Research by Experimentation
for Dependability on the
Internet of Things

D-5.1 – Report on 1st year cooperation, dissemination and joint activities

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Abstract This deliverable presents concrete dissemination and exploitation efforts of the project within the first year of the project. Dissemination includes the completion of the RELYonIT website, the publication of several conference papers and posters, as well as a number of invited presentations of the project to external stakeholders, the scientific community, and the general public. The industrial partners worked on identifying the right receiving organizations and obtaining requirements from them to understand and align with their strategic development agenda to ensure future exploitation of the project results. In addition, coordination with related research projects and research units was started and the academic partners could use the work done in RELYonIT in lectures and seminars.

Disclaimer

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Executive Summary

This document summarizes all efforts with respect to dissemination and exploitation done by the consortium as a whole and by the individual partners within the first year of the project. On the dissemination side, we can report the completion of the RELYonIT website, the publication of four conference papers and two conference posters as well as a number of invited presentations of the project to external stakeholders and at internal events. Due to the early stage of the project, first results but mostly our innovative approach was presented externally. Substantial media attention was received in several press articles. Regarding exploitation, the industrial partners mainly worked on identifying the right receiving organizations within their companies, obtaining requirements from them and trying to understand and align with their strategic development agenda. Coordination with related research projects and research units was started. The academic partners could use the work done in RELYonIT in various lectures and seminars.

1 Introduction

This deliverable reports on all dissemination, exploitation, and joint activities of the first twelve months of the project RELYonIT. Specifically, the report covers dissemination activities (publications, invited talks, web portal, project leaflet, publicity); exploitation activities (business models, strategies, transfer opportunities, specific activities); and joint activities (among the members of the RELYonIT project and with external partners and projects).

2 Dissemination

Starting from the very beginning of the project, project goals and results were disseminated to industry, academia, and the general public whenever possible through a number of different means. The following sections describe different levels of dissemination activities for promoting the wide adoption of our research and technology.

2.1 Project Website

The RELYonIT website is reachable at the URL `http://www.relyonit.eu`. It provides relevant information about the project, its goals, ongoing work and of course all public results achieved. The web site is continuously updated in order to provide news regarding issues of importance for the project and its partners, such as awards that project partners have received. The project coordinator UZL/TUG has delivered the website in accordance with the time plan. Figure 2.1 gives an impression.

2.2 Project Fact Sheet

The RELYonIT project fact sheet provides a brief overview of the project, its goals, its structure, and planned work. In addition it includes relevant contact details to allow interested people to initiate further communication. The fact sheet was distributed at several events, such as the Future Internet Assembly in Dublin (see Sec. 4.2.2). Figure 2.2 gives an impression.

2.3 Publications

A significant number of RELYonIT-related papers has been published at conferences and workshops. This includes leading conferences in our research area, such as the IEEE/ACM International Conference on Information Processing in Sensor Networks (IPSN) or the IEEE Real-Time Systems Symposium (RTSS).

- UZL, TUD, and SICS published a joint paper titled "JAG: Reliable and Predictable Wireless Agreement under External Radio Interference" [2] at the *33rd IEEE Real-Time Systems Symposium (RTSS)*. The paper presents a novel MAC layer mechanism that employs targeted jamming to ensure agreement with probabilistic guarantees even under external interference.
- UZL published a poster abstract titled "Non-invasive Measurement of Core Body Temperature in Marathon Runners" [3] at the *10th European Conference on Wireless Sensor Networks (EWSN)*. The poster presents a body sensor network to record core body

