, Tibucon, among others. This list of relevant related FP7 project was updated during the project lifetime, adding new projects as ADAPT4EE, RESILIENT, SEEMPubS, etc.

All projects identified are shown in the following table:

Acronym	Full title of the project
3e-Houses	*Saving Energy & the Environment across Europe*
ADAPT4EE	*Occupant Aware, Intelligent and Adaptive Enterprises*
BEAMS	*Buildings energy advance management system*
CAMPUS21	*Control and automation management of buildings and public spaces*
CASCADE	*ICT for Energy Efficient Airports*
E3SoHo	*ICT services for Energy Efficiency in European Social Housing*
EnRiMa	*Energy Efficiency and Risk Management in Public Buildings*
EPIC-HUB	*Energy Positive Neighbourhoods Infrastructure Middleware based on Energy-Hub concept*
HESMOS	*ICT Platform for Holistic Energy Efficiency Simulation and Lifecycle Management Of Public Use Facilities*
ICT4E2B Forum	*European stakeholders forum crossing value and innovation chains to explore needs, challenges and opportunities in further research and integration of ICT systems for Energy Efficiency in Buildings*
IREEN	*ICT Roadmap for Energy Efficient Neighbourhoods*
KnoholEM	*knowledge-based energy management for public buildings through holistic information modelling and 3D visualization*
Pebble	*Positive-energy buildings thru better control decisions.*
REEB	*European strategic research Roadmap to ICT enabled Energy-Efficiency in*

Acronym	Full title of the project
	Buildings and construction
RESILIENT	*coupling REnewable, Storage and ICTs, for Low carbon Intelligent Energy maNagemenT at district level*
RETROKIT	*Toolboxes for systemic retrofitting*
REViSITE	*Roadmap enabling vision and strategy in ict-enabled energy-efficiency*
S4EEB (or S4ECoB)	*Sounds for Energy-Efficient Buildings*
SEEMPubS	*Smart energy-efficient middleware for public spaces*
Tibucon	*Self Powered Wireless Sensor Network for HVAC System Energy Improvement – Towards Integral Building Connectivity.*

Table 18. List related FP7 projects

The SEEDS project has collaborated with HESMOS, ICT4E2BForum, RESILIENT, DEAMS, EPIC-HUB, ADAPT4EE, SAEM4US, CASACADE, among other. See *D9.3 Dissemination and Exploitation Activities.*

3 Deliverables and milestones tables

Tables 8 and 9 in sections 3.1 and 3.2 provide an overview of the deliverables and the milestones from the beginning of the SEEDS project.

3.1 Deliverables

During the third period of the project, 14 technical deliverables (plus management report) were scheduled. The table of deliverables below shows that the deliverables have been submitted.

Del. no.	Deliverable name	Version	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (proj month)	Forecast delivery date	Actual delivery date	Status No submitted/ Submitted	Comments
1.1	Development of a methodology for the modelling of BEMS for a wide spectrum of construction types	0	WP1	CIDAUT	R	PU	7	31/03/2012	05/06/2012	Submitted	Deliverable submitted at the first period. Status: accepted
1.2	Requirements for the Energy Management System to be developed in the two validation pilots	0	WP1	CEMOSA	R	PU	8	30/04/2012	05/06/2012	Submitted	Deliverable submitted at the first period. Status: accepted
2.1	Relevant energy affecting operating parameters for the system and sub-systems.	0	WP2	CEMOSA	R	PU	6	29/02/2012	30/03/2012	Submitted	Deliverable submitted at the first period. Status: accepted
2.2	SEEDS modelling ontology. BIM methods and standards. IFC data models and IDM requirement analysis.	0	WP2	FhG	R	PU	9	31/05/2012	06/06/2012	Submitted	Deliverable submitted at the first period. Status: accepted
2.3	Modelling methodology	0	WP2	CEMOSA	R	PU	18	28/02/2013	26/03/2013	Submitted	Deliverable submitted at the second period. Status: accepted
2.4	Library architecture	1	WP2	FhG	P	RE	18	28/02/2013	27/02/2013	Submitted	Deliverable submitted at the second period. Status: accepted
2.5	Optimized Models for the energy system and for subsystems verified	0	WP2	FhG	R	RE	21	31/05/2013	19/06/2	Submitted	Deliverable submitted at the second

