MONROE

Measuring Mobile Broadband Networks in Europe

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First Year Report

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Abstract

This report summarizes the status of project up to the end of the first year.

Participant organisation name	**Short name**
SIMULA RESEARCH LABORATORY AS *(Coordinator)*	SRL
CELERWAY COMMUNICATION AS	Celerway
TELENOR ASA	Telenor
NEXTWORKS	NXW
FUNDACION IMDEA NETWORKS	IMDEA
KARLSTADS UNIVERSITET	KaU
POLITECNICO DI TORINO	POLITO

1 Explanation of the work carried out by the beneficiaries and Overview of the progress

1.1 Objectives

The main objectives of MONROE are defined in DoA as:

1. To build an open and large-scale measurement and experimental platform, targeting MBB networks and WiFi connectivity, distributed over multiple European countries, with multi-homing capabilities.
2. To operate this large-scale platform by providing both maintenance and external user support.
3. To use the platform for the identification of key MBB performance parameters, thus enabling accurate, realistic, persistent and meaningful monitoring and performance assessment of such networks.
4. To achieve a user-oriented closed-loop system design in which the experimental platform is open to external users, and where users are incorporated early on in the experimental design process.
5. To provide Experiments as a Service (EaaS), thus lowering the barrier for using the platform to external users, by providing well-documented tools and adjustable, flexible, high-level scripts to execute experiments, collect results, and analyze data.
6. To develop models for sustaining and extending the platform and its usage beyond the project budget and project ending.

Next, we will describe the work carried out during the reporting period towards the achievement of each listed objective.

Objective 1: To build an open and large-scale, transnational experimental platform

Building the first European transnational, open, independent and large-scale MBB testbed is the main goal of MONROE project. During the first year, our efforts were concentrated on System Design and Software Implementation and, Hardware Design and Node Deployment mostly. Towards achieving this objective, we have selected representative use cases for the platform and we have designed the MONROE system in light of these use cases. Next, we will elaborate on the selected use cases, MONROE system design and node hardware selection.

Use Cases:During the first 6 months, we have finalized the representative use cases for MONROE and presented them in Deliverable 1.1. The use cases are organized under three main categories: (i) key mobile broadband metrics, (ii) application performance and (iii) service and protocol innovations. For each category, we have carried out numerous interactions with academic and industry partners in order to identify examples of these use-case categories. We have further conducted a thorough analysis of the state of the art on MBB measurement and assessment techniques. These efforts resulted in a set of experiments to be implemented by the consortium. The requirements of these experiments were provided as input to the design of the MONROE system, to ensure that the platform can cater for the requirements of the experiments in order to enable each use case. By submitting Deliverable 1.1, milestone MS1 was achieved.

System Design and Implementation: We have finalized the system design of the MONROE platform at month 6 and accelerate our implementation efforts afterwards. Specifically, MONROE platform consists of seven different components: (i) the user access portal, (ii) the scheduling system, (iii) the management and maintenance system, (iv) the software running on the MONROE node (core components and experiments), (v) the repositories and data importer, (vi) the central database, and (vii) the online visualization tool. Deliverable 1.2 describes the different components of the MONROE platform and the basic functionality of

each component developed for the prototype implementation, ready at M12. With the delivery of D1.2 and the prototype system implementation provided as open source in github (https://github.com/MONROE-PROJECT), milestone MS4 is achieved.

Hardware Design and Selection: The hardware design for the MONROE measurement node is completed in month 12. We have first identified the equipment requirements. Then, we have evaluated different alternatives and selected the components. We have followed a through testing procedure in order to validate the applicability of the node and the components we selected. We further identified the limitations of the hardware and the MONROE node life cycle. D2.1 describes the hardware design and selection for the MONROE measurement node. With the delivery of D2.1, milestone MS2 is achieved with the exception of the converter selection (please see Section 1.2.2 for details).

In summary, we have achieved the goals we have set out for the first year towards achieving this objective. In the second year of the project, we will finalize the MONROE implementation with the help of our external experimenters (D1.3) and complete the node deployment (D2.2) for large-scale testing of the system. Final verification of this objective is provided by these deliverables that are due M24 and M15, respectively.

Objective 2: To operate a transnational and large scale platform

This objective was not applicable during the first year since the maintenance and user support have not started yet.

Objective 3: Identification of key performance parameters

This objective was not applicable during the first year since the large-scale experiments (WP3) has not started yet.

Objective 4: User-oriented closed-loop system design

For a testbed to be used widely by users, capabilities of the testbed have to meet their expectations. MONROE involves the users of the testbed early on, in the design and the implementation process of the testbed. First, we have designed the MONROE nodes as small programmable computers and we have developed open software for managing the testbed, resulting in a fully programmable MONROE system. The node selection and prototype implementation has been completed during the first year. The node selection process has been summarized in D2.1 and the prototype implementation has been summarized in D1.2 with the open source code already available in github (https://github.com/MONROE-PROJECT).

Moreover, we announced the first open call for the MONROE project in order to select the first users of the platform. These users will have access to the prototype system at an early stage and provide feedback in order to improve the infrastructure. In the second year, the experiences and feedback from the first phase external users (D5.1) will be used in extension and modification of the system design and implementation of the platform. Specifically, the impact of internal and external feedback on the system design will be documented (D1.3 in particular) and will be measurable in terms of design modifications between the prototype, the initial release, and the final release of the platform. Final verification of this objective is provided by these deliverables both of which are due end of the second year.

Objective 5: Lowering the barrier for external users

One of MONROEś main targets is to make the experimental platform and designed experiments open to external users. However, learning and getting used to a new tool is always a time-consuming task and designing experiments, especially for large-scale complex systems such as MBB networks, requires experience and time. Therefore, one fundamental objective of MONROE consists in taking all necessary steps to make it easy to use the platform for external users. Towards this end, we took some initial steps in the first year. We have started working on the user manual. Further, we already provide some high level scripts to run simple experiments in our public github repository (https://github.com/MONROE-PROJECT/Experiments). The first user workshop has been scheduled to take place in early June 2016. In the second year, with the external

users accessing the platform, we will provide support for External Users both in terms of using the platform as well as designing their experiments. Final verification of this objective is provided by deliverables on experimental software as EaaS (D3.1) and on the user manual (D5.1) both of which are due end of the second year.

Objective 6: Sustainability of the platform

For MONROE, increasing the user base and size of the testbed is of paramount importance. As such, MONROE will focus on developing funding models to prolong the usage and impact of MONROE also after the project has ended. During the first year, we have focused on Dissemination and Exploitation activities. We have already presented the platform in many different venues, including standardization bodies, high ranked conferences and venues that industry is highly involved. One of the first MONROE acknowledged paper got the best paper award in TMA. The transnational platform is already planned to be used for national and international projects beyond FIRE+ initiatives, including FP7 FLEX, H2020 MAMI and H2020 NEAT. During the next year, with the platform operational, we will accelerate our dissemination and exploitation activities focusing on demonstrations. We will further focus on building business models to sustain the platform.