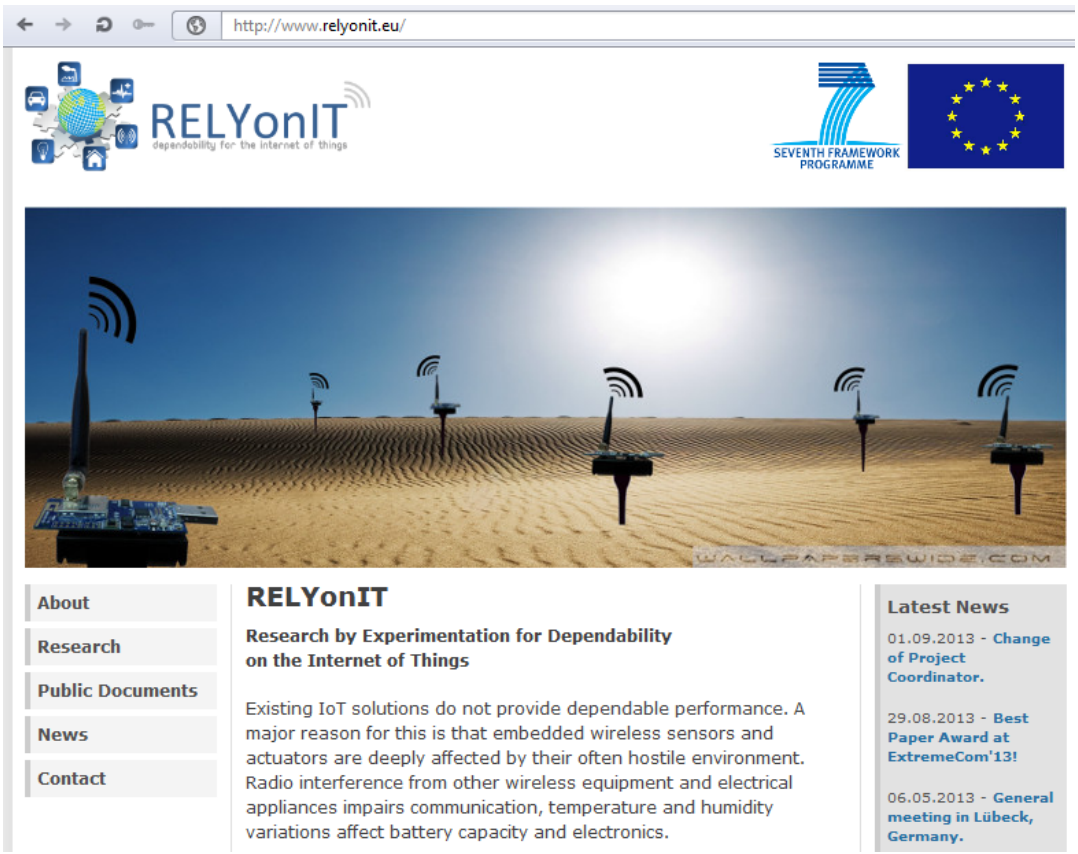


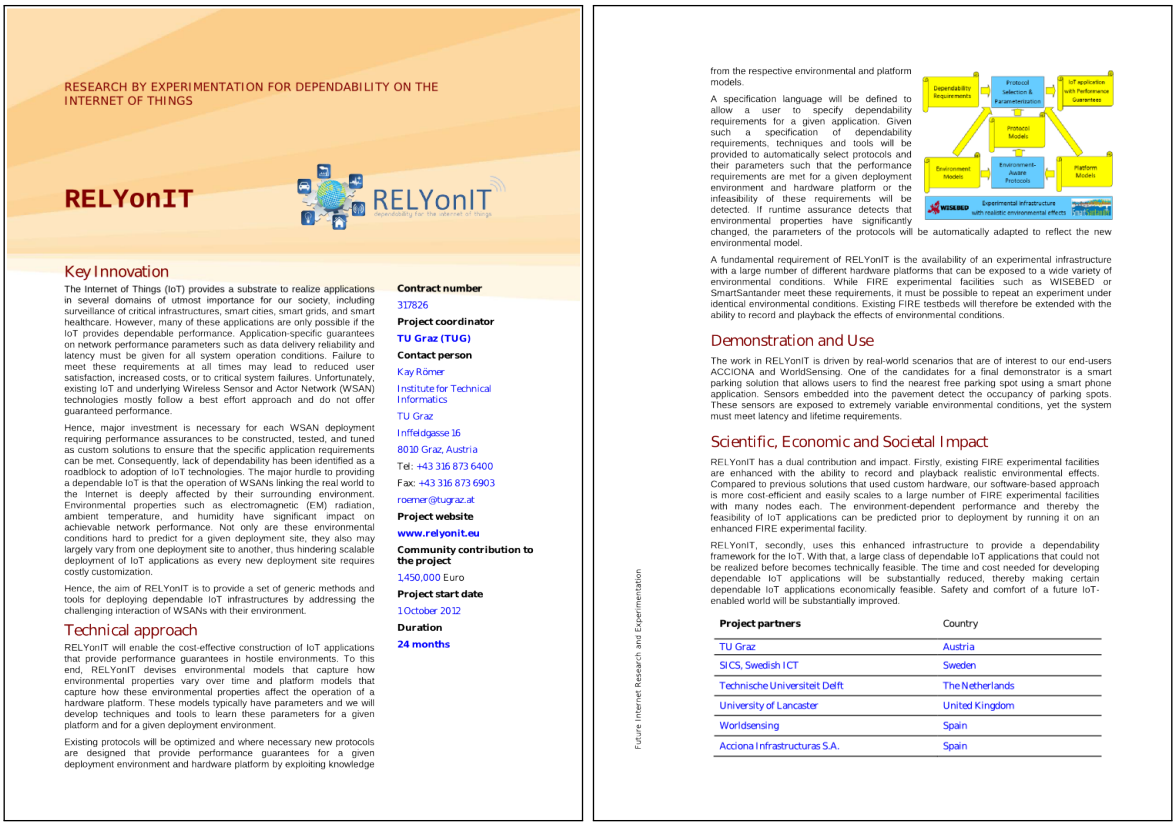
Figure 2.1: The RELYonIT Website at www.relyonit.eu.

temperature in Marathon runners and aims to understand the impact of environmental temperature on the measurement accuracy. The poster was the **best poster runner-up** at the conference.

- SICS published a joint paper with the university of Uppsala titled "SoNIC: classifying interference in 802.15.4 sensor networks" [7] at the *12th IEEE/ACM International Conference on Information Processing in Sensor Networks (IPSN)*. The paper presents a system to classify sources of interference. It was the **best paper runner-up** at the conference.

- UZL published a paper titled "Non-invasive Measurement of Core Body Temperature in Marathon Runners" [4] at the *10th International Conference on Wearable and Implantable Body Sensor Networks (BSN)*. This paper is an extended version of the poster abstract presented at EWSN 2013.

- UZL, ULANC, TUD, and SICS published a joint paper with the university of Uppsala titled "Hot Packets: A Systematic Evaluation of the Effect of Temperature on Low Power Wireless Transceivers" [5] at the *5th Extreme Conference on Communication (ExtremeCom)*. The paper investigated the effect of temperature on low power communication



RESEARCH BY EXPERIMENTATION FOR DEPENDABILITY ON THE INTERNET OF THINGS

RELYonIT

RELYonIT

Key Innovation

The Internet of Things (IoT) provides a substrate to realize applications in several domains of utmost importance for our society, including surveillance of critical infrastructures, smart cities, smart grids, and smart healthcare. However, many of these applications are only possible if the IoT provides dependable performance. Application-specific guarantees on network performance parameters such as data delivery reliability and latency must be given for all system operation conditions. Failure to meet these requirements at all times may lead to reduced user satisfaction, increased costs, or to critical system failures. Unfortunately, existing IoT and underlying Wireless Sensor and Actor Network (WSAN) technologies mostly follow a best effort approach and do not offer guaranteed performance.

Hence, major investment is necessary for each WSAN deployment requiring performance assurances to be constructed, tested, and tuned as custom solutions to ensure that the specific application requirements can be met. Consequently, lack of dependability has been identified as a roadblock to adoption of IoT technologies. The major hurdle to providing a dependable IoT is that the operation of WSANs linking the real world to the Internet is deeply affected by their surrounding environment. Environmental properties such as electromagnetic (EM) radiation, ambient temperature, and humidity have significant impact on achievable network performance. Not only are these environmental conditions hard to predict for a given deployment site, they also may largely vary from one deployment site to another, thus hindering scalable deployment of IoT applications as every new deployment site requires costly customization.

Hence, the aim of RELYonIT is to provide a set of generic methods and tools for deploying dependable IoT infrastructures by addressing the challenging interaction of WSANs with their environment.

Technical approach

RELYonIT will enable the cost-effective construction of IoT applications that provide performance guarantees in hostile environments. To this end, RELYonIT devises environmental models that capture how environmental properties vary over time and platform models that capture how these environmental properties affect the operation of a hardware platform. These models typically have parameters and we will develop techniques and tools to learn these parameters for a given platform and for a given deployment environment.

Existing protocols will be optimized and where necessary new protocols are designed that provide performance guarantees for a given deployment environment and hardware platform by exploiting knowledge

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www.relyonit.eu
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1 October 2012
Duration
24 months

from the respective environmental and platform models.

A specification language will be defined to allow a user to specify dependability requirements for a given application. Given such a specification of dependability requirements, techniques and tools will be provided to automatically select protocols and their parameters such that the performance requirements are met for a given deployment environment and hardware platform or the infeasibility of these requirements will be detected. If runtime assurance detects that environmental properties have significantly changed, the parameters of the protocols will be automatically adapted to reflect the new environmental model.

A fundamental requirement of RELYonIT is the availability of an experimental infrastructure with a large number of different hardware platforms that can be exposed to a wide variety of environmental conditions. While FIRE experimental facilities such as WISEBED or SmartSantander meet these requirements, it must be possible to repeat an experiment under identical environmental conditions. Existing FIRE testbeds will therefore be extended with the ability to record and playback the effects of environmental conditions.

