1. Summary for publication

1.1 Summary of the context and overall objectives of the project

DOSSIER-Cloud proposes a series of coordination and support actions for promoting research in the area of Software Engineering for Distributed Systems development. It brings together two internationally recognized scientific groups from the Netherlands (Tilburg University, UvT) and Italy (Politecnico Milano, POLIMI) that collaborate with Cyprus University of Technology (CUT) to facilitate transfer of scientific knowledge, expertise and best research practices from UvT and POLIMI to CUT.

Three research topics are investigated: (i) A unified framework for developing distributed software systems with a dedicated DevOps-oriented life-cycle model that directs practitioners (developers and operators) on how to deliver services faster and accommodate easy changes. (ii) Definition of new, customized Monitoring and Control Mechanisms that permit automatic deployment and reconfiguration (iii) Automating procedures for adjusting and reconfiguring the DevOps environment driven by quality indicators, such as performance, security and elasticity.

DOSSIER-Cloud has three main intertwined objectives:
(i) Acquire new and enhance existing knowledge on the three research topics of interest; (ii) Share research experiences and best practices with the leading institutions; (iii) Form a collaboration basis with stakeholders and secure industrial involvement.

A variety of actions are performed to achieve the objectives:
- Exchange personnel and perform site visits
- Organise schools and workshops with industrial and market participation
- Deliver special purpose/theme lectures and presentation by members of UvT and POLIMI
- Offer training , tutoring and mentoring on specific research methods and tools developed by UvT and POLIMI
- Continuous raising of awareness through distribution of electronic material to target groups and maintenance of social network accounts

1.2 Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

The work performed so far followed the initial plan and executed the corresponding activities of four work packages. Apart from WP1, which is concerned with Project Management activities and WP6 that comprises Dissemination, Communication and Exploitation tasks, two core work packages were also executed, fully or in part, namely WP2 - New software process for developing and operating distributed applications and WP3 - Metrics and Measurement activities.

WP2 was involved with studying the software process and the phases of a life-cycle model for a DevOps oriented software development approach of distributed systems and services. During this WP, 4 different site-visits were organized and performed to POLIMI, 3 to UvT (2 on premises and 1 to Greece participating to a summer school with lectures organized by UvT and delivered by various faculty members and researchers of universities worldwide, including UvT's team - 10th Symposium and Summer School on Service-Oriented Computing, http://www.2016.summersoc.eu/). The CUT team numbered 3-5 persons on average in each visit comprising faculty, master and PhD students, and senior researchers. During these visits members of the leading institutions delivered talks and lectures, discussion and brainstorming sessions were held, and essentially knowledge and research expertise was transferred on a

number of different scientific topics, such as, distributed software services or applications, DevOps principles, activities and workflows, and communication and organizational structure in DevOps environments. In addition, CUT was able to meet and discuss opportunities of collaboration with local stakeholders in the Netherlands and in Cyprus.

WP3 deals with a framework for Metrics and Measurements of the Cloud environment. In this context 2 site visits were organized to POLIMI and 1 to UvT, with a total of 13 people attending. During the visits to Milan the CUT team had the chance to attend exhibitions and study the POLIMI's Cloud infrastructure. In Tilburg groups from CUT and UvT had the chance to meet with people from the province of North Brabant and discuss about future collaboration in the field of smart agriculture and livestock production. A series of talks and lectures were again delivered by members of the leading institutions to CUT, while discussion and brainstorming sessions were held, which led to creating a new research capacity on a number of different scientific topics, such as distributed systems, Cloud computing environment, service delivery and transition to Microservices;

The collaboration between the partners of the Dossier project so far has resulted in the preparation and submission of two H2020 proposals for funding and the expansion of CUT's network of collaborators to other European countries and centers of research excellence. The first one was submitted under the pillar Spreading Excellence and Widening Participation, Teaming Phase 1, while the second under Co-Creation for Growth and Inclusion. Both proposals include a number of significant institutions like LIRIS/CNRS from France, Fraunhofer Institute for Industrial Engineering from Germany and the Universitat Politècnica de Catalunya. In addition, two papers are currently being prepared as a result of research efforts in the areas of DevOps oriented Software Engineering and the migration of traditional monolithic software to a set of interacting microservices.

Finally, WP6 dealt with Dissemination, Communication and Exploitation activities, which were structured around two main axes, digital presence (web site and accounts on social networks), and organization of stakeholders open days or meetings in each of the partner counties.

1.3 Progress beyond the state of the art, expected results until the end of the project and potential impacts (including the socio-economic impact and the wider societal implications of the project so far)

DOSSIER-Cloud aspires to investigate new areas in distributed software development with emphasis on software engineering, DevOps and automations. We currently investigate two subjects that will potentially lead to publications: (i) Definition of research challenges on DevOps oriented Software Engineering; (ii) Substitution of monolithic software development with the use of microservices. Other research areas have also been identified, which will be pursued at later stages, such as automatic Cloud resource management, where we will employ recommender systems based on machine learning and optimization algorithms to guide the provision of resources (servers, VMs) so that demand is properly served according to SLAs and energy consumption is lowered. Finally, we are investigating pricing schemes for Cloud services provision and team organization structures for distributed systems development.

DOSSIER -Cloud is expected to have a high socio-economic impact. Industrial and market stakeholders (e.g. software solution developers, cloud service providers and vendors, etc.) will increase productivity, reduce development effort/cost, and improve quality of software services and applications. So far the consortium has managed to attract interest among specific groups of stakeholders in the participating countries and investigate collaboration with medium to large companies from various disciplines (e.g. light equipment manufacturers,

automotive industry, agricultural and livestock production, shipping and finance) concerning methodologies and tools for distributed software services development and delivery, as well as smart data processing. In addition, one software development SME in Cyprus has agreed to become a living case-study for migrating its systems (CRM, time and attendance, personnel management) to the Cloud utilizing concepts and methodologies resulted by the project.

Project Number: 692251

Project Acronym: DOSSIER-Cloud

Project title: DEVOPS-BASED SOFTWARE ENGINEERING FOR THE CLOUD

Periodic Technical Report

Part B

Period covered by the report: from 01/01/2016 to 31/03/2017

Periodic report: 1st

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

1.1 Objectives

DOSSIER-Cloud revolves around three main objectives:

Objective#1: Acquire new and enhance existing knowledge on a set of research topics of interest that revolve around DevOps oriented software engineering processes and tools for distributed software systems development.