1.2 Explanation of the work carreid per WP

1.2.1 Work Package 1

Work Package 1 involves the design of the systemś building blocks and the implementation of required components. During the first year, the effort has been dedicated to provide a proof of concept of the system components, system design and use case analysis, under the umbrella of Task 1.1. The result of this effort has been the successful achievement of milestones MS1 (System Design and Proof of Concept) and MS4 (Prototype Implementation).

Once the node's hardware selection was finished (MS 2) and Task 1.1 was completed, the effort has been focused on the (still ongoing) parallel tasks:

- Implementation of the modules to orchestrate access to and utilization of experimental resources (Task 1.2)
- Implementation of the modules for collecting, storing and visualizing measurement data (Task 1.3).

As it was planned, Tasks 1.2 and 1.3 are following a two-phase implementation, being the first one the development of a prototype implementation for the different system modules. This first phase has been completed during this first year. The second phase, the final complete implementation of the system, is still a work in progress and it will be available at the end of the second year.

The main result of WP1 during this first year is a working prototype of the platform. This prototype has been deployed into production and is currently being used with real nodes running experiments and collecting measurements. Extremely useful feedback from these early experiments has been gathered, and a refinement of the design of the overall architecture is in place based on user comments. It is worth to mention that a key element in the success of Task 1.1 was the joint development forces during the coding days that took place in January 2016.

Monroe is compliant with the FED4FIRE architecture, since the testbed entry point is an Aggregate Manager that implements the GENI Aggregate Manager API Version 3. Moreover, MONROE is a registered project in the Fed4Fire federation, and it reuses the same certificates issued by Fed4Fire, and so, any already registered user in Fed4Fire could be granted access to MONROE.

A full integration with mPlane has been deployed. MONROE platform natively supports the mPlane protocol inside its own container, and the tstat monitoring tool suite forms part of the collection of MONROE permanent measurements. Data collected by MONROE nodes can be seamlessly exported to any mPlane-compliant monitoring system.

The objectives of the Work Package 1 are included below, with a summary of the status of the completion of each objective:

- Definition of MONROE use cases and analysis of system requirements - status completed: System requirements and use cases have been collected and documented in deliverable D1.1. A total number of 10 use cases, grouped in 3 broad categories (key mobile broadband metrics, application performance measurement, and innovative protocols and services), have been fully analyzed and documented.
- Design a measurement system for mobile broadband technologies (3G/LTE and WiFi) - status completed: The overall architecture design of the MONROE platform has been completed (milestone MS1) and a working prototype implementation has been implemented and deployed (milestone MS4) in order to validate the seamless integration of system components and the fulfillment of use case requirements.
- Design and implement FED4FIRE-compliant modules for managing the access and the utilization of nodes - status ongoing: The MONROE scheduler system is compliant with GENI Aggregate Manager API Version 3, and the MONROE user authentication and authorization is ready to be adapted to use certificates issued by Fed4Fire certification authorities. Additional work on an advanced user management system, experiment definition facilities and scheduling policies is required after receiving feedback from the initial users of the platform.
- Design and implement the modules for collecting, storing, and accessing measurement data - status ongoing: MONROE prototype implementation provides a data storage and management system based on the combination of a big-data, NoSQL database, a publisher/subscriber based solution for data transfer, and a visualization framework. Support for Fed4Fire ETL middleware has been added. Additional work is required to deal with massive data transfers, and advanced visualization techniques.
- Implement a mPlane-compliant interface to allow the MONROE probes to be integrated into the mPlane architecture: status ongoing. The container-based architecture of MONROE node's middleware allows the deployment of multiple paradigms of measuring and data collection. A fully functional mPlane client is embedded in all MONROE's nodes, together with the tstat monitoring tool. Additional work is required to provide support for advanced uses of mPlane.

Progress in Task 1.1

Task 1.1 focused on defining the experiment use cases (deliverable D1.1, submitted in September 2015), and analyzing the hardware and software requirements for the measurement tool used in MONROE; the first system prototype implementation was also designed and completed in the second quarter. All activities for this task were concluded in the second quarter.

The following list summarizes the progress made in Task 1.1:

- Analysis of the state-of-the-art on measurement systems and techniques for mobile broadband networks, included in deliverable D1.1.

  - First, we surveyed the available measurement tools that could be ported and used in MONROE. During the kick-off, several such measurement tools were presented. After the kick-off, all partners contributed to populate a list with the state of the art in measurement tools. Second, we surveyed the existing measurement platforms (including both broadband and MBB platforms) and the concrete experiments that run on them. With the contribution of all partners, we produced a list of different platforms and potential measurements that can be reused in MONROE.
  - Then, we further compared these tools and the measurements that run on each of the platforms and selected the ones that seemed more appropriate for MONROE. The consortium decided to use tstat as the traffic analysis tool. A light version of Tstat, optimized for mobile scenarios with bandwidth limitations, was selected for implementation in MONROE. The consortium established collaboration also with the Netalyzr 2 developers. Therefore, plans for the likely implementation of this tool in MONROE were started.

- A definition of use cases and system requirements, included in deliverable D1.1.
  - We considered three main use-case areas in MONROE: (i) Key MBB parameters, (ii) application performance and (iii) innovative protocols. For each of the use-case areas, we produced a list of use cases with detailed descriptions that will be considered in the scope of MONROE. Besides the main interest use cases, we also generated a list of other possible use cases that are out of the scope of MONROE, but that may still be of interest to the rest of stakeholders.
  - The specification of all the use cases (i.e., main-interest and other possible use cases) was considered while designing the HW and SW to build a generic system that can support as many use cases as possible. Therefore, for each of the use cases we defined its HW and SW requirements, both in the node and in the backend system. These requirements were provided to WP2 to be used for the HW design.
  - Based on the comments from the technical review, the list of use cases implemented in the prototype was modified to align its focus with the key MBB parameters. Milestone 1 was achieved by the completion of this task and the submission of D1.1.

- A design of the measurement system (system design), included in deliverable D1.2.
  - MONROE is composed of three main systems: (i) core system, (ii) scheduling system and (iii) measurement, database and visualization system. The core system is responsible for ensuring the nodes are up and running, and connected to the back-end. All the SW running in the nodes and in the backend is part of the core system. Since the core system was vital to support the rest, we first focused on its proof of concept.

- A proof of concept of the MONROE system, in milestone MS4.
  - We completed the proofs of concept of the scheduling system and of the measurement, database and visualization system. The outcome of this step was reported in D1.1.