Demonstration and Use

The work in RELYonIT is driven by real-world scenarios that are of interest to our end-users ACCIONA and WorldSensing. One of the candidates for a final demonstrator is a smart parking solution that allows users to find the nearest free parking spot using a smart phone application. Sensors embedded into the pavement detect the occupancy of parking spots. These sensors are exposed to extremely variable environmental conditions, yet the system must meet latency and lifetime requirements.

Scientific, Economic and Societal Impact

RELYonIT has a dual contribution and impact. Firstly, existing FIRE experimental facilities are enhanced with the ability to record and playback realistic environmental effects. Compared to previous solutions that used custom hardware, our software-based approach is more cost-efficient and easily scales to a large number of FIRE experimental facilities with many nodes each. The environment-dependent performance and thereby the feasibility of IoT applications can be predicted prior to deployment by running it on an enhanced FIRE experimental facility.

RELYonIT, secondly, uses this enhanced infrastructure to provide a dependability framework for the IoT. With that, a large class of dependable IoT applications that could not be realized before becomes technically feasible. The time and cost needed for developing dependable IoT applications will be substantially reduced, thereby making certain dependable IoT applications economically feasible. Safety and comfort of a future IoT-enabled world will be substantially improved.

Project partners	Country
TU Graz	Austria
SICS, Swedish ICT	Sweden
Technische Universiteit Delft	The Netherlands
University of Lancaster	United Kingdom
Worldsensing	Spain
Acciona Infrastructuras S.A.	Spain

Future Internet Research and Experimentation

Figure 2.2: The RELYonIT Fact Sheet.

used in WSN. It won the **best paper award** at the event (see Fig. 2.3).

- UZL and SICS await the publication of a poster abstract titled "Temperature Hints for Sensornet Routing" [10] at the *11th ACM Conference on Embedded Networked Sensor Systems (SenSys)* in November 2013. In the poster abstract, temperature effects on the routing layer are analyzed, finding that temperature fluctuations may cause undesirable. Furthermore, an approach to make these protocols robust to temperature fluctuations by augmenting the ETX link metric with temperature hints is presented.
- ULANC awaits the publication of an accepted article "Constructing Schedules for Time-Critical Data Delivery in Wireless Sensor Networks" [13] in the *ACM Transactions on Sensor Networks* (TOSN) in August 2014. The paper addresses the problem of finding the best TDMA schedule for industrial process automation and control applications which can support delay and reliability requirements within an environment subject to interference.

2.4 Presentations

In addition to the publication of papers and posters at scientific conferences and workshops, the project partners also used the opportunity to introduce the project goals and results as

Figure 2.3: Best paper award for the paper "Hot Packets: A Systematic Evaluation of the Effect of Temperature on Low Power Wireless Transceivers" [5] at the *5th Extreme Conference on Communication (ExtremeCom)*.

part of invited talks and presentations.

- WOS presented RELYonIT as part of a presentation at the *Internet of Things and Smart Cities PhD School*, which took place on September 16–20, 2013 in Lerici, Italy. Mischa Dohler spoke about the Internet of Things vision and future directions while Màrius Montón's speech was focused on application scenarios and real-world deployments for the Internet of Things and Smart Cities. The event was organized by Parma Univeristy and European Project Calipso. It was attended by 40 PhD students.
- SICS presented RELYonIT by means of a poster "RELYonIT: Research by Experimentation for Dependability on the Internet of Things" during the *SICS open house* event with about 300 participants in March 2013.
- UZL gave an invited talk about "Dependable Sensor Networks for Medical Applications" in front of 40 participants of the *Localization and Sensing Symposium* at the University of Twente in April 2013.
- UZL gave an invited talk about "Dependable Sensor Networks for Medical Applications" in front of 20 participants of the *Embedded Software Seminar* at TU Delft in November 2012.
- UZL presented RELYonIT by means of an invited talk about "Mitigating the Impact of the Environment in Wireless Sensor Networks" during the *Cyber-Physical Systems Workshop* at the TU Graz with about 40 participants in March 2013.

2.5 Publicity

In addition to the previously outlined efforts to disseminate RELYonIT ideas to the scientific community, the project also made some effort to inform the general public about project goals,

ideas, and results. Press releases are also a way to arouse the interest of potential future users in industry. During the first year, the RELYonIT project attracted attention in the following media:

- At project start, University of Lübeck issued a press release titled "Verlässliche Werkzeuge für das Internet der Dinge" [14] that introduces the main goals of the project.
- Another press release about Future Internet Research by Lancaster University in English language also mentions RELYonIT [11].
- The project was also mentioned in *I&U-Nachrichten* of IHK Braunschweig [9].
- In February 2013, RELYonIT was mentioned in the German national newspaper *DIE WELT* as part of the article "Wenn der Mähdrescher mit dem Trekker spricht" [17].
- The information technology fair CeBIT mentioned RELYonIT as an example for Internet of Things related research in Germany [6] and indicated the IoT as one of the trend topics in 2013.
- In March 2013, the project was mentioned in the German *New Scientist* newspaper as part if the article "Smart Cities: Deine Stadt spricht zu Dir!" [15].
- *IBM insider* published an interview about RELYonIT with Prof. Dr. Kay Römer [8].
- In September 2013, the online magazine *HL-live.de* published an article about RELYonIT and the Internet of Things [18].
- A project report on RELYonIT was published by SICS in the SICS Annual Report 2012–2013 [16].

2.6 Organization of Events

Conferences and Workshops provide an adequate platform for the presentation of novel findings, techniques, and their application in theory and practice. These international events are commonly organized by universities and also create valuable opportunities for researchers from academia and industry to get in touch and exchange ideas or discuss visions. In the context of IoT topics, two workshops with a RELYonIT-related focus have been organized or supported by RELYonIT members – with more to come.

- In March 2013, ULANC organized the *5th Intl. Workshop on Performance Control in Wireless Sensor Networks* (PWSN) with focus on methods, protocols and tools to construct sensor networks with deterministic performance.
- In September 2013, SICS, TUD, ULANC, and UZL organized the *5th Intl. Workshop on Real-World Wireless Sensor Networks* (RealWSN) with focus on on real-world deployments and performance of sensor networks.

In addition, project partners participated in the organization of a number of major WSN and IoT conferences and workshops:

- Representatives of TUD and SICS supported the *10th ACM Conference on Embedded Networked Sensor Systems* (SenSys) 2012 as program co-chairs and committee members.
- Representatives of TUD, UZL, and SICS supported the *10th European Conference on Wireless Sensor Networks* (EWSN) 2013 in the steering and program committee.
- Representatives of UZL, SICS, and TUD supported the *10th IEEE Intl. Conference on Information Processing in Sensor Networks* (IPSN) 2013 as program co-chairs and program committee members.
- Representatives of SICS, TUD, UZL, and ULANC supported the *9th IEEE Intl. Conference on Distributed Computing in Sensor Systems* (DCOSS) 2013 as program track chairs and program committee members.
- Representatives of TUG and TUD support the *12th IEEE Intl. Conference on Pervasive Computing and Communication* (PerCom) 2014 as vice-technical program chair and program committee members.