Objective#2: Share research experiences and best practices with advanced scientific groups in the leading institutions. Change the research culture and scientific approach/philosophy of CUT's staff.

Objective#3: Form a collaboration basis with stakeholders and secure industrial involvement. Engage SMEs and practitioners to facilitate real-world experimentation and validation using real world feedback.

The above objectives are closely related and intertwined, with a variety of actions being performed during the reporting period to achieve them, each action serving one or more objectives. These actions involved:

- Exchanging personnel and performing site visits to the leading institutions: A total of eleven (11) site visits were performed so far, six (6) to POLIMI and four (4) to UvT, while one (1) site visit was performed to Crete, Greece in the context of an international symposium and summer school organized by UvT. Thirteen (13) people from the CUT team – faculty, researchers/post-docs, PhD candidates, graduate (master) and undergraduate (final year BSc) students – participated in these site visits. Each site visit lasted from three (3) to seven (7) days depending on the availability of the hosting institutions, the maturity of the research areas investigated and the progression of the relevant brainstorming and discussion sessions.
- Organizing one (1) summer school in Cyprus and one (1) workshop in Italy with closed sessions dedicated only for the partners, as well as open sessions with industrial participation.
- Organizing meetings with stakeholders, either one on one, or in groups. Presentation of the scope and objectives of the project and discussion/brainstorming on specific areas of future collaboration, definition of industrial or market problems for applied research and formation of a network of collaborators. These activities also enabled show-casing DevOps benefits using real-world examples from SMEs worldwide and inviting local SMEs to join DOSSIER-Cloud. Specifically, in Italy three (3) stakeholders were involved in such activities, in the Netherlands five (5) and in Cyprus eleven (11). Therefore, a total of nineteen (19) companies/organizations were contacted thus far and the objectives of the project, as well as the potential of future collaboration with them, were discussed during these meetings. We provide more relevant details later in this document.
- Delivering special purpose/theme lectures and offering training on specific research methods and tools developed and used by members of UvT and POLIMI. The topics were aligned with the Key Knowledge Areas described in the DoA, but were also extended to cover new and emerging topics that were considered state of the art and were related to new, significant challenges in the broader scientific area of Cloud Computing (e.g. smart data processing, systems of deep insight, microservices, etc.). A total of above eighty (80) talks and presentations were prepared and delivered so far.
- Applying step-by-step problem solving techniques in joint, small-scale projects. Tutoring and mentoring offered by members of the leading institutions to people of CUT,

contributing to the development of a new collaborative research culture for CUT. Discussions and brainstorming between the partners on specific scientific topics in the areas of interest allowed the consortium identify new research challenges to be addressed. More specifically:

- o **Social Software Engineering**
  - Modeling and analysis of the organizational and social structures of teams aiming at investigating their impact on the software process for Cloud services
  - Improvement of teams' organizational and social structure targeting at optimizing the software process by decreasing waste (time, effort, code)
  - Definition and analysis of the optimal organizational structure for DevOps strategies that results in a framework/guideline for better organizational configuration setups
- o **Cloud Pricing**
  - Development of solutions for optimizing pricing policies
  - Focus on supporting Cloud providers to offer an attractive pricing scheme to their customers targeting to maximize their profit, while at the same time taking into account their services cost and market competition
- o **Cloud Resource Management**
  - Proposition of a dedicated group of services that support resource management on the Cloud (workload prediction, dynamic provisioning, automatic resource management)
  - Utilization of CI/AI techniques to address Cloud optimization problems (e.g. workload prediction and balancing, management of physical or virtual resources, and others)
- o **Self-Adaptive Systems for the Cloud**
  - Evolution and enhancement of MAPE (Monitor-Analyze-Planning-Execute) control loops to deal with complex scenarios of Cloud services and/or resource management by replacing conventional techniques (e.g. control theory) with Computational Intelligence / Artificial Intelligence models.
  - Development of recommendation systems for automatic software services/microservices synthesis

Small groups with specific research focus have been formed to examine each of the aforementioned challenges and to start investigating the relevant subjects in more depth targeting at producing high quality and publishable research outcomes.

- Gaining hands-on experience on the Cloud infrastructure premises of one of the leading institutions (POLIMI) through presentations, analysis and guided tours delivered to members of CUT.
- Continuous raising of awareness by distribution of electronic newsletters or leaflets to targeted groups, frequent update of the project's web-site with material concerning the activities carried out, as well as maintenance of social network accounts for direct communication with people interested in DOSSIER-Cloud.

1.2 Explanation of the work carried per WP

To meet its objectives, the work in DOSSIER-Cloud is organized in six work packages: One (1) for management (WP1), three (3) for strengthening the scientific knowledge of CUT to tackle the research targets in the corresponding areas described in detail in section 1.1.3 of the DoA (WP2 through WP4), one (1) for engaging practitioners and extending the community basis to facilitate future piloting and extensive experimentation with synthetic data and real-world

case studies (WP5), and, lastly, one (1) for dissemination and exploitation of results (WP6). The current report involves activities only for work packages 1, 2, 3, and 6.

Table 1 lists the people from each of the participating institutions that took part in the activities of the first fifteen (15) months of the project, while the number of trips performed, either for site-visits or workshop and summer-schools, is given in square brackets.

Table 1. Human resources of each partner institution that took part in the activities of the project and their corresponding trips

HUMAN RESOURCES			
No	CUT [#trips]	POLIMI [#trips]	UvT [#trips]
1	Prof. Andreas Andreou [5]	Prof. Carlo Ghezzi [1]	Prof. Mike Papazoglou [2]
2	Prof. Sotirios Chatzis [4]	Prof. Luciano Baresi [1]	Prof. Willem Jan van den Heuvel [2]
3	Dr. Constantinos Stylianou [7]	Prof. Ardagna Danilo [0]	Prof. Arian van den Born [1]
4	Andreas Christoforou (PhD cand.) [8]	Prof. Raffaela Mirandola [0]	Dr. Indika Kumara [0]
5	Panayiotis Christodoulou (PhD cand.) [3]	Prof. Sam Guinea [0]	
6	Charalambos Partaourides (PhD cand.) [1]	Dr. Clement Qinton [0]	
7	Marios Athanasiou (master stud.) [1]	Dr. Srjdan Krstic [1]	
8	Kyriaki Antoniou (master stud.) [2]		
9	Adonis Podinas (master stud.) [2]		
10	Dimitris Christodoulou (master stud.) [2]		
11	Maria Papachristodoulou (master stud.) [1]		
12	Sotiris Vasou (undergrad stud.) [2]		
13	Lambros Odysseos (undergrad stud.) [1]		
	Total CUT trips = 41	Total POLIMI trips = 3	Total UvT trips = 5