Progress in Task 1.2

Task 1.2 comprises the implementation of the mechanisms needed for user access control and orchestration of the testbed measurements in presence of internal and external experimenters. This task consists of two phases:

- Phase I (prototype implementation with basic functionality to implement the mechanisms needed to control user access and orchestrate all measurements without any conflicts) was finished and included in D1.2, resulting in the following milestones (MS4):
  - During Q3, the consortium analyzed the dependencies and duplicities between Fed4Fire middleware and MONROE's planned middleware. Besides, work was done on the installation and evaluation of alternative Aggregate Managers (GENI AM) and middleware (FITeagel, GRAM and Vagrant).
  - Implementation of a user-friendly access module to the nodes (reusing mechanisms defined in other FIRE projects where possible). During Q4, IMDEA worked on the design and development of a web-based portal for the user access to the MONROE testbed, registering the project with the FED4FIRE portal. SRL and CWY worked on the implementation of the scheduler, setting up a container network and implementing container quotas and accounting. SRL, CWY and IMDEA worked together during the coding days on the implementation of the user access portal and scheduling system.
  - SRL/CWY implemented and deployed an experiment management system that allows users to deploy and schedule their experiments on the selected nodes without violating the predefined usage quotas, such as system processing time, bandwidth and data quota for each operator. The resulting scheduling system supports the REST API used by MONROE's web portal and the nodes, and the FED4FIRE AM API (GENI).
  - IMDEA generated a draft of the user manual for the external experimenters which explains how to access the platform and execute experiments on it.
  - SRL, CWY and IMDEA worked on the implementation of result and status reporting to the web client.
  - The prototype implementation is functional at the end of this phase, and it will go through extensive tests and functionality upgrades starting Q5.
- Phase II (final implementation) will advance on the basis of the feedback received both from the internal and external users, and the insights gained during the prototype implementation. It will modify and extend the system design and implementation with new functionalities. Phase II will be completed in M24, resulting in MS9 and will be described in Deliverable 1.3.

Progress in Task 1.3

Task 1.3 concerns the design and implementation of the modules that collect the experiment results on nodes and servers, the database that will store the performance results of the experiments and the metadata, and the visualization tool that presents the results in a user-friendly public website. This task consists of two phases:

- Phase I (prototype implementation with basic functionality) was completed and included in D1.2, resulting in the following milestones (MS4):
  - SRL and CWY focused on the core components. They implemented and extended the metadata exporter, incorporating modem information, node sensors and system events to be saved as metadata. Furthermore, KaU implemented container technology (docker) on the nodes. Sample experiments are designed, implemented and tested in the containers. These sample experiments provided a basis to produce a template for the user experiments.

- KaU has completed the first implementation of the software to collect experiment results and node metadata, transport them to a central repository and import them into the database with a production-quality metadata importer. Together with SRL and IMDEA, they evaluated the whole pipeline in the production environment. As a result, experiment and metadata information is collected and initially stored on nodes, and then sent to the backend system on a regular basis.
- Database: The original plan of migrating MONROE data servers to a cloud environment was reevaluated due to its excessive cost. After evaluating all the available solutions, we chose a MONROE-hosted database solution. IMDEA performed the installation and configuration of a non-relational database (Cassandra) together with the analysis of its performance through a series of stress-tests and imports of data from experiments. IMDEA also developed a simulator that allowed extensive comparison of results. Finally, IMDEA completed the design and deployment of the initial MONROE database schema. Together with KaU and SRL, they worked on the storage of metadata in the main database of the project. The system is currently gathering data and metadata from experiments running on live MONROE nodes. NXW and IMDEA have designed database tables for the sample experiments including metadata (node state, GPS position, modem connectivity, system activity statistics, etc.).
- The consortium has worked on the integration of the database with the visualization tool. NXW has finished the visualization system design and the first round of developments of the tool frontend and backend is completed. NXW continued refining the visualization tool to show the experiment data in nearly real-time. The visualization tool is deployed in a public server and does currently support the demos scheduled for upcoming public events.
- Consortium defined the requirements for provisioning the interoperability with existing FIRE measurement architectures; in particular, the mPlane solution. MONROE plans to be fully integrated into the mPlane architecture as a "probe" so that measurements collected from the MONROE users can be processed and analyzed using the mPlane architecture and protocols. POLITO finalized the installation of the mPlane passive probe on the MONROE nodes and several nodes are now fully working (in beta state) with tstat (e.g., in Turin and Oslo). POLITO has also implemented a standard mechanism to export data collected by the nodes to the central repository. Therefore, preliminary work to provide an interface to the FP7 mPlane project is completed.
- SRL and CWY have implemented an inventory database with information about each available node.
- KaU registered an Internet domain for access to MONROE services (monroe-system.eu). All the systems, database, visualization, scheduling, user access and temporal metadata repository, are deployed on a public server (non-production hardware temporarily lent by KaU until the performance evaluations are concluded) under the monroe-system.eu domain.
- SRL and CWY concluded a PXE-based node installation system and installation routines and implemented an Ansible-based configuration, management and global MONROE system configuration. They together with KaU also made progress on the development of a node recovery system that can restore the node software to a default state in the event of some commonly expected node failure scenarios such as file system corruption due to sudden power outages when buses (for mobile nodes) are powered off.
- SRL and CWY performed an analysis of the test deployments in Norway and Italy and implemented system self-check and repair solutions.

- Phase II (final implementation with extended functionality and modifications) will be included in D1.3, resulting in MS9. It will consist of the following tasks:
  - The consortium will finalize the deployment of software on the nodes and implement more sensors and node events as needed. IMDEA, in collaboration with NXW, will extend the database tables based on new designed experiments. NXW will support the enhancement of the database schema for the planned use cases (traceroute, http streaming, etc).
  - KaU and IMDEA will work on the implementation of repository and data/metadata importer with access for external users.
  - KaU will produce the final templates for the experiments.
  - Work will be conducted to deploy APIs that expose data in a well-described and open access manner.
  - Continued development of the visualization application to add missing and advanced functionality.
  - The consortium will continue working on a joint evaluation of the database and metadata importer with real experiment data to identify performance risks and decide about the final production hardware.
  - Implementation and deployment of a test application for the OML library will be completed, providing a publicly accessible server with an up and running installation of the OML framework.

1.2.2 Work Package 2

WP2 aims to manage and implement the procedures for setting up the MONROE experimental infrastructure in terms of hardware-related requirements. The WP2 work mainly consists of analysing and selecting the hardware components, testing the materials in different borderline conditions and finally purchasing and assembling the MONROE nodes. Part of the activities carried out by the WP2 is also the distribution of the nodes to the partners in order to deploy the devices (both stationary and mobile) in Norway, Sweden, Italy and Spain. Moreover, WP2 is also devoted to implement the maintenance of the nodes with the development of proper recovery functions.