2.7 Teaching

RELYonIT related topics were covered in the lectures "Organic Computing" and "Drahtlose Sensornetze" (Wireless Sensor Networks) held at the University of Lübeck, Germany (UZL). The lecture "Organic Computing" took place during the winter term 2012 and is concerned adaptive systems able to adjust to changing environments, user needs, and system structure. The lecture "Drahtlose Sensornetze" (Wireless Sensor Networks) took place during the summer term 2013 and covered a broad range of wireless sensor network topics, including deployments and communication protocols of relevant in the project context.

As part of the "Organic Computing Seminar" at UZL and the "Wireless Sensor Networks" seminar at TUD in the winter term 2012/13, several students gave talks on RELYonIT-related topics like MAC protocols, routing, deployments, and the Future Internet in general.

In the winter term 2013/14, RELYonIT-related topics will also be covered in the lecture "Context-Aware Computing" at TU Graz.

3 Exploitation

In the following section, the industrial partners Worldsensing and ACCIONA present their business model and the related interest in the RELYonIT project results. In addition, both partners describe exploitation activities and explore future internal and external exploitations and transfer opportunities.

3.1 Worldsensing

Worldsensing is a cutting-edge hard, middle, and software company offering complete end-to-end technology and service solutions, which are facilitated by IP-enabled sensors with reliable local wireless and global Internet connectivity. The company was founded in 2008 from private equity, and has grown very quickly into a serious market contender with its Smart Parking product for the emerging Smart City market. Today, it counts on a dozen highly qualified engineers and four experienced executives.

3.1.1 Worldsensing's Business Model

Worldsensing's (WOS, [21]) core business is centered on the development of the smart city and smart transportation market, offering complete end-to-end technology and services on top of ultra low power wireless sensor technology.

WOS' prime product, referred to as FastPrk [20], is targeting the outdoors smart parking market, being it privately owned (such as shopping malls) or public (such as town halls). It addresses the obvious headache of losing a lot of time, money and health by not being able to find a parking spot quickly. It also addresses the enormous traffic problem and occupation optimization in cities improving the street parking management and income optimization due to strict parking enforcement. The technology is composed of sensors, which are installed in each parking spot and which communicate wirelessly with an Internet-enabled gateway to inform about the absence/presence of a car.

The information of available parking spots is made available to the citizen via a smart phone application; and/or via GPS; and/or via panels along the street. The information of citizens not having paid their parking ticket or shooting over allowed time, is signaled to the law enforcement via SMS; and/or email; and/or dedicated smart phone application. Payment is correlated and facilitated by means of integration into the parking meters and/or mobile payment, which addresses 24% of parking infringements.

Latest statistics from IBM reveal that SMEs and spin-offs are surprisingly the major and only constant providers of jobs at European and international levels. Their involvement in the project is hence pivotal for economic stimulus and growth in impacted regions as well as Europe at large. We thus aim to exploit the generated innovation and – importantly – will be able to market these due to the availability of a viable technology platform and the presence of and

contact to important players in the field. The structural arrangement of this project is vital in the development and positioning of SMEs, such as WOS. Acting as ambassadors between more academic innovation and large industries/utilities, our products and services are eventually able to reach the market with a shorter TTM. A close cooperation with large industries also gives us credibility to our product lines and thus sustainability in the longer run, i.e. beyond this project. According to a new report from MarketsandMarkets, a marketing research company, the global smart cities market is expected to top $1 trillion by 2016. Currently, the report estimates the value of the smart cities market at $526.3 billion, with a compound annual growth rate of about 14.2 percent from 2011-2016. Over that time, the smart energy industry is expected to see the largest growth, from $22.9 billion in 2010 to $80.7 billion in 2016, a 28.7 percent compound annual growth rate. The smart transportation and smart security market, where WOS focuses on are also expected to see growth, up to $68.8 billion and $307.2 billion by 2016. According to the report:

"Globally, there are some 700 cities, each with population exceeding 500,000 and are growing faster than the average growth rate of cities. This opens up the market for industry players to grow their business in new and emerging smart cities. The infrastructure investment for these cities is forecasted to be $30 trillion to $40 trillion, cumulatively, over the next 20 years.".

These projections follow along with another report estimating growth in smart cities. Pike Research forecasts that investment in smart city technology infrastructure will total $108 billion during the years from 2010 to 2020. By the end of that period, the cleantech market intelligence firm anticipates that annual spending will reach nearly $16 billion.

The key industry and service sectors for smart cities include Smart Utilities, Intelligent Transports Systems (ITS), Smart Building, and Smart Government. The GIA global strategic business report on the ITS market suggests that global market is projected to reach US $18.5 billion by 2015. Factors such as increase in vehicular traffic across the globe, the socio-environmental and economic implications of traffic congestion and rising emphasis on enhancing road safety, are driving investments in this market worldwide. Additionally, innovation triggered by the need to differentiate product offerings and sturdy demand patterns in developing markets, such as Asia-Pacific and Latin America, are together expected to drive growth in the short to medium term period. As stated by the new market research report on the ITS, the US continues to remain the largest regional market, accounting for a share of almost 40% of global revenue generated. However, growth in the market remains encouraging in developing markets, particularly Asia-Pacific and Latin America. With significant activity in progress in relation to transportation infrastructure in countries such as Brazil, Argentina and Mexico, Latin America holds tremendous opportunities in store for ITS. Similarly, demand for ITS in Asia-Pacific will be driven by rapid infrastructure developments in countries such as China, Australia, New Zealand, Malaysia, Thailand and Korea. Worldsensing focuses on optimizing parking, a cornerstone of ITS, as a key part on smart cities transport management systems. Worldsensing's smart parking solution targets cities above 200.000 inhabitants, shopping malls and outdoor parking spaces. There are more than 200 cities of this size in Europe and more than 100 in the US. Cities like Barcelona or Los Angeles have about 40.000 parking spaces to control. The IBM first-ever Parking Index that ranks the emotional and economic toll of parking in about 20 international cities reveals major problems in a wide range of cities worldwide with many of these cities having identified parking is their biggest headache. The market is hence not only large but also addressable.