Del. no.	Deliverable name	Version	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (proj month)	Forecast delivery date	Actual delivery date	Status No submitted/ Submitted	Comments
	and optimised for demonstrator								013		period. Status: accepted
2.6	Optimized Models for the energy system and for subsystems verified and optimised for demonstrator (new release)	0	WP2	FhG	R	RE	42	28/02/2015	27/27/2015	Submitted	
2.7	Complete libraries necessary for the demonstrators	0	WP2	FhG	P	RE	21	31/05/2013	16/07/2013	Submitted	Deliverable submitted at the second period. Status: accepted
2.8	Energy control strategy. First release	0	WP2	FhG	R	PU	21	31/05/2013	19/07/2013	Submitted	Deliverable submitted at the second period. Status: accepted
2.9	Energy control strategy. Final Version	0	WP2	FhG	R	PU	42	28/02/2015	27/27/2015	Submitted	
3.1	State of the technology in communications and sensor/actuator nodes for building automation.	0	WP3	SOFTCRITS	R	PU	3	30/11/2011	30/11/2011	Submitted	Deliverable submitted at the first period. Status: accepted
3.2	Sensor/Actuator Positioning: report of results on test measurements with evalution kits	0	WP3	NSC	R	PU	9	31/05/2012	05/06/2012	Submitted	Deliverable submitted at the first period. Status: accepted
3.3	Hardware and sotware design of the sensor/actuator nodes	0	WP3	SOFTCRITS	R	RE	22	30/06/2013	31/07/2013	Submitted	Deliverable submitted at the second period. Status: accepted
3.4	Prototype of WISA with selected sensors/actuators integrated and local signal analysis	0	WP3	SOFTCRITS	R	PU	22	30/06/2013	31/07/2013	Submitted	Deliverable submitted at the second period. Status: accepted
3.5	Positioning system and Physical Network Design Framework	0	WP3	SOFTCRITS	R	PU	23	31/07/2013	02/08/2013	Submitted	Deliverable submitted at the second period. Status: accepted
4.1	Integration reliability, QoS and security protocols in mesh based building automation infrastructure	0	WP4	SOFTCRITS	R	PU	9	31/05/2012	05/06/2012	Submitted	Deliverable submitted at the first period. Status: accepted

Del. no.	Deliverable name	Version	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (proj month)	Forecast delivery date	Actual delivery date	Status No submitted/ Submitted	Comments
4.2	Communication infrastructure design	0	WP4	SOFTCRITS	P	RE	12	31/08/2012	15/10/2012	Submitted	Deliverable submitted at the first period. Status: accepted
4.3	Plug & Play conformance requirements: API, Integration Web services and libraries	0	WP4	SOFTCRITS	R	PU	12	31/08/2012	15/10/2012	Submitted	Deliverable submitted at the first period. Status: accepted
4.4	Communication infrastructure and tool support implementation	0	WP4	SOFTCRITS	P	RE	22	30/06/2013	31/07/2013	Submitted	Deliverable submitted at the second period. Status: accepted
4.5	Communication infrastructure and tool support validation	0	WP4	SOFTCRITS	R	PU	23	31/07/2013	31/07/2013	Submitted	Deliverable submitted at the second period. Status: accepted
5.1	Report on applicability of different types of self-learning and optimization algorithms.	0	WP5	USAL	R	PU	6	29/02/2012	29/02/2012	Submitted	Deliverable submitted at the first period. Status: accepted
5.2	Self-learning algorithms that have been verified with sample scenarios and test data	0	WP5	USAL	P	PU	18	28/02/2013	27/02/2013	Submitted	Deliverable submitted at the second period. Status: accepted
5.3	Optimisation algorithms that have been tested on sample scenarios based on planned use cases	0	WP5	UiS	P	PU	20	30/04/2013	31/10/2013	Submitted	Deliverable submitted at the second period. Status: accepted
5.4	Specification and implementation of interfaces that have been integrated and tested	0	WP5	FhG	P	PU	21	31/05/2013	13/06/2013	Submitted	Deliverable submitted at the second period. Status: accepted
5.5	Implementation and refinement of self-learning algorithms and global optimization in the two pilots	0	WP5	UiS	P	PU	35	31/07/2014	12/09/2014	Submitted	
6.1	Study of alternatives for the development of SCADA systems and FP7 funded projects	0	WP6	SOFTCRITS	R	PU	12	31/08/2012	30/08/2012	Submitted	Deliverable submitted at the first period. Status: accepted