The WP2 efforts are planned to achieve the following objectives:

1. Design of the hardware components of the MONROE nodes through an evaluation of the available alternatives in terms of suppliers, prices and delivery time;
2. Purchase of the selected components and assembly the pieces into MONROE nodes;
3. Selection of the subscriptions and SIM cards for 3G/4G connectivity;
4. Identification of the proper node hosts in which to deploy the whole infrastructure;
5. Define robust node recovery functions in order to discover possible hardware failures and implement appropriate actions to solve the causes and restore the node's resources.

To fulfill its requirements, WP2 has been structured in three tasks:

1. T2.1: Selection and Assembly of the Nodes (started on M1);
2. T2.2: Deployment and Logistics (started on M7);

3. T2.3: Robust Node Recovery (starts on M16).

The activities in the first year focused on the design of the hardware components of the MONROE nodes and the implementation of the procedures to assemble the devices. In particular, T2.1 has carried out the design of the hardware and the selection of the components. Moreover, the procedures to assemble the elements have been studied, tested and finalized in the laboratory or in a safe test environment. Furthermore, consortium has decided to also initiate T2.3 earlier than planned since it can significantly reduce the maintenance efforts, especially for the mobile nodes.

The main outcome of the T2.1 has been the selection of all different components for the MONROE node, purchase of all the selected components from different suppliers and the assembly of test nodes that provide input of the T2.2. During the first year of the project, T2.2 has carried out the selection of the MBB subscriptions allowing us to start the deployment procedures of the two mobile and several stationary test nodes. The first mobile node was installed on a GTT's bus in Turin, Italy, and the latter on a bus in Karlstad, Sweden. The stationary nodes were tested mainly in Norway and Sweden.

A detailed per-task description of the activities developed in WP2 is provided in the following sub-sections:

Progress in Task 2.1

Task 2.1 deals with the selection of the different hardware components and the assembly of the materials for providing the designed MONROE infrastructure. Based on the use-cases requirements that are the main outcome of the WP1, SRL and CWY have evaluated different off-the-shelf routers, router boards, single board computers and computers like the Intel NUC. The NorNet node has also been evaluated as a candidate for the MONROE hardware. The analysis of the different choices raised the problem that most of them lack one (or more) of the desired features, i.e. affordable price, enough technical characteristics as network interfaces, CPU, memory, or simply the availability for high numbers etc. The most important result of this phase has been the selection of the PC Engines APU as the main MONROE board.

The device has been extensively tested and evaluated in the laboratory of CWY in order to verify the stability of the device in more challenging conditions, such as high vibration, high temperature or humidity environments etc. To support multiple USB modems, MiFis and/or smart phones, the evaluation of some USB hubs able to power cycle the whole hub or individual ports has been dealt with. We have found and successfully tested the YKUSH component from Yepkit. We have also evaluated several LTE (including GPS) and WiFi AC cards. At the end, we have identified ZTE MF823 and MF910 as good options for the project.

The final stage of the selection activity was focused on the choice of converters, connectors, power adapters, passive antennas, boxes to be used to assembly the hardware for the deployment etc. CWY and NXW investigated the suppliers for all these materials and acquired the components for the first batch of nodes (both for stationary and mobile nodes).

For the stationary nodes, all the components have been assembled and tested in challenging environment conditions, i.e heat and humidity testing in a combined heat/damp oven (up to 80 degrees and 80% humidity or 60-60 in a long term scenario). As result of these tests, a new software module has been developed by SRL to support the management of the power on/off of the device. Furthermore, the nodes have been monitored closely and the problems have been provided as input to the development of the recovery procedures in T2.3 that is currently ongoing.

For mobile nodes, one important component is the converters that provide the correct power from the bus power supply to the APU and the USB hub. We have purchased some sample converters and assembled all the components for the mobile test nodes. During our tests on the mobile nodes on the busses, one of the converters has failed due to power spikes. To better analyze the issue, we started an extensive experimentation phase with different kind of converters and different brands. The new components have been re-evaluated through a series of stress tests which implement e.g. very high ingress voltage (close to 2x of

the power supply of a bus), sudden transactions or peaks of the inputs, etc. The extensive tests together with long delivery time of some of the components resulted in some delays in T2.1. At the time of writing this report, a plan has already been elaborated (please see Section 5.1).

The main contribution of the Task 2.1 has been the deliverable D2.1 that was submitted on March 1st. The deliverable details the hardware design including the selection and testing process, and the capabilities and limitations of the nodes.

Progress in Task 2.2

Task 2.2 deals with the deployment on the MONROE nodes. During the first year of the project, the consortium has replaced one partner before the project has started (Gowex is replaced by NXW) and initiated the removal of another one (NET1). The partners that left the consortium were responsible for hosting mobile nodes in Italy and Sweden. Therefore, the consortium has updated the host of the nodes and took all necessary actions to avoid any deployment related delays. For the mobile nodes in Italy, NXW took the responsibility. For the mobile nodes in Sweden, KaU took over the responsibility from NET1 and reached an agreement with a bus company in Sweden to host the MONROE nodes. In this context, visits have been made to look at buses from the regional bus operator Värmlandstrafik and city local bus operator Karlstadsbuss, in order to determine if and how the MONROE nodes may be installed in these buses, how they can be powered, and also to check options for the best antenna placement. NXW, SRL, KaU and IMDEA have also been working on the selection of suitable hosts for the stationary nodes. Some stationary nodes are already deployed with up and running status both in Sweden and Norway. These nodes are devoted for testing of different software components of system implementation. Furthermore, NXW finalized the deployment strategies, especially for the new hosts, covering all the procedures for ordering, assembling and delivering the MONROE nodes to the partners.

In parallel, the evaluation of the different subscription models (i.e. price, data quotas and coverage) for different operators and for different countries has been finalized. In Italy, NXW and POLITO negotiated and signed contracts with Vodafone, Wind and TIM, three of the major mobile operators in Italy. In Sweden, KAU negotiated agreements with 3Bredband, Telia and Telenor while in Spain IMDEA negotiated agreements with Orange, Yoigo and Vodafone. In Norway, we have negotiated deals with Telenor and Telia as two main operators. For the third operator, we chose ICE. However, ICE is going through a large-scale technology upgrade, hence the arrival of the new subscriptions may be delayed. The plan is to move to virtual operators in case of failure in the ongoing negotiations.

Task 2.2 has also devoted to implement the needed logistic procedures, i.e. selecting the proper suppliers for the hardware components, organizing the depot to store the materials, choosing the couriers to entrust the shipments etc. NXW has concluded this phase successfully in time.

Progress in Task 2.3

Task 2.3 has the main objective to implement a robust recovery procedure to prevent unexpected malfunctions, which may run the nodes into an unstable condition. As said before, the scheduled date to start this task was planned on M16. However, the Consortium agreed to advance in this task earlier considering the importance of its outcomes in terms of stability and sustainability of the platform. A deep discussion and analysis on this topic has been taken place during the meeting in Torino (26-29 Jan). The complete workflow of the actions and events has been identified. The development of the software modules is currently ongoing with the involvement of KaU and SRL.