3.1.2 General Exploitation Strategy

The RELYonIT project is contributing to increase WOS' expertise in low power autonomous wireless sensor networks and complements WOS' product development strategy by extending the range of scenarios and different climate scenarios where WOS' products can be deployed. RELYonIT also provides the framework to research and receive knowledge transfer that will empower the developments in a mid term future. WOS is using research activities carried out during the project execution to develop innovative solution or at least make use of the innovative concepts developed withing the project, which will undoubtedly strengthen the quality and performance of the company's products. The results will set a stronger basis for WOS products and technologies, and hence impact on the quality and innovation of their future solutions. The WOS business model is supported by a sensing and communication platform focused on offering services addressed to high demanding scenarios (urban, oil and gas as well as civil structure monitoring) specifically addressed to provide innovative solutions for sustainable development, energy efficiency, and improved life quality. In this sense, the project perfectly addresses – from a technological point of view – WOS' business lines requirements.

It is also important to highlight that the synergies achieved in the project are enabling more ambitious developments which will permit to access wider markets and with more ambitious scopes. Moreover, issues addressed in this project will be of great importance to improve interoperability, robustness, ease-of-use, and security of products on the road map of WOS with applications in RELYonIT scenarios. More specifically, exploitation in the context of WOS in RELYonIT is essentially equivalent to achieving a return of investment (ROI) which is typically measured in financial, strategic, branding, and social terms. As for the first, the financial exploitation, the RELYonIT project offers little gains whilst paving the way for subsequent phases where WOS is expected to support large Smart City trials and thus leverage on first returns.

With WOS being part of this project, the cooperation allows us to position and brand us as a company making a significant and viable step towards more sustainable and reliable M2M/WSN/IoT deployments.

3.1.3 Transfer Opportunities

WOS business units are continuously updated with the opportunities offered by the RELYonIT project. Clearly, RELYonIT results can be applied to WOS' Loadsensing business unit. Loadsensing is the line of products designed to wirelessly monitor infrastructure assets like bridges or tunnels where ambient conditions can be extreme and monitoring system reliability is a very important aspect of the overall product.

Periodic internal reports and meetings kept the Loadsensing business unit up-to-date with latest news about the various RELYonIT steps.

Apart, the enhancement on radio communications can also be suitable for another WOS product named SpiderNano. This product is a seismic data acquisition unit with real-time characteristics and high throughput, designed for oil and shell prospecting as well as for civil infrastructure monitoring. These systems are typically deployed in hazardous environments like jungles, deserts or tundra in case of oil prospecting. The product is currently under development, and its engineering team is periodically updated with RELYonIT achievements.

3.1.4 Exploitation Activities

RELYonIT will be of central value to WOS' developments as the project advances exactly along WOS' business portfolio, notably the vertical Smart City market. This allows WOS to sell Smart City hardware solutions (e.g., for smart parking) on the short term, and to resell and co-sell services to the owning company as well as to city administrations on the longer run. With such a solid strategic exploitation, WOS has the potential and vision to cross-link markets to leverage further benefits, such as pollution policies in conjunction with traffic information.

Internal meetings with LoadSensing Business Unit are held periodically. In these meetings RELYonIT achievements and future work is introduced; also discussions about how to get profit for this project are performed.

With this information, the LoadSensing Business Unit is about to start the design of a new line of products, focused on critical hazard monitoring. This topic is based on the necessity of monitoring critical or dangerous infrastructures like oil and gas pipelines or dams. These installations are currently monitored by wired systems, since wireless systems can not yet fulfill their high reliability requirements. Other critical systems deal with the detection of "minor" events typically preceding and announcing major disasters like pipe leakages, wildfire, etc., where an early alarm can prevent far-reaching consequences. Once more, the reliability of the wireless communication is of vital importance. Beyond that, the increased reliability we expect to gain from the RELYonIT project, allows us to even think about products with actuators for responding to the detected events or alarms.

3.2 ACCIONA

ACCIONA Infrastructure is a leading European construction company constructing and managing buildings and civil infrastructures under the sustainability principles. It has an international presence in more than 30 countries employing 15.800 people. In 2010, it had a total turnover of 3,1 billion Euros. It is part of ACCIONA Group, whose business lines are Construction, Real Estate, Urban-Environmental Services, Energy, Logistic and Transport.

3.2.1 ACCIONA's Business Model

The ACCIONA group [1] has three main divisions which are interested in the results from RELYonIT; ACCIONA Infrastructure, ACCIONA Services, and ACCIONA Trasmediterranea.

The activities of ACCIONA Infrastructure are split into two main lines of business: public works and construction. They cover the full range of construction activities, from engineering projects to maintenance services. These projects pay particular attention to environmental, social, and economic factors as a central focus in their activities.

In addition, the division has a number of specialist support units such as metal structures workshops, machinery services, the infrastructure maintenance area, installations or engineering. Not to mention civil works concessions management, roads, highways, railway lines and social infrastructure; the latter includes hospital services and education center concessions. This is where we can use a ventilation-on-demand system intensively. In order to do that, ACCIONA Infrastructure relies on cutting-edge technologies to develop and apply the most advanced materials and the most sustainable construction processes.

The use case in which ACCIONA Infrastructure is most interested is the monitoring of civil structures (see Section 3.2.2). Improvements in this direction would enable to tackle more complex projects, as well as reducing the current costs.

ACCIONA Service is a worldwide services operator for customers from both private and public sector which is based on a business model that is ready to handle any of a range of services simultaneously with any other (Facility Services) and their management (Facility Management). Its business model is to have flexibility when it comes to the management and operation of customers' non-core business.

Today, ACCIONA Service in known as the services partner of choice for the top companies listed on Spain's blue chip stock market index, the Ibex-35, for a number of reasons: more than 45 years experience in service management and execution, a solid, multidisciplinary management team, well-acquainted with international markets, and a workforce of around 12,000 highly qualified employees. ACCIONA Service satisfies the needs of a variety of customers from many sectors regarding a broad range of services, such as cleaning (offices, commercial premises, bank network branches, etc.), ancillary services (help desks, telephone helplines, concierge, reception, etc.), technical support (building maintenance, installations, energy plants, pest control, etc.), energy management (energy efficiency studies, consumption optimization solutions, etc.), environmental care (green-space maintenance, sports facilities, parks and gardens, irrigation systems, environmental monitoring, etc.), urban services (waste management, landfill management, assorted cleaning services, etc.), handling tasks (passenger services, cargo, ticket sales, finger services, etc.), production and design support (events, exhibitions and museums), catering (catering, vending, etc.), and security tasks (security systems installation, surveillance and asset protection), among others.

The revenues from the business grouped in this new division come to a total of 598 million Euros. The average workforce stands at 12,000 employees. The division operates in 11 different countries: Spain, Portugal, Belgium, Holland, Germany, the UK, Italy, Canada, Mexico, Romania and Qatar.

The interests of this section are the use cases Civil Infrastructure Monitoring (see Section 3.2.2) and Ventilation on Demand (see Section 3.2.2). The first use case could enable ACCIONA Service enter new market niches such as monitoring of ancient buildings continuously, the second use case could be applied in hospitals or factories.