Del. no.	Deliverable name	Version	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (proj month)	Forecast delivery date	Actual delivery date	Status No submitted/ Submitted	Comments
6.2	Definition of the system parameters and variables to be displayed	0	WP6	NSC	R	PU	13	30/09/2012	14/05/2013	Submitted	Deliverable submitted at the second period. Status: accepted
6.3	Hardware and Software Platform	0	WP6	NSC	P	PU	16	31/12/2012	04/07/2013	Submitted	Deliverable submitted at the second period. Status: accepted
6.4	Validated Graphical User Interface	0	WP6	CEMOSA	P	PU	21	31/05/2013	02/08/2013	Submitted	Deliverable submitted at the second period. Status: accepted
7.1	Report describing the implementation and the validation of the SEEDS technologies in UiS	0	WP7	UiS	R	PP	42	28/02/2015	27/02/2015	Submitted	
7.2	Report describing the implementation and the validation of the SEEDS technologies in FERROVIAL	0	WP7	FERROVIAL	R	PP	42	28/02/2015	27/02/2015	Submitted	
8.1	Validation Methodology.	0	WP8	CIDAUT	R	PU	6	29/02/2012	29/02/2012	Submitted	Deliverable submitted at the first period. Status: accepted
8.2	Report on the initial situation of each case study	0	WP8	CIDAUT	R	PU	24	31/08/2013	07/05/2014	Submitted	
8.3	Report on the final situation of each case study (validation outcomes)	0	WP8	CIDAUT	R	PU	42	28/02/2015	28/02/2015	Submitted	
8.4	Methodology on Impact Assessment	0	WP8	CIDAUT	R	PU	33	31/05/2014	22/05/2014	Submitted	
8.5	Methodology on Impact Assessment applied to SEEDS case studies	0	WP8	CIDAUT	R	PU	42	28/02/2015	28/02/2015	Submitted	
8.6	Report on 'Best practises for Energy Efficient Buildings and Open Spaces'	0	WP8	CEMOSA	R	PU	42	28/02/2015	27/27/2015	Submitted	
8.7	Report on 'Roadmap of environmental impact of SEEDS technologies'	0	WP8	CIDAUT	R	PU	42	28/02/2015	28/02/2015	Submitted	

Del. no.	Deliverable name	Version	WP no.	Lead beneficiary	Nature	Dissemination level	Delivery date (proj month)	Forecast delivery date	Actual delivery date	Status No submitted/ Submitted	Comments
8.8	Survey on post-occupancy	0	WP8	CIDAUT	R	PU	41	31/01/2015	28/02/2015	Submitted	
8.9	Report on project performance and lessons learned	0	WP8	CEMOSA	R	PU	42	28/02/2015	27/27/2015	Submitted	
9.1	Web site of the project.	0	WP9	CEMOSA	O	PU	3	30/11/2011	30/11/2011	Submitted	Deliverable submitted at the first period. Status: accepted
9.2	Dissemination and Exploitation plan.	0	WP9	USAL	R	PU	6	29/02/2012	29/02/2012	Submitted	Deliverable submitted at the first period. Status: accepted
9.3	Report on dissemination & exploitation activities	0	WP9	CEMOSA	R	PU	42	28/02/2015	27/27/2015	Submitted	
10.1	Project Quality Plan.	0	WP10	CEMOSA	R	PU	2	31/10/2011	02/11/2011	Submitted	Deliverable submitted at the first period. Status: accepted
10.2	Progress report.	0	WP10	CEMOSA	R	PU	6, 12, 18, 24, 30, 36	29/02/2012	29/02/2012	Submitted	Deliverable submitted at the first period. Status: accepted
10.3	Activity report, management and financial reports, audit certificates	0	WP10	CEMOSA	R	PU	12, 24, 36	31/08/2012	30/08/2012	Submitted	Deliverable submitted at the second period. Status: accepted
10.4	Final report	0	WP10	CEMOSA	R	PU	36	30/04/2015	30/04/2015	Submitted	