1.2.3 Work Package 3

This Work package is active from M13 and the progress will be reported during the second period.

1.2.4 Work Package 4

This Work package will be active from M16 and the progress will be reported during the second period.

1.2.5 Work Package 5

WP5 concerns the support for external users of the MONROE platform. Three objectives are defined for this WP in the DoA:

- Make the MONROE experimental platform available to external users through open calls
- Provide efficient support for external users of the MONROE platform
- Gain input on how to extend and enhance the MONROE platform from external users

The WP started in M10 towards the end of the reporting period, and only the first of the two tasks in the WP, Task 5.1 "Call for users and User Selection", started during the first year. Task 5.1 targets the first of the three WP objectives and handles all the practicalities involved in announcing MONROE open calls for external users as well as the associated user selection.

The consortium publicly announced the first Open Call on December 23, 2015 via the project website, twitter and by sending the news to the list of subscribers interested in knowing more about the project. The FIRE website also published the announcement in December.

Consortium work towards announcing the first Open Call started a bit early in November 2015 by the joint effort from SRL, KaU, CWY and IMDEA in writing the detailed guide for applicants and the proposal template. The first open call has a total budget of 1,8 million EUR, and will fund up to 12 proposals (maximum funding per proposal of 150.000 EUR). Deadline for proposals submission was set to M13, mid-March, and 40 proposals were received.

Anna Brunstrom (KAU), Özgü Alay (SRL), Hakon Lonsethagen (Telenor), and Pedro Andres Aranda Gutierrez (Telefonica) form the Call Committee. The partners have provided at least three reviewers each for the open call: two internal and one external. The consortium plans to close the review in the end of April, 2016, and notify the successful applicants in early May.

1.2.6 Work Package 6

The description of the work carried out in WP6 (Management) is structured around the main objectives of this WP, as follows.

- **Conduct and control external communication by the project management to EC:** During the first year of the project, SRL communicated with EC on behalf of the consortium. The deliverables are submitted on time. The changes in the consortium were communicated to EC and SRL has submitted two amendments due to departure of the partners Gowex and NET1.
  - Departure and replacement of Gowex: Gowex was no longer eligible to participate in H2020 projects after its appearance in the media due to allegedly falsify the accounts during the summer of 2014. Therefore, Gowex was removed from the consortium and all its tasks and budget were taken over temporarily by the coordinator, who was seeking for a new partner to replace Gowex during the Grant Agreement phase. After evaluating several potential partners, the MONROE consortium agreed on Nextworks (NXW) to take over all responsibilities of GOWEX. Towards this end, we have submitted an amendment request on 07 April 2015 and EU accepted the amendment on 07 May 2015, formalizing NXW as a new partner in the project.

  - Departure of NET1: NET1 has left MONROE's consortium due to lack of resources after their representative in MONROE has resigned. Consortium decided not to find a substitute beneficiary for NET1, therefore, NET1's original budget and tasks were redistributed between KAU and SRL. SRL is now the lead partner for D7.3 - Exploitation on Sustainability. NET1 had a total of 8 man-months in the budget; 2 for WP1, 2 for WP2 and 4 for WP7. Two person-months from WP2 were transferred to KaU, who took over the deployment and logistics of the nodes in Sweden. The budget for the other 6 person-months were transferred to SRL under the category other direct costs. This represents extra 67745 Euros for SRL. The reason for transferring part of NET1's budget to Simula other direct costs was that NET1's main contribution to MONROE would have consisted in hardware (150 modems for the nodes) and 100 high quota subscriptions in Sweden as in-kind. Total estimated budget for the consortium remains the same. An amendment was submitted to the European Commission to formalize the reallocation of budget and tasks.

- **Coordination of all technical and non-technical activities carried out in the project, and overall management of the consortium:** Project management and coordination have been smooth during Year 1 and no major issues have arisen. Cooperation between partners has been strong; this is attested by joint software development as well as authorship of scientific papers under submission. The pre-financing was distributed by SRL to all concerned partners at the beginning of the second quarter. The two amendments submitted in Year 1 were completed in close collaboration among partners. Quartely management reports were leaded by SRL and partners actively contributed with information. Finally, plenary meetings were organized and informed to all partners in good time.

- **Monitoring the quality of the outputs of the project, and ensuring they are well aligned with the project's objectives and according to the work plan:** Procedures for ensuring the quality of deliverables were defined early on (Deliverable 6.1). SRL has been involved in the deliverable production process, has supported the consortium in this process, and has acted as final reviewers of all reports. Overall, the project is on schedule and the work progress aligned with the work plan. All milestones during the reporting period have been achieved by their deadline, and all deliverables submitted without undue delays, as summarized in Appendix A.

- **Ensuring communication, collaboration, consensus and information sharing between partners, and maintaining private online collaboration tools:** SRL has organized three plenary face-to-face meeting with the help of the partners:

  1. March 10-12, 2015: Project kickoff meeting in Oslo, at SRL's premises, lasting 2.5 days. The agenda was split between administrative / project management topics (one day, including a Project Board meeting) and research collaboration (one and a half days).
  2. September 2-4, 2015: Project plenary meeting in Karlstad, Sweden, at Karlstad University's premises, lasting 3 days. The agenda was mostly technical during the first two days with some time used to discuss project management topics during a Project Board meeting. The third day was dedicated to an Advisory Board Meeting.
  3. January 27-29, 2016: Project plenary meeting in Torino, Italy, at POLITO's premises, lasting 3 days. The first day was mostly used to discuss project management topics due to the ongoing coding days that took place in parallel. The agenda was mostly technical during the next two days.

  Finally, monthly teleconferences had been held since April 2015, coordinated by SRL. During the first 6 months, we held telcos once a month. However, for the second half of the year, we have increased

the frequency of the telcos and held them bi-weekly. A set of four online collaboration tools was set up by the launch time of the project: a wiki, mailing lists, a repository with a version-control system and a teleconferencing system (Deliverable 6.1). SRL administers all these tools.