Regarding ACCIONA Trasmediterranea, this division has its sights set on transporting people and goods along sea and land routes while adhering to the strictest efficiency requirements. ACCIONA Trasmediterranea is Spain's largest shipping line and one of the leading European maritime carriers of passengers and goods. In 2012, it carried more than 2.6 million passengers, 594,502 vehicles and 5,083,858 linear meters of cargo. Obiously the main interest of this section is on the Condition Based Maintenance use case (see Section 3.2.2), due to the great savings that could be possible if the condition based maintenance on ships becomes an standard in the company. The Ventilation on Demand use case (see Section 3.2.2) could be applied for solving some security issues regarding toxic gases.

3.2.2 General Exploitation Strategy

ACCIONA is a pioneer in the development of sustainable construction projects, an area in which it provides a comprehensive range of services aimed at improving the energy and environmental

efficiency of our customers in an effective and innovative way.

The ACCIONA subdivision of Innovation develops wireless monitoring systems for various areas (monitoring of buildings, energy production plants, manufacturing plants composite, etc.), and would be interested in improving the reliability of such systems.

To accomplish that in the context of this cooperation, ACCIONA would like to achieve, most of all, a higher reliability when using wireless sensor networks in a business environment, of course without losing the technology's versatility. Thus, ACCIONA wants to verify the achieved reliability in various diverse scenarios, e.g., when using WSN installations in different application domains. After confirming the project results, ACCIONA will establish a training team for instructing the installers of these systems based on the results from RELYonIT.

Civil Infrastructure Monitoring Exploitation Strategy

At a first stage of an evaluating setup, ACCIONA plans to use a redundant installation consisting of a traditional gauge wired monitoring system accompanied by a new wireless sensor network. Then, ACCIONA will compare the results of both systems and will decide if it is possible to rely on a WSN (using RELYonIT results) for doing the task. If the WSN approach shows to be feasible, this fact can lower monitoring cost by up to 30%. In addition it could also be possible to take into account new factors to be monitored; especially in places which are hard to reach with wires.

Taking these considerations into account, it is possible to say that ACCIONA will probably find new market niches in monitoring ancient structures. ACCIONA has sufficient expertise for being quite competitive in this field. This kind of business is based on the opportunity, so the goal is being ready for the chance in case it appears.

Condition-Based Maintenance Exploitation Strategy

Condition-based maintenance can enable significant savings in energy (thanks to improvements in spare part logistics) and money (due to a reduction of holding time). In addition, it is possible to increase the efficiency of the machinery and to reduce the need for periodic maintenance.

ACCIONA hopes that, using RELYonIT achievements, the deployment and application of sensors in heavy machines can be accomplished with much more confidence than ever before. This is the main issue that determines the usability of WSN inside heavy machinery. If the system succeeds in this, ACCIONA will create an expert team for implementing the WSN solution with RELYonIT performance levels inside its vessels, and, as a natural consequence of the possible success, also in their heavy factories. This expert team will be teached by the envisioned team introduced in Section 3.2.2.

Currently the main focus of interest for ACCIONA in the development of condition-based maintenance is on their ship engines. Nevertheless, the opportunity for also improving other heavy machinery involved in almost all industrial processes is so high (and tempting) that it is going to be studied if having a specialized team in general condition based maintenance is a better idea than having one team just for vessels. ACCIONA has heavy industry involved in several of its activities such as large construction machines, manufacturing processes of wind turbine blades, recycling factories, etc. Heavy machinery is part of its core business.

Ventilation on Demand Exploitation Strategy

It is proven that a ventilation on demand system can save up to 30% of the energy wasted in HVAC. Other attempts for using WSN as control system for such systems (with cost savings in hardware and development) have been made, but there is always a lack of confidence in the communications reliability that traditionals WSN offers. The RELYonIT framework is going to give more chances for using the WSN approach, given that it will provide confidence in the network behavior.

If it is possible to improve the performance of current systems without losing their reliability, it would be possible to study the use of WSN for supporting ventilation on demand in places administered by ACCIONA, such as hospitals, recycling factories, wineries, etc.

3.2.3 Transfer Opportunities

The ACCIONA group companies with a need for the monitoring of environmental variables and/or re-acting on events automatically, will be informed about the opportunities offered by RELYonIT. Most probably, the framework results can be applied by ACCIONA Services, ACCIONA Infrastructures, and ACCIONA Trasmediterranea.

A team will be established to teach the resulting procedures and techniques from the project framework regarding the reliable use of WSN installations. This team should be able to support the various ACCIONA divisions if these face related problems.

Civil Infrastructure Monitoring

The division ACCIONA Infrastructure also focuses on civil infrastructure monitoring. Due to the expected impact of the underlying technologies, and the new opportunities that will hopefully arise from this cooperation, some of the civil engineers working on related construction sites will be teached by the newly established team.

One of the teams that is expected to be beneficiary from this technology is the tunneling machines expert team. This kind of construction demands for a very careful monitoring due to the always existing risk of terrain movements or collapsing tubes. At tunnel sites, a totally guaranteed system is mandatory. The option for also monitoring, e.g., gas or temperature-humidity conditions endured by workers, could draw an additional benefit from WSN installations.

Condition-Based Maintenance

Using RELYonIT achievements, ACCIONA hopes to collect more maintenance-related data than ever, e.g., in difficult-to-access parts of vessels. Usually the responsible chief engineers are reluctant to the application of different and novel technologies inside their engines, and so it will take a big effort in teaching them a novel methodology that is going to assure a proper (and reliable) sensing inside the vessels. If the system succeeds, ACCIONA will create an expert team for implementing the solution inside its ships as in the previous cases. Yet, this team will be a small one of one or two chief engineers, which will also be responsible for illustrating the benefits of WSN installations inside their engines to the remaining team members.

In case of success, ACCIONA industrial facilities (e.g., recycling factories, construction parts workshop, repair shops for mobile machinery used in construction) will be informed that it

might be possible to use WSN for monitoring some tasks that previously were impossible to be monitored. If the facility responsibles identify a situation that could be handled better using a WSN than a traditional wired system, the expert team created for general purposes could evaluate the viability of using a WSN, having help from the RELYonIT framework for knowing if it is feasible or not.

Ventilation on Demand

While the RELYonIT results would already assure the functionality of the current ventilation systems, the ventilation on demand system using WSN technologies would be even cheaper and easier to use than the current one. ACCIONA will show the benefits of the system to the experts, and, if they evaluate that those benefits are sufficient, seminars will be held to instruct about its use.