Table 19. Table of deliverables submitted

3.2 Milestones

Milestone no.	Milestone name	Work package no	Lead beneficiary	Delivery date from Annex I	Achieved Yes/No	Actual achievement date	Comments
MS1	Methodology for the modelling of BEMS in a wide spectrum of construction types	WP1	CIDAUT	31/03/2012	YES	31/03/2012	
MS2	Modelling methodology	WP2	FhG	28/02/2013	YES	28/02/2013	
MS3	Models verified and optimized for the demonstrators	WP2	FhG	31/05/2013	YES	31/05/2013	
MS4	Final Model Library	WP2	FhG	31/08/2014	YES	16/07/2013	
MS5	Analysis of the state of the technology	WP3	SOFTCRITS	30/11/2011	YES	30/11/2011	
MS6	WISA hardware and software design	WP3	SOFTCRITS	30/11/2012	YES	31/07/2013	
MS7	Sensor/Actuator Positioning: mini test network with positioning running	WP3	-	-	-	-	This MS was deleted in the amendment stage.
MS8	Prototypes of WISA with local signal analysis	WP3	SOFTCRITS	31/03/2013	YES	31/07/2013	
MS9	Positioning system and Physical Network Design Framework	WP3	SOFTCRITS	31/03/2013	YES	31/07/2013	
MS10	Design of the communication infrastructure	WP4	SOFTCRITS	31/08/2012	YES	31/08/2012	
MS11	Communication infrastructure validated	WP4	SOFTCRITS	31/03/2013	YES	31/07/2013	
MS12	Implemented Self-Learning and Optimisation algorithms	WP5	USAL/UiS	31/05/2013	YES	31/05/2013	
MS13	Integration of the Algorithms into the overall architecture	WP5	FhG	31/08/2013	YES	13/06/2013	
MS14	Validated GUI for Efficient Energy Building Management, Users' Manual and Software	WP6	CEMOSA	31/05/2013	YES	02/08/2013	
MS15	Validation of the implemented technologies in the two validation pilots	WP7	CEMOSA	28/02/2015	NO	28/02/2015	The whole validation has not been completed on time
MS16	Validation Methodology	WP8	CEMOSA	29/02/2012	YES	29/02/2012	
MS17	'Best practises for Energy Efficient Buildings and Open Spaces'	WP8	CEMOSA	28/02/2015	YES	28/02/2015	

Milestone no.	Milestone name	Work package no	Lead beneficiary	Delivery date from Annex I	Achieved Yes/No	Actual achievement date	Comments
MS18	'Roadmap of environmental impact of the SEEDS technologies'	WP8	CIDAUT	28/02/2015	YES	28/02/2015	
MS19	Evaluation of the project and lesson learned	WP8	CEMOSA	28/02/2015	YES	28/02/15	
MS20	Dissemination and Exploitation Plan	WP9	USAL	29/02/2012	YES	29/02/2012	
MS21	Final Report on Dissemination and Exploitation activities	WP9	CEMOSA	28/02/2015	YES	16/04/2015	
MS22	Governance structure confirmed	WP10	CEMOSA	30/09/2011	YES	27/09/2011	Governance structure confirmed on kick off meeting.

Table 20. Table of milestones

4 Explanation of the use of the resources

Within the tables below the major cost items per partner are shown for the 3rd period (M25-M42). Below a table per partner is included. After that, a summary table for the whole consortium has been included, also for the 3rd period.

Overall the major part of costs has been used for personnel, being the addition of personnel costs (47,16 %) and indirect costs (38,27 %) equal to 85,43 % of project costs. After that, the sum of equipment and consumables represents 7,82 % while travels costs represents 4,57% of total costs for progress meetings, demonstration meetings and dissemination events. A table showing the costs per WP hasn't been produced because partner UiS has not clearly shown the different costs per WP.