- **Coordinating strategic collaboration with other on-going projects and activities of relevance to MONROE:** We have initiated collaboration activities with two H2020 projects: NEAT and MAMI. Both of these projects are planning to use MONROE testbed to run their experiments. NEAT will use the MONROE platform to test relevant NEAT components, especially the multihoming feature of MONROE is crucial for NEAT. The real-network measurements produced in MONROE will provide input to NEAT system for smart interface selection in multihomed networks. MAMI project investigates middleboxes in internet and will use MONROE platform to specifically test the middlebox behaviour in mobile networks. Furthermore, we have started collaboration with FP7 FLEX project, which provides a controlled environment for LTE experiments. Our collaboration with FLEX will lead to a better understanding of mobile networks considering both controlled (FLEX) and operational (MONROE) settings.
- **Maintaining the liaison with the Advisory Board (AB):** The AB was engaged via early sharing of deliverables, and attendance to a full-day meeting where the project's work and plans were presented to the Board, in September 2015. The AB members have provided useful comments and feedback that the project will consider. The consortium is planning a second plenary meeting with the AB during Year 2.
- **Communicating to third party external users to ensure fulfillment of users:** We have announced the first MONROE open call in December 2015. In order to communicate with the external users, we established an email address: info@monroe-project.com. We have received many emails to this address during the open call. Consortium members were also active disseminating the open call in different venues (please see the dissemination activities).

1.2.7 Work Package 7

WP7 Dissemination and Exploitation has the goal of establishing MONROE as the European benchmark platform for MBB measurements and testbed activities. This WP includes activities to ensure impact and future sustainability of MONROE and is organized in 3 tasks. Task 7.1 focuses on the general dissemination of MONROE features and results. Task 7.2 focuses on the specific management, dissemination and exploitation of the OPEN data resulting from the measurements, and task 7.3 focuses on sustainability. During the first year, only task 7.1 is active. Milestone 3 was foreseen for the first year and it was achieved by the completion of dissemination plan and the launch of the project website.

Tools and guidelines.

We have developed a set of tools, templates and guidelines in order to coordinate and ensure swift dissemination and exploitation. We have created a public website (www.monroe-project.eu), including news feed (blog) and a twitter page to publish information and achievements related to MONROE. Within the consortium, we use Github to share and collaborate on code (incl. open source), and we use bitbucket to collaborate on papers and reports. We share publication results and datasets as open reproducible data through zenodo.org. We have created an internal wiki page, which, among other things, serves as a tool to manage dissemination activities.

EC events and projects.

It is important for MONROE to be visible in the EC community and contribute to others' experiences. CWY and SRL participate and contribute to the regular FIRE WG teleconferences and, in the first year, SRL has presented MONROE in two EC events:

- SRL presented MONROE in the FIRE Concertation meeting in March 2015 (http://www.ict-fire.eu/events/past-events/fire-concertation-meeting.html)
- SRL presented MONROE in the workshop Future Internet Opportunities For Innovative European Businesses in March 2015

  https://www.digitalcatapultcentre.org.uk/event/future-internet-opportunities-for-innovative-european-businesses

MONROE has had a close collaboration with the FP7 project mPlane (through MONROE partner POLITO), and MONROE has implemented support for several mPlane features, including the tstat traffic analyzer.

Industrial and societal outreach.

Industrial and societal outreach is key to place MONROE as a benchmark platform in the continent.

- SRL presented MONROE in one-to-one meetings with stakeholders NSB (trains) and Netbuss (buses) (May 2015)
- CWY presented MONROE in one-to-one meetings with stakeholder ICE (operator) (May 2015)
- CWY presented MONROE to Norwegian industry and public sector entities in a seminar for companies, research institutes and public sector (approximately 20 attendees) hosted by the Regional Research Funds in Norway (November 2015)
- Presentation about MONROE by SRL at Train Communication Systems Conference. London, June 2015.
- Poster by SRL at the Opening SUURPh: The Simula-UiO-UCSD Research and PhD Training Collaboration with industry and politicians present. Oslo, June 2015.
- Standardization Conference: KaU presented the project during the 93rd IETF (The Internet Engineering Task Force) in HOPS group. Prague, July 2015.

Media.

Establishing contact with press in different countries has been important to MONROE to inform MBB users, industry, and policy makers about MONROE's objectives and status, to advertise to a broad audience the first Open Call and to ensure general visibility. In total, we have had 22 press articles (appearances), where 11 were about project funding and project start, 9 about open call and 2 with various content.

For promoting the Open Call, partners' web pages and twitter have been used to disseminate practical information. The project has also produced some business cards with open call info that have been handed out on workshops, meetings and conferences. Press release about the Open Calls is published on the website of some partners (Simula, IMDEA and POLITO):

- https://www.simula.no/news/monroe-announces-first-open-call-total-budget-eur-18-million-external-experimenters - 2016
- http://www.networks.imdea.org/whats-new/news/2016/monroe-announces-first-open-call-total-budget-eur-18-million-external - 2016
- http://www.politocomunica.polito.it/en/press_room/news/(idnews)/7369- 2016

This press release was also disseminated to the media. The following venues announced the open call:

- Published in NETCOM research group at Universidad Carlos III de Madrid website: http://netcom.it.uc3m.es/news/2016/monroe-announces-first-open-call-total-budget-eur-18-million-external-experimenters (IMDEA)
- Picked up by the Italian national newspaper La Stampa: http://www.lastampa.it/2016/02/25/tecnologia/news/reti-mobili-a-banda-larga-il-politecnico-di-torino-partner-pagina.html - February 2016 (POLITO)
- Picked up by the Italian tech news website bitMAT: http://www.bitmat.it/search-results?mssearch=MONROE&mswhere=all - February 2016 (POLITO)
- Picked up in the tech section of Il Secolo XIX, Italy: http://www.ilsecoloxix.it/p/magazine/2016/02/25/ASp6kuiB-politecnico_partner_progetto.shtml - February 2016 (POLITO)
- Picked up in the tech section of Diario Del Web, Italy: http://scitech.diariodelweb.it/scitech/articolo/?nid=20160224_375708- February 2016 (POLITO)
- The local television in Piemonte Italy (GRP TV) aired 50 seconds news about open call in two days - February 2016. (POLITO)

In connection with the funding announcement and start of the project, press releases were published on the websites of Simula, IMDEA, POLITO, KaU:

- http://ghost.simula.no/news/unprecedented-eu-project-turnout-for-simula-1
- http://www.networks.imdea.org/whats-new/news/2015/platform-measure-mobile-broadband-networks-europe
- http://www.tlc-networks.polito.it/public/project/measuring-mobile-broadband-networks-europe
- http://www.kau.se/cs/nyheter/2015.03.20/nya-projektframgangar-for-datavetenskap-vid-karlstads-universitet

The information about MONROE have been picked up by tech press and other web pages:

- Norwegian technical press Teknisk Ukeblad: http://www.tu.no/it/2014/09/29/norske-simula-skal-lede-fire-store-forskningsprosjekter-i-europa (Simula)
- Norwegian tech press Inside Telecom: http://www.insidetelecom.no/artikler/norsk-stabilitetstest-ut-i-europa/167938 (Simula)
- NETCOM research group at Universidad Carlos III de Madrid website: http://netcom.it.uc3m.es/news/20150509-MONROE-EN.html (IMDEA)
- Madrid city web page: http://www.madrimasd.org/informacionidi/noticias/noticia.asp?id=63624&origen=notiweb&dia_suplemento=viernes (IMDEA)
- Telefonica blog: http://blogs.it.uc3m.es/it/?p=1823(IMDEA)
- Research web page Alpha Galileo news: http://www.alphagalileo.org/ViewItem.aspx?ItemId=152559&CultureCode=en(IMDEA)

- Research web page framtidensforsking.se: http://framtidensforskning.se/presentation/nya-projektframgangar-for-datavetenskap/(KaU)

Other articles in media:

- Celerway was featured in a Norwegian tech magazine and the article have a brief introduction to MONROE (September 2015). http://www.digi.no/tele-kommunikasjon/2015/09/24/gjor-en-vanlig-ruter-om-til-multinettverksruter

Scientific community outreach.