1.2.1 Work Package 1 - Project Management [January 2016 – end of project]

WP1 comprises the management activities for the smooth operation of the project. During the first fifteen (15) months of execution the activities performed were concerned with the coordination between the partners to achieve the project objectives, meet the research targets and exchange knowledge and expertise within the time plan and the requested budget. In addition, PM tasks were devoted to preserving high quality of the final results of the activities of the rest WPs and of their deliverables through adherence to quality and risk management plans. In this context, a Project Handbook was prepared and delivered describing the roles and responsibilities of the management of the project, the planning and control of the quality of the delivery of knowledge, the communication, effort and cost management plan and the risk management plan.

The leader of this WP is CUT. All project partners were involved in the project management processes and activities. Financial and other administrative issues were addressed, such as the

coordination and organization of site visits, workshops, schools and meetings of the project, the delivery of reports and other documents on time, and the establishment of a financial plan to coordinate the submission of the costs and control payments.

Project management meetings were regularly held during the site visits, in which two partners were physically present (CUT and the host institution) and the third one participated through teleconferencing. In addition, such meetings were also held during the workshop organized in Italy and the summer-school. Virtual meetings for project management were also conducted usually through Skype whenever there were issues that necessitated discussion and decision making, mostly for planning and organizing site visits, as well as for performing follow-ups on research ideas or subjects that were addressed during these visits. Finally, another project management meeting with presence from all partners was held after the first quarter of the first year. This frequent communication enabled better planning of joint events, tackling difficulties in the smooth progression of the project, handling potential risks and maximizing the transfer of knowledge between the partners.

The deliverables produced thus far for this WP are D1.1: Project Handbook, Quality Plan & Risk Management, and the present periodic report (D1.2: Periodic Reports, mid-report)

1.2.2 Work package 2 - New software process for developing and operating distributed applications [February 2016 – August 2016]

This aim of this WP was to create a solid scientific background on methods to accelerate and control the software process for the development and deployment of distributed applications. The process is based on DevOps which promotes cooperation between development and operations (maintenance & support) teams. In this context, the classic software engineering approach consisting of a life-cycle model, the people that execute its stages and the tools they use, was reviewed and assessed for possible revision where necessary. In this context, specific activities were addressed so that a new life-cycle model may be proposed at the end of the project, which will be used as the backbone of a DevOps-oriented production of distributed software applications that will offer elasticity, efficient change management and rapid deployment.

The leader of this WP was UvT, the team of which has extensive research experience with software engineering (SE) methodologies for distributed services. POLIMI worked closely with UvT, contributing to all actions for transferring knowledge to CUT complementing with its expertise the particular topics of interest.

The actions performed are summarized to the following:
- Execution of site visits from CUT members to POLIMI and UvT: A series of site visits were performed in the period February 2016 – July 2016 to the two leading institutions. More specifically, an average of three to four (3-4) people from CUT visited POLIMI four (4) times and UvT three (3). During these visits members of the leading institutions prepared training material/presentations and delivered talks/lectures to the people from CUT, held discussion and brainstorming sessions, and essentially managed to transfer knowledge and research expertise on a number of different scientific topics: Distributed software services or applications; Distributed software life-cycle methodology; DevOps principles, activities and workflows towards continuous delivery and deployment on the Cloud; Communication and organizational structure in DevOps environments; Discovery of open source tools and available Cloud offerings; Efficient Cloud resource management aiming to minimum energy consumption, and minimum cost; QoS assurance.

- Participation to a summer-school co-organized by UvT: Members of CUT participated to a summer school with lectures organized by UvT and delivered by various faculty members and researchers of universities worldwide including UvT's team (10th Symposium and Summer School on Service-Oriented Computing, June 26 – July 1, 2016 in Crete, Greece, http://www.2016.summersoc.eu/).
- Organization of a closed workshop (i.e. partners only sessions) in Milan, mid-April of 2016. During this workshop the partners were able to sum-up the results of the project thus far and focus on specific research challenges identified during the site visits to POLIMI. Follow-up discussions on potential papers were performed, initiated by researchers from CUT and backed-up by the corresponding members of POLIMI and UvT.
- Organization of a summer-school in two parts (mini-schools) on Cloud Computing and Software Services were organized in Cyprus at the CUT's premises. The mini-schools included project meetings, lectures by senior researches from POLIMI and UvT, a stakeholders meeting, and a closed workshop. Analytically:
  - During the 1st mini-school (September 2016) researchers from POLIMI delivered lectures to audiences consisted of undergraduate and graduate students at the dept. of Electrical Engineering / Computer Engineering and Informatics of CUT, as well as members of the academic staff. Throughout the stakeholders' meeting and workshop, the DOSSIER-cloud project was presented to various representatives from the Cypriot market industry, and the public sector.
  - The activities of WP2 were completed with the 2nd mini-school (October 2016) which followed the same structure and organization with the 1st mini-school. During the 2nd mini-school senior researchers and academics from UvT delivered talks on relevant topics of the project and discussed with CUT's faculty members, researchers, graduate and undergraduate students issues related to distributed systems, service oriented computing, Internet of Things (IoT) and smart data processing. Also, one-on-one meetings with various local stakeholders were held offering the opportunity to members of the DOSSIER-Cloud consortium to present ideas for future collaboration with public authorities, as well as industrial and market stakeholders in Cyprus.