The values indicated in the following tables take into account the costs entered by partners in Participant Portal until 30 April 2015 at 14:00h.

BENEFICIARY 1: CEMOSA **PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M25-M42**			
Work Package(s)	**Item description**	**Amount in €**	**Explanations**
2, 5, 6, 7, 8, 9 and 10	Personnel direct costs	122,899	WP's 2, 5, 6, 8:46,127 € (WP2: 0.52 PMs / WP3: 0.6 PMs /WP4: 0.45 PMs / WP5: 4.28 PMs / WP6: 2.15 PMs / WP8: 3.09 PMs) WP7: 25,343 - 7.85 PMs WP9: 11,115 € : 2.30 PMs WP10: 40,314 € - 9.11 PMs
9	Subcontracting	2,000	Audit cost
	Equipment		
7	Consumable	90	Equipment for prototype for pilots
10 7 9	Travel cost	12,381 €	-Final Review Meeting (Noemi Jimenez Redondo and Francisco Marquez)+ Safford Meeting (Noemi Jimenez Redondo, Francisco Marquez, Alvaro Barragan and Gloria Calleja)+ 2nd review meeting (Noemi Jimenez Redondo and Francisco Marquez)+ Stavanger meeting (Noemi Jimenez Redondo and Francisco Marquez): **7298,00 €** -WP7 (Francisco Marquez, pilot Madrid and Stavanger): **3319 €** -WP9 Dissemination. Travel cost for Noemi Jimenez Redondo: ICT4SP (Nice, Sep2013), WS Impact EeB PPP (Brussels, April 2014), WCSB (Barcelona, Oct2014), Workshop at Madrid (PTEC, April 2014) **1764 €**
10, 9	Remaining direct costs	1,390	Post services: 231 € Organisation Final meeting (Málaga, February 205): 813 €

			Organization of the Workshop for s/w developers (April 2014): 111 € Registration for conference ICT4SP 2014 (Noemi Jimenez):235 €
2, 5, 6, 7, 8, 9 and 10	Indirect costs	158,538	WP's: 2, 5, 6, 8: 59,504 € WP7: 32,692 € WP9: 14,338 € WP10: 52,005 €
TOTAL COSTS		**297.299 €**	

Table 21. Use of resources partner CEMOSA

BENEFICIARY 2: FRAUNHOFER **PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M25-M42**			
Work Package(s)	**Item description**	**Amount in €**	**Explanations**
2, 5, 7	Personnel direct costs	38,051	-WP's 2, 5: direct personnel costs of 3 scientists and 2 graduates for the total of 5,71 PM: 30,506 € -WP7: direct personnel costs of 1 scientist and 1 graduate for the total of 1,41 PM. 7,545 €
9	Subcontracting		
	Equipment		
	Consumable		
10 7 9	Travel cost	8.711,00 €	- P. Stenzel to Nizza,08.09.-12.09.2013 4th workshop on eeBuildings: 970 € . Haufe, U. Donath, J. Wurm 17.09.-19.09.2013 project mtg 2,179 € J. Haufe, U. Donath 03.12.-05.12.2013 Brussels project review mtg: 849 € J. Haufe, J. Wurm, 24.03.-26.03.2014 Stavanger project mtg: 1,882 € R. Meyer, J. Wurm 22.04.-25.04.2014 SEEDS integration mtg: 1,405 € J. Haufe, R. Meyer 23.02.-27.02.2015 to Malaga, final mtg: 1,426 €
	Remaining direct costs	0	
2, 5, 7	Indirect costs	29,670 €	
TOTAL COSTS		**76,432 €**	