MONROE is a Research and Innovation action. Therefore, contributions to scientific community are a big component of the project. To this end, the consortium has produced successful papers describing the platform and has received a best paper award for one of them.

Published papers:

- MONROE: Measuring Mobile Broadband Networks in Europe. Paper accepted for presentation during RAIM in Cooperation with ACM SIGCOMM. (All, october 2015)
- Andra Lutu, Yuba Raj Siwakoti, Özgü Alay, Dziugas Baltrünas, and Ahmed Elmokashfi (Simula Research Laboratory). Profiling Mobile Broadband Coverage. In Traffic Monitoring and Analysis Workshop, Submitted January 2016, Accepted March 2016. Awarded the **Best Paper Award**.
- Acknowledged: Behind the NAT- A measurement based evaluation of cellular service quality (Imdea, nov 2015) 11th International Conference on Network and Service Management

Presentations:

- SRL presented MONROE on the International Workshop on Traffic Monitoring and Analysis (TMA) in Barcelona (April 2015) http://tma-2015.cba.upc.edu/smart.
- Presentation about MONROE during NorNet workshop at Simula. Oslo, August 2015.
- Presentation about MONROE at IRTF & ISOC & Workshop on Research and Applications of Internet Measurements (RAIM) in cooperation with ACM Sigcomm. Yokohama, October 2015.
- Presentation about MONROE at RIPE 71 meeting in Bucharest, Romania, November 2015.

Sustainability.

To grow and to sustain the MONROE platform are important goals of the project. Although this activity has not officially started according to DoA, we have initial actions that contribute to the sustainability of MONROE.

- The 22 media articles and appearances facilitate the approach to actors that can help sustaining and growing the platform.
- The open call text specifically asked for business ideas and the first review indicates that several proposals have given valuable input on this.
- An internal wiki page is created to list ideas for discussion. Currently, there are discussions and activities towards other projects that can fund continuation, services to regulators, services to operators, services to customers that will control SLAs, special services for tech media, and software and hardware products using MONROE results and code.

1.3 Impact

The impact section has been updated based on the partner replacement and this is reflected in the amendment and the current DoA. The expected impact and measures presented in the DoA are still relevant for the work and plans in the project.

2 Update of the plan for exploitation and dissemination of result (if applicable)

The plans for exploitation and dissemination from the DoA are still valid except for contribution to IEEE802.16.3 Mobile Broadband Performance Measurement. This project has been withdrawn upon request from the 802.16 working group.

3 Update of the data management plan (if applicable)

In Month 6 (September 2015), we have submitted the deliverable D6.2 Data management plan, presenting the first template and guidelines for open data. No updates have been made to data management since D6.2. MONROE will use Zenodo for sharing, archiving and identifying (via DOIs) the open data. Github is the code repository chosen for all open-source software released by the project. The prototype implementation of MONROE system has already been shared as open source in github.

Scientific publications (and related public deliverables) will be shared on Zenodo together with results files as well as the scripts that are used to produce these results in order to ensure reproducibility. To this end, we have provided the data together with the publication in Zenodo for *Profiling Mobile Broadband Coverage* TMA conference paper at http://dx.doi.org/10.5281/zenodo.47707.

4 Follow-up of recommendations and comments from previous review(s) (if applicable)

We have had an early technical review at month 6 and the review took place at IMDEA premises in Madrid, Spain. The consortium has addressed the main points that have been raised during the review as described below:

1. **Deployment:** The reviewers expressed their concerns on how expensive these boxes are and how expensive it is to keep them connected without frequent maintenance. To this end, we have decided to test all the components on most challenging scenarios, including mobility, before deciding on the final set of nodes. We have also prioritized node recovery mechanisms in order increase the uptime of the nodes and reduce the maintenance efforts.

2. **Use Cases:** The reviewers further suggested to focus on a small number of use-cases and analyze them thoroughly. To this end, we have decided to focus on basic MBB parameters. The connectivity test and performance tests are already implemented and provided as templates. Metadata is collected. Traceroutes are collected on-demand.

3. **Analysis of the HW and system:** Following suggestions from the reviewers, we have done a thorough analysis of the limitations of the HW and the system in general. This is provided in D2.1. We have also

developed tools to build coverage maps. Further analysis of the paths will be done once the deployment is in place.

4. **Focus on SMEs:** Following recommendations from the reviewers, we have targeted SMEs and disseminated the project in many different venues. We have also described the system in details in the open call text indicating many different potential areas that the platform can be useful. Our efforts resulted in 40 applications to the first open call and in 18 of the proposals, there is industry involvement. Furthermore, 11 of the proposals target industrial innovation.

5. **Communication:** The reviewers further suggested to open a communication channel with regulators and virtual operators. We have been in touch with Norwegian regulators during the first year and we plan to be more active regarding the regulators in other countries as well as the regulator body BEREC. We have also contacted different virtual operators and they have expressed their interest to the project. In Italy and Spain, we have negotiated good deals with virtual operators and we will invest more in this direction.

6. **Sustainability:** To grow and sustain the MONROE platform is one of the main goals of the project. Following the reviewers comments, we have initiated some activities in this direction and we will intensify these efforts once the platform is operational and producing results. So far, we have reached out to the main actors that can help sustain and grow the platform through 22 media articles and appearances. Furthermore, we have made sustainability one of the main themes of the open call and, in the open call text, we specifically asked for business ideas on how to grow and sustain the platform. The first review from applications indicates that several proposals have given valuable input on this. We are gathering a list of ideas on sustainability on our internal wiki page. One promising model seems to be funding the platform through other projects and the platform has already attracted additional funding through national and EU projects. One suggestion regarding sustainability was to put MONROE SW on hotspots. Although this approach will greatly increase the scale of the platform, it will only provide benefits in terms of monitoring of MBB networks. However, during the first open call, we observed that the majority of the applications require active measurements, multiple interfaces or kernel modifications. Therefore, we believe there is a great need for such a platform especially for novel services and protocols. To this end, we will focus both on increasing the use of the MONROE SW for monitoring applications and sustaining the platform for novel services and protocols.