Apart from the above, the meetings between the partners facilitated the exchange of ideas and brainstorming for the preparation of proposals to attract additional EU and national funding. In this context, two new HORIZON-2020 proposals were prepared: The first one is called ARTEMIS and was submitted under the pillar Spreading Excellence and Widening Participation, WIDESPREAD-04-2017: Teaming Phase 1 call, which is closely related to the DOSSIER-Cloud project. The second proposal is called GEODESIC and was submitted under Co-Creation for Growth and Inclusion. A brief presentation of the two proposals follows:

A. The SmARt DaTa and SystEMs of Deep InSight for Sustainable Development (ARTEMIS) consortium will provide a unique, invaluable contribution to the pursuit of excellence in Cyprus' research and innovation system. It will establish an outward looking Centre of Excellence by launching a high concentration of outstanding cutting-edge research in the fast-growing area of Smart Data, Services & Applications that is vital for Cyprus' and Europe's competitiveness. ARTEMIS boasts an impressive partnership of 4 leading European research institutions that together with Cyprus Univ. of Technology will conduct ground-breaking research and push the frontiers of knowledge in Smart Data by converting raw data into valuable insights leading to smarter decisions, increased automation, performance improvement and substantial cost savings. The ARTEMIS business plan will ensure that it will deliver new discoveries that are crucial to Cyprus and the region's knowledge base and innovative capacity, creating the scientific

breakthroughs essential to propel an agglomeration of high-tech industrial activity and attract funding. ARTEMIS will be properly embedded with the regional and national structures of Cyprus and become part of its "innovation system" by targeting squarely its Smart Specialization Strategy. Research in ARTEMIS will be embedded in priority sectorial specialization areas such as tourism, healthcare, shipping and food industry for sustainable development to generate broader social and economic benefits. This is expected to attract international collaborations and top talent, and lead to successful partnerships with government and local industry encouraging greater investment and job creation. ARTEMIS targets at progressively becoming financially autonomous by following a well-defined, realistic business plan comprising analysis of the potential markets, financial planning of the Centre and market strategy for the introduction of the products and services it will deliver. The consortium consists of seven partners: the three partners in DOSSIER-Cloud (CUT, POLIMI and UvT) and, additionally, the Laboratoire d'InfoRmatique en Image et Systèmes d'information / CNRS from France, the Fraunhofer Institute for Industrial Engineering from Germany, and the Cyprus Chamber of Commerce and Industry.

B. The codesiGn and cocrEation Of Demand-drivEn Smart publIc serviCes (GEODESIC) project proposes an open Platform approach comprising both technology and market behaviour. The open collaboration and innovation digital Platform in GEODESIC provides a single point of access to shared digital services through an innovative, on-line scalable Shared Services Marketplace. The inclusion of digital Marketplace functionality in the heart of open platforms offers increased market choice to drive both innovation and convergence on cheaper, higher quality, standard "utility" public services. Using the GEODESIC open Platform, public agencies act as an intermediary: orchestrating participants, facilitating collaboration, connecting people and providers, and ultimately, overseeing public service delivery models that will advance beyond the public services we know today. The digital Marketplace offers automated facilities for service registration, storage, discovery, delivery, and procurement, and supports both the demand side (i.e., citizens and stakeholders who search among public offerings) as well as the supply side (i.e., developer stakeholders that furnish public services). Using a digital collaboration and innovation platform, public agencies transform static, siloed public service models into more flexible and agile digitally powered structures by detailed meta-data descriptions of their services electronically through the Marketplace, providing thus stakeholders with a wide range of options and allowing them to select their preference. Stakeholders, such as public agencies, citizens, NGOs, private companies and entrepreneurs, can then query, retrieve, inspect and select digital service descriptions stored in the Shared Services Marketplace or design new services. They can then collaborate and innovate by joint participation (either planned or opportunistic) in the co-design, aggregation, co-creation and delivery of bespoke services. Once improved value-adding services are stable and have been certified they are stored in the Marketplace and are made available to the wider public. The service meta-data descriptions are done by means of knowledge-intensive modular structures (called public service blueprints) which can be combined with others to create detailed descriptions of value-added service. Blueprint descriptions include functional, performance, quality, physical factors, interoperability, time, service charges if any, etc. The partners of this proposal comprise, apart from CUT and UvT, are the Universitat Politècnica de Catalunya, Software AG, Mathema SRL, 's-Hertogenbosch City Council (Municipality of DenBosch), Global Process and Product Improvement, S.L., Lucentia Lab, Comune Di Patro, Athens University of Economics and Business, Veterinary Services of Cyprus, SEM ISSY MEDIA, INTRASOFT and finally, the DAFNI Network of Sustainable Greek Islands.

This WP was concluded with the production of two deliverables: D2.1: DevOps oriented software engineering training content (talks, lectures, seminars), and D2.2: DevOps oriented software engineering discussions' minutes and notes. In addition, the preparation of a paper on DevOps oriented software engineering challenges and trends has been initiated, which is anticipated to be concluded in the next three to four (3-4) months. It is also worth mentioning that there was a delay of four and a half (4,5) months in completing the tasks of WP2 for the reasons explained in section 5. It should be noted that the corresponding tasks were only one and a half (1,5) months late, but it took three more months to complete the corresponding deliverables. This delay and its roots are analyzed and justified in section 5.

1.2.3 Work package 3 - Metrics and Measurement activities (DevOps oriented, Cloud focused) [October 2016 – February 2017]

The aim of this WP was to facilitate the transfer of knowledge and hands-on expertise on Cloud and distributed software and hardware environment from UvT and POLIMI to CUT members so as to deliver in the future a set of metrics and measurement processes for the development and operation of distributed software services and applications. Each metric will be associated with a certain measurement process. The whole spectrum of parameters within the distributed technical and software environment were examined on-site utilizing mainly the infrastructure of POLIMI, thus gaining also experimental knowledge.

POLIMI leads this WP, putting in practice its research expertise and also the experience gained from its participation to other related EU projects. UvT is actively involved in the tasks of WP3 assisting POLIMI to define and deliver knowledge to CUT on the relevant Key Knowledge Areas.

Specific activities involved the following:
- As in the case of WP2, this work package consists of a series of site visits to POLIMI and UvT. An average of four to five (4-5) people from CUT visited POLIMI two (2) times and UvT one (1) in the period December 2016 – March 2017. During these visits members of the two leading institutions again prepared training material/presentations and delivered talks/lectures to the people from CUT, held discussion and brainstorming sessions, and essentially managed to transfer knowledge and research expertise on a number of different scientific topics: Distributed environment; Cloud computing environment (technical, software); Service delivery environment and transition to Microservices; Definition of standardized metrics; Server side metrics; Client side metrics; DevOps oriented metrics; Integration of metrics and measurement activities; Software Engineering techniques for big data and distributed environments.
- Hands-on experience was developed on the Cloud infrastructure of one of the leading institutions. Specifically, members of POLIMI delivered presentations, demonstrations and guided tours to members of CUT in which POLIMI's Cloud infrastructure was analyzed and described in depth during a site-visit at the end of February beginning of March 2017. These activities analyzed the Cloud equipment, network protocols and software services that support both research groups and the general university population of POLIMI, while they also enabled the participants to touch upon issues of collecting metrics and integrating the technical infrastructure of CUT and POLIMI to facilitate further research activities.