Table 22. Use of resources partner Fraunhofer

BENEFICIARY 3: SOFTCRITS PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M25-M42			
Work Package(s)	Item description	Amount in €	Explanations
3, 4, 7, 10	Personnel direct costs	55,170	WP3: 6 PMs / WP4: 11,82 PMs->48,844 € WP7: 1 PM: 3,012 € WP10: 1 PM: 3,314 €
	Subcontracting		
	Equipment		
	Consumable	7,563 €	
10 7	Travel cost	15,032 €	-Second review meeting. Brussels (Belgium) on December 2013. Fernando Diaz and Manuel Diaz: 1,970 € -Progress meeting Stavanger (Norway) on March 2014. Fernando Diaz, Manuel Diaz and Jorge España: 3,667 € - Visits to Demo Madrid (Spain) and Stavanger: Fernando Diaz Jorge España: 4296 €€ - Final review meeting Brussels (Belgium) on April 2015. Manuel Diaz and Jorge España: 3,660 € Progress meeting Salford (UK) September 2013. Fernando Diaz and Jorge España: 1,439 €
3, 4	Remaining direct costs	219 €	Visit Wisan nodes manufacturer 219 €
3, 4, 7, 10	Indirect costs	46,789 €	
TOTAL COSTS		124.773 €	

Table 23. Use of resources partner SOFTCRITS

BENEFICIARY 4: CIDAUT PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M25-M42			
Work Package (s)	Item description	Amount in €	Explanations
2, 7, 8, 9	Personnel direct costs	60,176 €	WP2: 0.31PM (1,400€) WP7: 8.13PM (38,484€) WP8: 4.1PM (19,317€) WP9: 0.3PM (975€)
	Subcontracting		

	Equipment		
	Consumable		
9, 10	Travel cost	10,511 €	Worpksohp and dissemination of results. Niza (France), 09/09/2013-11/09/2013; Luis Antonio Nieto (604€) Meeting of the project. Madrid (Spain), 12/09/2013-12/09/2013, Luis Antonio Nieto (97€) Meeting of the project. Manchester (United Kindom), 17/09/2013-20/09/2013, Valentin Castaño and Luis Antonio Nieto (1,516€) Visits to Ferrovial demo (Madrid, Spain): 16/10/2013 (2p, 102€), 20/02/2014 (1p, 55€), 08/05/2014 (1p, 60€), 12/05/2014-14/05/2014 (1p, 162€), 19/05/2014 (1p, 57€), 14/07/2014-15/07/2014 (1p, 145€), 25/06/2014-27/06/2014 (1p, 267€), 03/09/2014-04/09/2014 (1p, 114€), 18/09/2014- 19/09/2014 (1p, 122€), 23/ 09/2014-24/09/2014 (1p, 146€), 30/09/2014-03/10/2014 (1p, 306€), 22/10/2014-23/10/2014 (1p, 123€), 28/10/ 2014-29/10/2014 (1p, 123€), Meeting of the project, Malaga (Spain), 11/02/2014-14/02/2014, Luis Antonio Nieto, Valentin Castaño and Francisco Javier Nuñez (1,191€) Meeting of the project, Stavenger (Norway), 24/03/2014-27/03/2014, Luis Antonio Nieto and Valentin Castaño (2,048€) Visit to the demonstrator and integration software, Malaga (Spain), 22/04/2014-25/04/ 2014, Valentin Castaño (489€) Final project meeting, Malaga (Spain), 23/02/2015-25/02/2015, Luis Antonio Nieto y Valentin Castaño (636€) Final meeting, Brussels (Belgium), 21/04/ 2015-23/04/2015, Luis Antonio Nieto (840€)
9	Remaining direct costs	235 €	Registration for conference ICT4SP 2014:235 €
2, 7, 8, 9	Indirect costs	49,646 €	
TOTAL COSTS		**120,568 €**	

Table 24. Use of resources partner CIDAUT

BENEFICIARY 5: SALFORD **PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M25-M42**			
Work Package(s)	**Item description**	**Amount in €**	**Explanations**
2, 5, 7, 9	Personnel direct costs	113,861 €	WP2 2.5PM, WP5 21PM, WP8 0.48PM: 89,564 € WP7 3PM: 12,532 € WP9 3PM: 11,765 €
	Subcontracting		