3.2.4 Exploitation Activities

The RELYonIT project was introduced to different ACCIONA business units in face to face meetings with the goal of convincing them to adopt this technology in their task:

- ACCIONA Services. Technical staff working on HVAC systems participatated in the meeting. They are interested in using WSNs for controlling the HVAC system. They informed us that it is expected to be the next generation of control systems.
- ACCIONA Trasmediterranea. The meeting brought together a group of researchers of the division interested in the potential of WSN. Their interest comes from the fact that they are currently involved in many projects (Retrofit, Adam4eve, etc.). It is expected that the entire fleet will work with condition based maintenance and, at the same time, the current sensors of the ships (currently more than four thousand signals) will be progressively changed to WSN in a few years, so this division is willing to learn how that goal can be accomplished, with a sepecific interest in reliable solutions.
- ACCIONA Infrastructure. The main conclusion of this meeting was, that they are waiting for a new and cheaper way of monitoring various structures compared to the classical approaches.

As a result of this meeting series it was decided to move ahead with the idea of creating an *expert group* that could be able to teach others how to use WSN efficiently and with reliability. RELYonIT is a fundamental part of this goal, as it can ensure the use of WSN in tasks with enough confidence for being accepted by the staff. In order to acquire that confidence, we need them to acquire technical expertise as well as we also require systems to be reliable enough.

Beyond these company-internal acitivies, responsibles of ACCIONA Infrastructure are in contact with WOS for developing an infrastructure monitoring system based on the WOS product "LoadSensing".

4 Joint Activities

During the first year of the project, the RELYonIT project partners participated in a number of internal and external events. This includes FIRE related activities, such as the Future Internet Assembly 2013 in Dublin.

4.1 Internal Project Meetings

The whole consortium met five times during the first year of the project. These meetings were used to discuss fundamental research issues and for detailed planing of the prevailing work.

4.1.1 Kick-off Meeting in Lübeck

The kick-off meeting took place on October 18, 2012, in Lübeck, Germany (UZL).

After the introductory sessions which fulfilled the task of briefly introducing all participants and presenting the technical overview and the overall goals of RELYonIT, dedicated sessions for all the work packages were organized. The goal of these sessions was to present a concise overview of the work packages, their contribution to the overall project results and the input/output dependencies of the individual work packages. This offered everyone a possibility to clarify and discuss these dependencies and better plan the necessary work towards the individual deliverables. This planning part of each work packages session was then followed by a working session for each work package. The result of these sessions was a clear understanding of the next steps. Based on this discussion a part of the meeting was used to discuss potential use case scenarios which we could use in RELYonIT for demonstrating our results.

4.1.2 Project Meeting in Ghent

The second RELYonIT technical meeting took place on February 12, 2013 in Ghent, Belgium. The meeting was adjacent to the *10^{th} European Conference on Wireless Sensor Networks (EWSN)* (February 13–15, 2013).

The focus of the Ghent meeting were Task 4.1 and Task 4.2. For Task 4.1 possible test bed extensions to enable the emulation of temperature and interference effects were discussed. The discussion of Task 4.2 resulted in a set of features of interest that are of relevance to the scientific partners during the selection of a suitable use case scenario. A number of candidate use cases was presented, including smart parking and civil infrastructure monitoring.

4.1.3 Project Meeting in Lübeck

The third RELYonIT technical meeting took place on May 6, 2013 in Lübeck, Germany (UZL).

This meeting was primarily focused on WP1 and the design of environment and platform models. The general approaches as well as numerous technical details were discussed. In

Table 4.1: Agenda of the First Review Meeting in Brussels

Start		End	Topic
9:00	-	9:15	Welcome (EC, UZL)
9:15	-	9:45	Project Overview (UZL)
9:45	-	10:15	WP4: Use Cases (WOS, ACCIONA)
10:15	-	10:45	WP4: Testbeds incl. Demo (UZL)
10:45	-	11:00	Break
11:00	-	11:30	WP1: Models (TUD)
11:30	-	12:00	WP2: Protocols incl. Demo (ULANC)
12:00	-	13:30	Lunch
13:30	-	14:00	WP3: Specification Language (SICS)
14:00	-	14:30	WP5: Dissemination & Joint Activities (UZL)
14:30	-	15:00	WP6: Management (UZL)
15:00	-	15:30	Reviewer Internal Meeting (EC)
15:30	-	16:00	Feedback to consortium and closing (EC)

addition, early ideas for the requirement specification language were presented. Other topics included the set-up of an experimental infrastructure and a planing of next steps.

4.1.4 First Project Review in Brussels

On June 11, 2013, we had the first review of the project in Brussels. The agenda of the meeting is shown in Table 4.1. On the day before the review meeting, a technical meeting among all project partners was held on the premises of Hanse Office, the representation of the German state of Schleswig-Holstein in Brussels. Besides the preparation of the review, project progress and future work have been discussed.

4.1.5 Teleconferences

In addition to the physical meeting, monthly teleconferences are held where all partners participate. Here, partners report about their progress and discuss next steps.

Further technical teleconferences are held among subsets of partners to discuss technical issues. The following is a list of such technical teleconferences:

- *WP1 phone conference* on March 11, 2013 with participation of UZL, SICS, and ULANC. In the Skype meeting our approach to investigate temperature effects in existing protocols was fleshed out.
- *WP1 phone conference* on March 19, 2013 with participation of UZL, SICS, and ULANC. The Skype meeting continued the work of the previous WP1 phone conference.
- *WP1 phone conference* on April 9, 2013 with participation of UZL, SICS, and ULANC. The call consisted of a discussion of temperature models and the observed temperature impact on the MAC layer.

- *WP4 phone conference* on September 26, 2013 with participation of TUG, SICS, ACCIONA, and WOS. In this meeting, the required changes for a revised version of D-4.1 were discussed.

Please note, that individual calls for technical discussion among smaller groups of participants are not include in the list. During the first year of the project we had more than 50 additional calls to discuss technical aspects of the conducted work.

4.2 Collaborations with External Partners

To supplement the work conducted in the RELYonIT project, we sought cooperation with a number of projects and research institutions.

4.2.1 FIRE Engineering Workshop in Gent

On November 7, 2012 the project was presented by Kay Römer (UZL) as part of the *General issues and networking* session at the Fire Engineering Workshop in Gent, Belgium. During this workshop, all new FIRE projects were presented, leading to a discussion of common interests among the different projects. The talk titled "RELYonIT: Dependability for the Internet of Things (new project presentation)" introduced the central goals and ideas of the project and outlined our approach to tackle those goals.

4.2.2 Future Internet Assembly 2013 in Dublin

From the 8th to the 10th May 2013 UZL participated at the Future Internet Assembly 2013 in Dublin, Ireland to present a project poster (see Fig 4.1) and to distribute the project leaflet. A large number of FIRE projects were present at FIA and representatives visited the poster, leading to discussions and exchange of ideas.

4.2.3 SmartSantander Project

The SmartSantander FIRE project provides an "Internet of Things" experimental facility. RELYonIT collaborates with several members of SmartSantander, specifically with the responsible persons for the individual testbeds in Lübeck, Guildford, and Santander regarding the use of environmental traces collected at those facilities.