The activities of this WP have just been concluded (end of May 2017) and not in February 2017 as a result of the delay caused by the reasons explained in section 5 and the decision of the partners to move some tasks later than the start time defined in the Gantt chart. As a result, the workshop that was supposed to take place in Cyprus in February 2017 was moved and has been executed in the period May 15-17, 2017. Consequently, the deliverables D3.1: DevOps

metrics and measurements training content (talks, lectures, seminars) and D3.2: DevOps metrics and measurements discussions' minutes and notes, which were due end of February 2017, were also late as they needed to include material from the workshop as well. The deliverables were submitted end of May 2017.

The overall delay of this WP is of the order of three (3) months, which, as already mentioned, has originally started from WP2 and continued with the tasks of WP3. It is anticipated that the overall delay experienced thus far will be fully absorbed by the end of 2017.

1.2.4 Work package 6 - Dissemination, Communication and Exploitation [January 2016 – end of project]

This WP is involved with publishing and sharing the activities, objectives and results of the project with the larger community of Cloud computing, stakeholders and other sectors of the society that can benefit from this project. So far its activities include the development of the project's web-site (http://www.dossier-cloud.eu), the establishment of social network accounts (Facebook - https://www.facebook.com/dossiercloud/ and Twitter - https://twitter.com/dossiercloud) and the production of several dissemination and exploitation newsletters and leaflets through which public and private stakeholders were informed about project activities, events, workshops and summer schools.

CUT acts as the leader of this WP, directing the efforts of the consortium to disseminate the results of the project to other researchers and the broader scientific community, as well as to practitioners. UvT and POLIMI work closely with CUT to further disseminate and exploit the outcomes of the project, targeting mostly the local practitioners.

CUT, with the help of the leading institutions, was able to promote the project to different stakeholders in the three participating countries. The following groups of stakeholders were identified and targeted for interaction:

- IT industry, including software solution developers, business analysts, cloud enablers, cloud service vendors, cloud service providers and SMEs.
- User companies and specific industry verticals in tourism, shipping, finance and agriculture
- Research Community, Organizations and Institutes.
- Public bodies (water management board, military, secondary general education) and policy makers.

DOSSIER-Cloud considers tourism and shipping as two of the main smart specialization strategy pillars of Cyprus that could be benefitted by this project. Additional collaboration has been sought and initiated with one local SME that produces software catering to the needs of local companies conducting business in the former domain, while at the same time brainstorming sessions have started with two major shipping companies in Cyprus. All of the above stakeholders have a vision of moving their business, or parts of it, to the Cloud, to offer their clients faster and more efficient services, and/or to exploit the benefits of smart data processing. It also became evident that Cloud service provision and systems of smart data processing & analytics have a lot of significant financial and business benefits to offer to these business domains thus contributing to

- improving their competitiveness through proven feasibility and impact to move the results into downstream RTD and innovation
- creating new methods, tools and applications of technology supported management of tourism and shipping business processes which in turn open new opportunities for

further business development (e.g. continuous process improvement, automatic deployment, forecasting of shipping indices, optimization of routes for saving fuel and lowering emissions, etc).

Members of the DOSSIER-Cloud consortium managed to meet and discuss opportunities for collaboration with local stakeholders that are interested in partnerships with academia to solve problems through applied research. Nineteen (19) companies/organisations were contacted thus far and the objectives of the project, as well as the potential of future collaboration were discussed with them. Among these stakeholders were: In Cyprus, SingularLogic, Betologic, Amdocs, Exertus Services, Interfusion, Logisoft, the Water Board of Limassol, Cyprus Hotel Association, Cyprus Institute of Neurology and Genetics, Climate-KIC and Lemissoler shipping. In Italy, AICA, Aipsi and ClubTi. In the Netherlands, the Municipality of DenBosch, Philips Lighting Research, Advertisement – Uden, Crossyn and VIVAT.

A total of four (4) leaflets and newsletters have been produced and distributed so far mainly during the events organized (workshops and summer-school), as well as the one-on-one meetings with the stakeholders.

Overall, thirteen (13) stakeholders meetings were organized during the first fifteen (15) months of the project: Six (6) in Cyprus – one (1) formal and five (5) informal, one (1) in Italy - formal, and six (6) in the Netherlands - two (2) formal and four (4) informal (formal corresponds to events organized - workshops/summer-school - while informal denotes a one-on-one meeting).

1.3 Impact

1.3.1 Expected impacts
The overall impact of the project is twofold:

 (i) <u>Scientific and research.</u> Improvement of CUT's research capacity, productivity and visibility, as well as increase of significance of research outcomes and enhancement of network of collaborators.
 (ii) <u>Industrial and market.</u> Formation of a stakeholder's collaboration basis and establishment of direct communication channels with practitioners. Recording of practical problems and challenges of the software industry and market that will facilitate applied research. The ultimate goal is to offer methodologies and tools that will increase developer productivity, reduce development effort/cost, and improve quality of software services and applications.

CUT, as the low RDI performing institution, has already started strengthening its scientific knowledge and expertise, which is anticipated to lead to improving its research position by increasing the number of high quality published research papers in the relevant fields. As already mentioned in section 1.1, four areas of research have been identified and research collaboration has been initiated on several topics aiming at producing papers to submit to journals with high impact factors, as well as conferences with high reputation. More specifically, DOSSIER-Cloud's plans as part of its dissemination activities to organize, contribute to and participate in scientific conferences and workshops, such as the International Conference on Software Engineering (ICSE), ACM PODC (Symposium on Principles of Distributed Computing), International Conference on Service Oriented Computing (ICSOC), USENIX Workshop on Hot Topics in Cloud Computing (HotCloud), International Conference on Cloud Computing and Services Science (CLOSER), IEEE Cloud, etc. The consortium has agreed to give more emphasis during the first two years of the project on knowledge transfer between the leading institutions and CUT, as well as the identification of research areas with significant topics and challenges to address, while joint investigation and

production of papers will be performed in the last year. In the meantime, the participation and/or organization of conference tracks or workshops will also be pursued.