	Equipment		
	Consumable	1,406 €	- Cloud computing services: 132 € - Laptop: 1,274 €
10 7 9	Travel cost	11,853 €	-Brussels, Belgium,03/12/2013 -06/12/2013: 3,052 € - Malaga, Spain,22/04/14 - 25/04/14: 1,036 € - Malaga, Spain,23/02/15 - 25/02/15: 1,287 € Stavanger, Norway,23/03/14 - 27/03/14: 6,478 €
10	Remaining direct costs	3,772	Project meeting organization cost (Salford, Sep 2013): 1,180 € + 2,592 €
2, 5, 7, 9	Indirect costs	78,534 €	
TOTAL COSTS		**209,426 €**	

Table 25. Use of resources partner USAL

BENEFICIARY 6: UiS **PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M25-M42**			
Work Package(s)	**Item description**	**Amount in €**	**Explanations**
5, 7, 8, 9, 10	Personnel direct costs	120,956 €	-
7	Subcontracting	743 €	Statsbygg invoice
7	Equipment	28,775 €	Nodes. Randal Invoice: 16,558 € Nodes. Randal Invoice: 12,217 €
	Consumable		-
	Travel cost		
5, 7, 8, 9, 10	Remaining direct costs	21,337 €	Travel, equipment, cluster/UPS, etc
5, 7, 8, 9, 10	Indirect costs	102,639 €	
TOTAL COSTS		**274,450 €**	

Table 26. Use of resources partner UiS

BENEFICIARY 7: NSC **PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M25-M42**			
Work Package(s)	**Item description**	**Amount in €**	**Explanations**
5, 6, 7	Personnel direct costs	32,175 €	- WP6 (3,5PM) + WP5 (1PM): 26,325 € - WP7)1 PM): 5,850 €

	Subcontracting		
	Equipment		
	Consumable		-
6, 7, 10	Travel cost	6,627 €	- Brüssel Review Meeting 03.12.13 - 05.12.13 Radka Peneva + Gunnar Weiß: 1,392 €€ - Stavanger 25.03.14 - 26.03.14 Radka Peneva + Gunnar Weiß 1,992 € - Malaga 24.02.15 - 25.02.15 Radka Peneva + Gunnar Weiß: 1,436 € - Brüssel 21.04.15 - 22.04.15 Radka Peneva + Gunnar Weiß: 1807
	Remaining direct costs		
5, 6, 7	Indirect costs	22,197 €	
TOTAL COSTS		**60.999 €**	

Table 27. Use of resources partner NSC

BENEFICIARY 8: FERROVIAL **PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M25-M42**			
Work Package(s)	**Item description**	**Amount in €**	**Explanations**
7, 8, 9, 10	Personnel direct costs	102,536 €	- WP8 (3.35 PM): 24,730 € - WP7 (7.20 PM): 53,150 € - WP10 (0.34 PM): 2,510 € - WP9 (3PM): 22,146 €
	Subcontracting		
	Equipment		
7	Consumable	70,236 €	Consumibles supplied by Randal (23,946€), Climapex (39,287€), Ferroser (4,750€), Danfoss (753€), Telefónica (1,500€)
10	Travel cost	3,605 €	Brussels dec´13 : 2 people*612 € ; Stavanger : 1210.5 € ; Malaga : 318.91 € ; Brussels april´15 : 850 €.
	Remaining direct costs		
7, 8, 9, 10	Indirect costs	35,275 €	
TOTAL COSTS		**211,652 €**	

Table 28. Use of resources partner FERROVIAL

BENEFICIARY 9: FASA PERSONNEL, SUBCONTRACTING AND OTHER MAJOR COST ITEMS FOR THE PERIOD M13-M24			
Work Package (s)	**Item description**	**Amount in €**	**Explanations**
6,8	Personnel direct costs	5,000 €	WP6 0.50PM; WP8 0.75PM
	Subcontracting		
	Equipment		
	Consumable		
	Travel cost	3,057 €	Progress Meeting Salford (UK) 18./19.09.2013: 1420€ 2nd Review Meeting Brussels (Belgium) 04./05.12.2013: 981€ Final Meeting Malaga (Spain) 24./25.02.2015: 656€
	Remaining direct costs		
6,8	Indirect costs	4,834 €	
TOTAL COSTS		**12,891 €**	