5 Deviations from Annex 1 (if applicable)

5.1 Tasks

Task 2.1: In order to provide a reliable platform that has high number of nodes available with large uptimes, we have done thorough analysis of all the components of the node. We tested the complete node on the buses, especially the buses in Italy, which showed additional challenges due to vibration. Since these are public vehicles, at times it is difficult to align with their schedules. One of the test nodes that is deployed on a GTT bus could not be tested for more than a month since the bus had to be in garage due to an unexpected failure of the bus engine. Some of the components, such as converters, that worked well in the lab tests also failed in the buses due to power spikes, therefore, we initiated a more extensive investigation. Furthermore, we have identified that the node recovery mechanism, originally planned to be implemented only in the second year, is also necessary for the deployment in order to increase the uptime of the system as well as

to reduce the maintenance efforts. Due to the complexity of the whole system, the activities in this task required more time than originally estimated and planned for.

Task 2.2: Due to the above mentioned reasons, we foresee, the deployment of the nodes will be delayed. Currently, the first batch of the nodes (100 nodes) is being assembled and deployed. Majority of the components for the second batch have been ordered. We expect to complete the deployment of the first batch by the end of May or early June and the deployment of the second batch by August (taking into account the summer vacations). We are currently working on accelerating the assembly process by carrying out different tasks in parallel in order to minimize this delay.

This delay might, in turn, impact the timeline for large-scale measurements for monitoring of MBB networks. However, since the deployment will be incremental and distributed over all countries, we believe that this delay is not critical and that it will not impact any other tasks significantly.

5.2 Use of resources

Regarding the use of resources, there are four deviations with respect to the DoA:

1. **CWY:** The financial reporting used evenly distributed PMs as planned resources. For CWY, this has lead to some deviations when counting actual resources. CWY has prioritized to spend more resources on WP1 and WP2 in order to ensure that software and hardware have been ready and tested properly before hardware selection and deployment. In order to ensure high visibility and success with open call, CWY (as dissemination manager) has also used some more resources in WP7.

2. **IMDEA:** Similarly, IMDEA has overspent resource effort in WP1 with respect to the original plan (26.54 PM instead of the expected 20.5 PM). This overspending was partially due to the need to concentrate the effort on the early design and deployment of key system components such as databases, repositories, and, most importantly, a Fed4FIRE-compliant user access interface to the testbed resources, integrated with a new experiment scheduler. Since the final system implementation is expected to require less effort than the prototype developed so far, part of the above mentioned IMDEA overspending will be compensated in the remainder of WP1 lifetime. Moreover, the development and testing of prototype databases and user access interface required the use of additional personnel (PhD students and young engineers) to help our senior engineers and speed up the work. The effort associated to those lower-experienced personnel was necessarily higher than the one required by senior engineers and researchers. IMDEA has also overspent 1.79 PM in WP7, due to the intense activity carried out for the preparation of several demos in public events. However, in terms of overall cost of personnel, IMDEA's overspending in the first year is less accentuated than PM overspending. Specifically, IMDEA has already spent roughly 40% of its budget for personnel in one third of the project duration, resulting in a mere 7% overspending.

3. **NXW:** NXW is responsible for the assembly and deployment of the nodes. Due to the delay incurred in the selection and testing of some components, as detailed in the section 1.2.2, NXW's efforts on the assembly of the nodes and their deployment in the buses and trucks will be carried out mostly in the second year of the project. In order words, the efforts that are planned for year one will be compensated in year two.

4. **POLITO:** During project preparation, POLITO forecasted a total number of 30 PMs. This amount is the sum of PMs forecasted for staffed personnel and for 24 months related to Researcher Under Grant (assegno di ricerca) cost, hired specifically for the project development. For the first 4 quarterly reports,

POLITO reported the PMs spent by both staffed and hired personnel working effectively on the project. Few months ago, the EC 'Common Legal Support Service' published a restrictive interpretation of the art. 6 of the Model Grant Agreement regarding the personnel costs (List of issues applicable to particular countries available at the following link: http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/amga/h2020-issues-list-countries_en.pdf), which affects the planned budget for Politecnico di Torino and PMs estimation since, according to this interpretation, 'assegni di ricerca' cannot be claimed under the category 'Personnel Costs' as it was for FP7 projects. For this reason, as the cost category to be used for 'assegni di ricerca' has to be duly checked with the EC offices and the Project Officer, the cost for the Researcher Under Grant will not be reported during this financial year. Instead, it will be claimed as an adjustment in next reporting period (in the same way PMs spent by the Researcher Under Grant will not be reported in POLITO effort in the Financial Statement). As a result, PMs spent by POLITO during the first year will be remarkably less than the ones forecasted in the proposal and indicated in the QMRs (only 3.6 PMs in total will be reported). According to the upcoming clarification with the EC related to this issue, costs will be adjusted and an amendment will follow if "assegno di ricerca" has to be allocated to 'Subcontract' category (we highlight that this change in budget will reflect in both costs and PMs estimation).

5.2.1 Unforeseen subcontracting (if applicable)

Not applicable.

5.2.2 Unforeseen use of in kind contribution from third party against payment or free of charges (if applicable)

Regarding open calls, there is no budget for external reviewer's fee and, therefore, external reviewers costs will represent an in-kind contribution free of charge to MONROE. The consortium plans to close the review on April 18, finalize the discussion on April 26 and notify the successful applicants in May 2.

6 ANNEX 1

Status of the Deliverables and Milestones

During the first year, SRL ensured (a) the verification of project deliverables by the appropriate persons in the project management structure, and (b) the timely submission of such deliverables to the EC Scientific Officer. To this end, 5 deliverables have been submitted and 4 milestones has been achieved as tabulated in the below Tables.

Furthermore, Quarterly Management Reports are generated and submitted to the Commission, containing basic facts and figures on a per-quarter basis, including brief updates on work progress and use of human resources. During the first year, 4 QMRs have been submitted to summarize the status of the project.

Number	Deliverable Title	Due date	Delivery date
D6.1	Report on project management tools	June 1st, 2015	June 1st, 2015
D6.2	Data Management Plan	September 1st, 2015	September 1st, 2015
D1.1	Report on use cases	September 1st, 2015	September 14th, 2015
D1.2	System Design and Prototype implementation	March 1st, 2016	March 1st, 2016
D2.1	Selection and design of the new node	March 1st, 2016	March 1st, 2016

Number	Milestone	Due date	Achieved date
MS1	System Design and Proof of Concept	September 1st, 2015	September 1st, 2015
MS2	HW selection	September 1st, 2015	September 1st, 2015
MS3	Dissemination Plan and public website	September 1st, 2015	September 1st, 2015
MS4	Prototype implementation	March 1st, 2016	March 1st, 2016

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