In the above context two workshop proposals have been prepared and submitted by members of the consortium; both of them have been accepted:

The first one is in the context of the 23rd ICE/IEEE International Conference on Engineering Technology and Innovation (http://www.ice-conference.org/Home.aspx) which will be held in Madeira, Portugal in June 2017. The workshop is entitled "Smart Data Systems and Applications" and will be involved with systems and services that offer smart processing on a distributed environment like the Cloud and beyond, according to the newest trends on big and smart data processing in a variety of scientific disciplines, like manufacturing, health, transportation, etc. (http://www.ice-conference.org/My-Files/Workshop_W1-14.aspx). The workshop is expected to foster discussions and brainstorming on future trends in smart data systems and applications and will bring together academics/researchers and industrial stakeholders, practitioners and experts, aiming at forming a network of collaborators that will promote applied research and enable the formation of consortia for submitting new proposals for funding.

The second workshop is submitted to ICSOC, the International Conference on Service-Oriented Computing (http://www.icsoc.spilab.es/), which will be held in Malaga, Spain, and is the premier international forum for academics, industry researchers, developers, and practitioners to report and share groundbreaking work in service-oriented computing. The workshop is entitled "Engineering Services Oriented Applications and Cloud Services (WESOACS - http://www.icsoc.spilab.es/call-for-workshop-papers/)" and focuses on core software engineering issues in the context of service-oriented systems, keeping pace with emerging application areas of service computing that include mobile, social and cloud computing. WESOACS encourages radically new approaches that address the challenges that arise from the unique characteristics of service-oriented applications, focusing on principles, methodologies and tools that support service-oriented System Development Life Cycle (SLDC) and DevOps-oriented software development.

DOSSIER-Cloud has offered CUT the potential to increase its networking capabilities for future joint research and submission of proposals for further funding. The collaboration with the leading institutions created the opportunity to meet and discuss with other research groups from universities and organizations in Europe, such as the University of Amsterdam, Technical University of Eindhoven, University of Gent, Fraunhoffer Germany, LIRIS/CNRS France, Universitat Politècnica de Catalunya and CSIRO Australia. As a result of the collaboration between the partners of DOSSIER-Cloud and the networking activities, two new proposals were prepared and submitted, as already described extensively in section 1.2.2 and work package 2. The first one is called ARTEMIS and was submitted under the pillar Spreading Excellence and Widening Participation, WIDESPREAD-04-2017: Teaming Phase 1 call, which is closely related to the DOSSIER-Cloud project. The consortium consists of seven partners: the three partners in DOSSIER-Cloud (CUT, POLIMI and UvT) and, additionally, the Laboratoire d'InfoRmatique en Image et Systèmes d'information / CNRS from France, the Fraunhofer Institute for Industrial Engineering from Germany, and the Cyprus Chamber of Commerce and Industry. The second one is called GEODESIC and was submitted under the call Co-Creation for Growth and Inclusion. The partners of this proposal comprise, apart from CUT and UvT, The Universitat Politècnica de Catalunya, Software AG, Mathema SRL, 's-Hertogenbosch City Council (Municipality of DenBosch), Global Process and Product Improvement, S.L., Lucentia Lab, Comune Di Patro, Athens University of Economics and Business, Veterinary Services of Cyprus, SEM ISSY MEDIA, INTRASOFT and finally, the DAFNI Network of Sustainable Greek Islands.

In addition, the CUT team was introduced to local organizations and companies in the Netherlands, such as the Municipality of DenBosch and Philips Lighting, and presented part of its research work thus far, discussing also the possibility of collaboration for applying it to practical problems faced by these stakeholders (e.g. modeling and scenario analysis, automations, smart data processing, etc.)

During the stakeholders meetings that were performed in the participating countries, either in groups (i.e. workshops), or one-on-one with SMEs or other organizations, the members of the DOSSIER-Cloud consortium emphasized on the improvements in software development productivity brought in by embracing DevOps and automations. The participants acknowledged the value of this approach and the fact that it creates the potentials to

- respond more quickly to business priorities by reducing the time needed to deploy new applications using self-service provisioning and policy-based automation;
- enhance productivity and reduce development effort with an integrated application lifecycle management solution to avoid the pitfalls of working in silos with broken communication, which results in project delays, low quality or budget overrun;
- increase visibility and traceability throughout all aspects of an integrated application life-cycle management solution;
- better manage distributed software development at global level;
- reduce business risk and improve predictability of software development outcomes as a result of standardizing and better controlling software development through rigorous well-defined processes, and compliance using automation to maintain configuration and security policies.

Based on the above, the expected impacts were fully materialized to the level allowed by the time period of the first fifteen (15) months of the project.

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

There is no need to update the plan for exploitation and dissemination of the results as described in the DoA. During the execution of the project some dissemination events (e.g. stakeholders' meetings) were moved earlier or later than the date planned to secure maximum availability of the stakeholders and comply with the busy schedule of the leading institutions.

3. Update of the data management plan (if applicable)

There is no need to update the data management or the knowledge protection plan described in the DoA.

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

Not applicable.

5. Deviations from Annex 1 and Annex 2 (if applicable)

5.1 Tasks

Some deviations were observed as regards the execution date of certain activities or tasks according to the project's schedule. More specifically, delays were experienced for work packages 2 and 3, which were attributed on one hand to the busy schedule of the senior personnel in the leading institutions and on the other to the differences in the start-end dates of the teaching semesters and the relevant exams periods of the participating universities. More specifically:

- Having on board world class and renowned researchers and scholars like professors Carlo Ghezzi and Mike Papazoglou, with many obligations in delivering keynote lectures worldwide, or participating in scientific conferences/workshops, or performing meetings in other on-going EU projects, made the task of finding suitable dates for performing the joint events, that is, site visits, workshops and the summer-school, quite difficult.
- As mentioned above, the three universities follow different schedules for their teaching, something that contributed to the difficulty in finding commonly suitable dates for the project's activities, especially the organization of site-visits, workshops and the summer school. More specifically, CUT starts early its two teaching semesters, in September and January respectively, with exams taking place in December for the Fall semester and May for the Spring semester, while UvT and POLIMI start their semesters approximately one month later. Therefore the most suitable periods for the participating institutions differed, and the partners put substantial effort to reach to commonly acceptable time periods so that preparations for the events could also be serviced.