Table 29. Use of resources partner FASA

	Cemosa	Fraunhofer	Softcrits	Cidaut	Usal	UiS	NSC	Ferrovial	FASA	TOTAL	%
Personnel (€)	122,899	38,051	55,170	60,176	113,861	120,956	32,175	102,536	5,000	650,824	47,16
subcontracting (€)	2,000					743				2,743	0,2
equipment (€)						28,775				28,775	2,08
Consumable (€)	90		7,563		1,406			70,236		79,295	5,74
Travel (€)	12,381	8.711,00	15,032	10,511	11,853		6,627	3,605	3,057	63,066	4,57
Remaining Other direct costs (€)	1,390		219 €	235 €	3,772	21,337				26,953	1,95
Indirect costs (€)	158,538	29,670 €	46,789	49,646	78,534	102,639	22,197	35,275	4,834	528,122	38,27
TOTAL 3rd period (€)	**297,298**	**67,721**	**124,773**	**120,568**	**209,426**	**274,450**	**60,999**	**211,652**	**12,891**	**1,379,778**	**100**

Table 30. Global use of resources (3rd period)

5 Financial statements – Form C and Summary financial report

The separate financial statements from each beneficiary are available in the Participant Portal. The following table summarises the EU contribution requested by partner and the total cost of the project in the third period.

Beneficiary	Organisation short name	EU contribution requested for the 3rd period	Total cost for the 3rd period
1	CEMOSA	240,141.00 €	297.299,00 €
2	FRAUNHOFER	53,966.00 €	76.432,00 €
3	SOFTCRITS	93,700.00 €	124,773.00 €
4	CIDAUT	79,051.00 €	120,568.00 €
5	USALF	158,271.00 €	209,426.00 €
6	UiS	198,007.00 €	274,450.00 €
7	NSC	43,409.00 €	60,999.00 €
8	FERROVIAL	120,619.00 €	211,652.00 €
9	FASA	9,668.00 €	12,891.00 €
TOTAL		996,832.00 €	1,388,490.00 €

Table 31(*). Overview of the EU contribution and cost for M25-M42

(*):The values indicated in the table take into account the costs entered by partners in Participant Portal until 30 April 2015 at 14:00h.

Furthermore, the following table presents the total EU contribution requested by partner after the finalization of the project. A comparison between the estimated costs and EU requested contribution according to GA - Annex 1 and actual total incurred costs and EU requested contribution is provided. Besides, it is shown whether a partner should provide a Certificate on the Financial Statement (CFS) for this period, in accordance with Article II.4.4 of the Grant Agreement.

Beneficiary	Organisation short name	Total Cost Annex I (€)	Requested contribution Annex I (€)	Total Incurred Cost (€)	EU requested contribution (€)	Certificate on the financial statements provided? YES/NO
1	CEMOSA	748,000	504,100	793,366	611,328	YES (Threshold reached)
2	FRAUNHOFER	459,157	337,150	455,654	338,055	NO (Threshold not reached)

Beneficiary	Organisation short name	Total Cost Annex I (€)	Requested contribution Annex I (€)	Total Incurred Cost (€)	EU requested contribution (€)	Certificate on the financial statements provided? YES/NO
3	SOFTCRITS	357,600	268,200	383,729	287,916	NO (Threshold not reached)
4	CIDAUT	449,024	327,834	513,008	369,917	NO (Threshold not reached)
5	USALF	467,478	356.945	468,527	356,912	NO (Threshold not reached)
6	UiS	748,760	536,120	665,452	486,482	YES (Threshold reached)
7	NSC	326,480	242,520	342,234	254,335	NO (Threshold not reached)
8	FERROVIAL	395,067	228,537	395,086	228,561	NO (Threshold not reached)
9	FASA	130,080	97,560	130,308	97,730	NO (Threshold not reached)
TOTAL		**4,081,646 €**	**2.898.966 €**	**4,147,364 €**	**3,031,236 €**	

Table 32(*). Certificates overview table

(*):The values indicated in the table take into account the costs entered by partners in Participant Portal until 30 April 2015 at 14:00h.