Both issues were identified from the beginning and were raised by the coordinator in the very first physical and virtual meetings, being acknowledged by all partners as project management issues that deserved particular attention. Nevertheless, the commitment of all partners and their willingness to resolve them by proposing alternative dates for the joint events or for breaking up these events into two parts and participating in both (e.g. summer-school organized in Cyprus in the period September-October 2016), one with physical presence and one with virtual (i.e. through teleconferencing means), did not allow these issues to threaten the quality of the end-result. Consciously and unanimously, the members of the consortium decided to allow for a small delay in performing the aforementioned activities so as to intensify senior involvement in the first half of the project and maximize the participation of key personnel by giving them more time and flexibility to respond to all their obligations, inside and outside the project. Therefore, up until now a total delay of three (3) months has been recorded, which originally started from WP2 with four and a half (4.5) months but was significantly reduced along the execution of WP3 by parallelizing the production of the deliverables of WP2 with the tasks of WP3. The consortium was continuously trying to control and minimize this delay as much as possible by swapping site visits to the two leading institutions based on the availability of their personnel. It is anticipated that the delay will be diminished and fully absorbed by the end of 2017 as there are upcoming activities with gaps (slack-time) that will be shortened without compromising the corresponding objectives or milestones.

5.2 Use of resources

Medium to small differences were observed in terms of the effort devoted to each work package and the associated budget spent as opposed to the original plan. Table 2 summarizes the effort planned in the DoA and the corresponding overall amount of effort devoted by the personnel of each partner to execute the tasks of the work packages involved in this periodic management report covering the first fifteen (15) months of the project's duration. It should be noted that WP1 and WP6 span the whole project duration and therefore only part of them is executed during the time period related to the review report, while WP3, as already mentioned, is three (3) months behind schedule and therefore effort is yet to be put beyond the last month included in the review, that is, March 2017.

Table 2. Summary of the planned vs actual staff effort (in man-months) for the work packages included in the first management report (figures in column "Planned" correspond to the total effort per work package, while those in "Actual" only to the reporting period)

WP	CUT		POLIMI		UvT	
	Planned	Actual	Planned	Actual	Planned	Actual
WP1	2,00	0,83	0,25	0,08	0,25	0,13
WP2	10,00	10,00	3,00	4,77	3,00	3,43
WP3	5,00	4,25	3,25	2,93	3,25	1,26
WP6	3,50	1,46	0,25	0,08	0,25	0,10
TOTALS	**20,50**	**16,54**	**6,75**	**7,87**	**6,75**	**4,92**
Notes: (1) Effort for CUT is not charged in personnel costs (2) WP1 and WP6 span 36 months						

The deviations observed can be summarized and justified as follows:
POLIMI spent approximately one (1) month more than originally planned and this was due to the fact that a lot of synergies were identified in WP2 which resulted in a plethora of potential research subjects that could possibly be investigated jointly with CUT. Therefore, it was considered useful to devote as much time as needed to explore deeply the corresponding areas identified. It is expected that less effort will be devoted in the next work packages to account for the excess month. Nevertheless, in case the number of new areas for joint research that will be identified during the upcoming WPs is also rich, POLIMI is willing to continue working with CUT pursuing common research targets without charging the project. POLIMI has spent €5.000 more on personnel than expected due to this extra man-month put in the project (planned €39.300, spent €44.300).

UvT has devoted 4,92 man-months instead of 6,75 compared to the plan due to mediating circumstances that will be explained below. The majority of the activities supported by UvT was concentrated more on creating and extending the network of CUT collaborators and also on initiating activities for writing new proposals to attract funding in the future (H2020 proposals ARTEMIS and GEODESIC – see section 1.2.2), as well as preparatory activities for submitting workshop proposals in international conferences (see section 1.3.1). Given that there were research areas under investigation with POLIMI that started according to the work-plan earlier, UvT gave less emphasis and consequently devoted less time to research teams where considerable progress was made. UvT identified additional cutting areas of research that were agreed upon (e.g. smart data and applications), which will be investigated thoroughly in the remaining project time. To this end, it was necessary that the involvement

of the senior UvT personnel was intensified so as to prepare the ground for expanding CUT's visibility by introducing its team to networks of collaborators and stakeholders, as well as presenting new research themes. Therefore, during the period covered by this report, almost exclusively senior academics (only full professors) from UvT worked on the project, something which also increased considerably the budget spent thus far. UvT has surpassed the planned budget by approximately €20.000 (planned €40.300, spent €59.900), while it is anticipated that with the involvement of the junior personnel (i.e. researchers, post-docs, PhD candidates) in the remaining twenty one (21) months of the project the overall budget spending will match the planned one.

Finally, the list of resources foreseen in the DoA has slightly been altered since the beginning of the project: CUT's team was enhanced by five (5) more persons and changed by one (1); POLIMI's team was enhanced by two (2) more persons and changed by one (1); finally, UvT's team was enhanced by one (1) more person and changed by one (1). It should also be mentioned that approximately one year after the initiation of the project prof. Carlo Ghezzi retired and he is no longer part of POLIMI's team, although he collaborates with us externally and on a voluntarily basis. Coordination of POLIMI's activities is now undertaken by prof. Luciano Baresi who was also member of the original team. Overall, the size, quality and diversity (in terms of skills, expertise and experience) of the participating human resources enhanced the capacity and effectiveness of the consortium compared to what was originally planned, something which contributes to increasing the outcomes and the benefits of the project.

Travelling evolves as planned with only minor adjustments not worthy of mentioning. Similarly, the budget for other costs is spent as planned. Therefore, there is nothing more here to report on these resources.

QUESTIONNAIRE ANNEXED TO PART B OF THE PERIODIC REPORT
H2020-TWINN-2015

First Reporting Period Review

1. How has the Twinning exercise so far, helped to raise the research profile of the coordinating institution within the country and abroad?

In the first 15 months of the project the Twinning exercise

- Has contributed towards introducing the coordinating institution to new, hot and quite promising research areas in terms of challenges and potential innovation
- Has established new collaborations between CUT and people within the leading institutions and beyond (i.e. collaborators and networks of the leading institutions)
- Has promoted the establishment of collaborations with local stakeholders that are interested in exploiting the benefits of DevOps, Cloud computing and smart data processing.

2. How has the Twinning exercise so far, helped to raise the research excellence of the coordinating institution in the chosen field of research?

The research excellence of CUT is expected to rise significantly in the scientific areas of DevOps, distributed software systems and Cloud computing compared to the period prior to the Twinning exercise. Several areas of research have already been identified and work has already started towards tackling specific research challenges (see section 1.1). It is anticipated that by the end of the project several high quality papers will be produced and published to esteemed journals and conferences in the areas of interest. Up until now no papers have been produced as the consortium agreed to focus and spend the first two years on transferring knowledge, experience and best research practices from the leading institutions to the widening, and materialize these efforts during the last year of the project.

3. Have you seen so far a leap forward in terms of reputation, attractiveness and opening of new networks of the coordinating institution as a result of the Twinning exercise?

So far new opportunities have been opened through the collaboration of the coordinator with the leading institutions. CUT's team of researchers was introduced to multiple groups of people within the leading countries, either inside or outside each of the two universities, but also beyond these, being able to reach to other countries and researchers that belong to the network of collaborators of the leading institutions. Examples of such groups are the University of Amsterdam, the Technical University of Eindhoven, the University of Gent in Belgium, the Laboratoire d'InfoRmatique en Image et Systèmes d'information / CNRS from France, the Fraunhofer Institute for Industrial Engineering in Germany Fraunhoffer Germany, the LIRIS/CNRS France, Universitat Politècnica de Catalunya, CSIRO Australia. 's-Hertogenbosch City Council (Municipality of DenBosch), etc. (please refer to section 1.3.1). The opportunity to collaborate with different groups of researchers with established research record worldwide provided the ability to CUT promote different research ideas and the chance to prove its potentials and capacity in conducting high quality research.

4. Has there been an improvement in terms of being able to attract more competitive

research funding (national/EU/international) by the coordinating institution as a result of the Twinning exercise?

As a result of the collaboration between the partners of DOSSIER-Cloud and the networking activities, two new proposals were prepared and submitted, as already described extensively in section 1.2.2 and work package 2. The first one is called ARTEMIS and was submitted under the pillar Spreading Excellence and Widening Participation, WIDESPREAD-04-2017: Teaming Phase 1 call, which is closely related to the DOSSIER-Cloud project. The second one is called GEODESIC and was submitted under Co-Creation for Growth and Inclusion. In addition, the work performed so far in the DOSSIER-Cloud opened new roads for attracting national (EU supported) funding and it is expected that CUT will pursue such opportunities later this year.

5. How have the non-Widening consortium beneficiaries contributed so far, and how have they been effecting and optimising the low performing partner institutions, in the Widening country?

As clearly and analytically described in section 1, the non-Widening consortium beneficiaries have been effecting and optimising the low performing partner institution by performing the following actions:

- Exchanging personnel and hosting site visits performed by members of CUT to their premises
- Participating and co-organizing scientific events (one summer school in Cyprus and one workshop in Italy.
- Organizing meetings with stakeholders, either one on one, or in groups. Presentation of the scope and objectives of the project and discussion/brainstorming on specific areas of future collaboration, definition of industrial or market problems for applied research and formation of a network of industrial collaborators.
- Delivering special purpose/theme lectures and offering training on specific research methods and tools developed and used by members of UvT and POLIMI.
- Applying step-by-step problem solving techniques in joint, small-scale projects.
- Tutoring and mentoring offered by members of the leading institutions to people of CUT, contributing to the development of a new collaborative research culture for CUT.
- Formation of small groups with specific research focus to examine specific research challenges and start investigating the relevant subjects in more depth targeting at producing high quality and publishable research outcomes.
- Delivering presentations, analysis and guided tours to members of CUT for gaining hands-on experience on the Cloud infrastructure (POLIMI).
- Contribution to the production and distribution of electronic newsletters or leaflets to targeted groups of researchers and stakeholders.

6. What were the main measures applied during the implementation of the Action so far, which have significantly enhanced the expected impacts of the project (i.e. staff exchanges, experts visits, short-term onsite or visual trainings, workshops, conferences' attendance, organisation of joint summer schools type activities, dissemination, exploitation, outreach activities, etc.)?

The main measure applied during the implementation of DOSSIER-Cloud so far included

the following:

- Exchange of personnel and execution of site visits. A total of six (6) site visits were performed to POLIMI and three (3) to UvT, while one more site visit was performed to Crete, Greece, organized by UvT. Thirteen (13) people from the CUT team participated in these site visits.
- Organizing one summer school (Cyprus) and one workshop (Italy) with closed sessions dedicated only for the partners, as well as open sessions with industrial participation.
- Organizing meetings with stakeholders, either one on one, or in groups. Presentation of the scope and objectives of the project and discussion/brainstorming on specific areas of future collaboration, definition of industrial or market problems for applied research and formation of a network of industrial collaborators. These activities also enabled show-casing DevOps benefits using real-world examples from SMEs worldwide and inviting local SMEs to join DOSSIER-Cloud. Specifically, in Italy three (3) stakeholders were involved in such activities, in the Netherlands five (5) and in Cyprus eleven (11). Therefore, a total of nineteen (19) companies/organisations were contacted and the objectives of the project, as well as the potential of future collaboration with them, were discussed during these meetings.
- Delivery of special purpose/theme lectures and training on specific research methods and tools developed and used by members of UvT and POLIMI (topics aligned with the Key Knowledge Areas described in the DoA, and also extended to cover new and emerging topics that were considered state of the art and were related to new, significant challenges in the broader scientific area of Cloud Computing - e.g. smart data processing, systems of deep insight, microservices, etc.). A total of more than eighty (80) talks and presentations were delivered so far.
- Gaining hands-on experience on the Cloud infrastructure premises of one of the leading institutions through presentations, analysis and guided tours to members of CUT.
- Distribution of electronic newsletters or leaflets to targeted groups, frequent update of the project's web-site with material concerning the activities carried out, as well as maintenance of social network accounts for direct communication with people interested in DOSSIER-Cloud. A total of four (4) leaflets and newsletters were produced and distributed so far mainly during the events organized (workshops and summer-school), as well as the one-on-one meetings with the stakeholders.

7. Any other aspects/points that you would like to communicate to the European Commission? Any particular difficulties or benefits at a consortium level?

None.