4.2.4 EVARILOS Project

The FP7 FIRE STREP EVARILOS investigates the impact of wireless interference on the accuracy of localization algorithms, which requires a testbed infrastructure for generating interference, which is a topic of the RELYonIT project. We are therefore currently investigating the possibility to exchange results and the mutual use of our infrastructure. A physical meeting among the project coordinators has has been scheduled for October 2013.

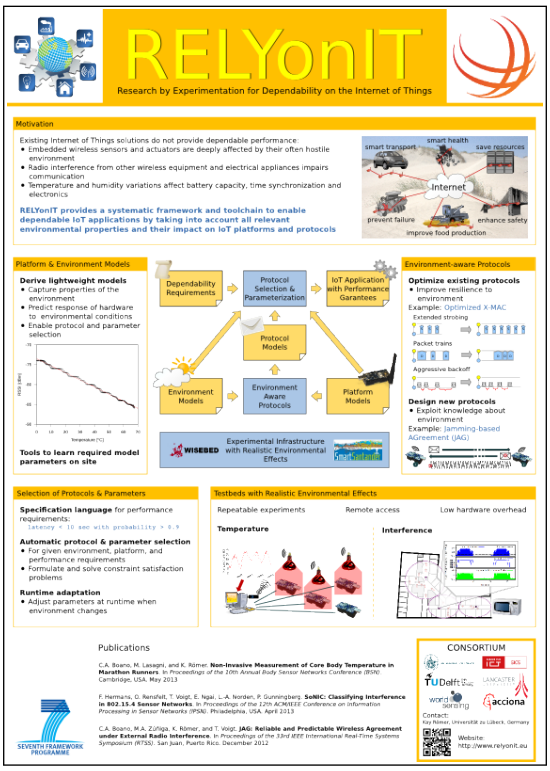

Figure 4.1: RELYonIT poster as presented at the Future Internet Assembly 2013 in Dublin

4.2.5 AmpliFIRE Project

On several occasions, project partners collaborated with the EU FP7 Support Action AmpliFIRE. A description of the project was contributed to the FIRE project booklet summarizing all projects. Information about project partners and standardization activities was contributed to several surveys. Apart, the project coordinator participates in the FIRE engineering board and the workshop on "Shaping Future Internet Research and Experimentation for Horizon 2020".

4.2.6 `make`*Sense* Project

The FP7 STREP `make`*Sense* investigates programming models to simplify the application development of wireless sensor networks. An important component of the `make`*Sense* framework is an extensible high-level macroprogramming language. This macroprogramming language allows to implement a wireless sensor network application without a need to resort to a node-centric view.

Together with partners from this project, we are currently investigating the possibility to augment the `make`*Sense* programming model with a specification for dependability requirements in the context of WP3. Such a combined framework would further reduce the need for the programmer to worry about low-level details, as the selection of suitable components could be handled by the RELYonIT framework, based on an assessment of the expected environment. More details can be found in deliverable D-3.1 [12].

4.2.7 University of Uppsala

A collaboration has been established with Lars-Åke Nordén's group in the Division of Computer Systems of the Department of Information Technology at Uppsala University, Sweden. In particular, close cooperation with Hjalmar Wennerström has been set-up to study the evolution of temperature from a long-term, outdoor deployment of a sensor network comprising 16 TelosB sensor nodes outside Uppsala, Sweden, in an open field isolated from human activity and absence of electromagnetic interference [19]. Novel results have been presented in a research paper that was published at the Extreme Conference on Communication [5] and awarded with the Best Paper Award (see Section 2.3). Furthermore, traces from the outdoor deployment have been used to analyses variations in radio signal strength, as well as to derive analytical models to estimate the temperature profile at a desired location.

4.2.8 University of Trento

Prof. Gian Pietro Picco and Dr. Amy Murphy have extensive experience testing sensor networks on outdoor environments including tunnels, vineyards and forests. The data gathered in these environments contains valuable information about the effects of environmental conditions on the operation of sensor networks. UZL and TUD (from the RELYonIT consortium) have shared the preliminary models and data from our work, and the University of Trento (UTrento) has shared results from their deployments.

The RELYonIT consortium and UTrento are looking forward to foster a relation of mutual interest, where our models and data could better explain the behavior of Utrento's networks in different environments, and where UTrento's variety of settings could be used to enhance the accuracy and extent of our models.

4.2.9 ETH Zurich

Dr. Jan Beutel's lab has a deployment of sensor networks running for several years on the mountains of Switzerland. The deployment consists of five networks with a few tens of nodes each. The goal of this deployment is to provide information for environmental scientists. The data from these networks is publicly available through the Permasense website. Dr. Beutel described to us the API needed to obtain the information from these networks and we are currently data mining their large data sets. We are looking forward to identifying information that may help in the validation or improvement of our models.

4.3 Exchange of Ideas with External Partners

Beyond the research and administrative collaborations with other projects described in the previous section, partners of the project actively approached several other research projects and institutions to introduce the RELYonIT project and to exchange ideas related to the research topics of the project. These interactions are briefly described below.

4.3.1 British Telecom

During a collaboration meeting on 21st February 2013 different aspects of secure and resilient infrastructures were discussed. The ongoing collaboration focuses on different aspects of anomalies and threats to communication and systems infrastructures and how they can be combatted. In this context it was of interest to the industrial partner to compare the specialised environment considered in RELYonIT with the more generic infrastructures currently considered in the collaboration. This is especially so since the RELYonIT scenario can be integrated within the set of services envisaged by BT in a potential portfolio related to our current collaboration project.

4.3.2 India UK Advance Technology Centre of Excellence

A meeting took place between 6th and 8th March at IIT Mandi, India. The IU-ATC project (http://www.iu-atc.com) brings together ten UK universities and seven IIT, as well as a number of major UK and Indian industrial partners to work on different aspects of next generation networks in different environments. This includes sensor networks in challenged areas (such as rural, mountainous locations with spare connectivity) but also high-speed networks connecting commercial Clouds. The research carried out by RELYonIT is of special interest to the work within the IU-ATC Group 1 "Application and Services" and the work packages WP 1 e-Agriculture and WP5 Provisioning and Delivery of Emergency Services. Further, research in Group 2 WP4 on resilient networks is related to work carried out in RELYonIT.

4.3.3 Anglian Water

ULANC together with Anglian Water is looking at the interconnection of pumping stations in the context of wastewater networks. Currently pumping stations make decisions mostly autonomously. The decision making process can be improved by giving pumping stations the ability to communicate. Communication is implemented wirelessly and must be reliable to ensure that correct decisions regarding water flow management are made. In particular, correct decisions have to be made when the system is under stress which is during times of heavy rain. However, exactly in these conditions communication links are subject to harsh environmental conditions and temperature variations are present which have an impact on communication links. Thus, the investigations carried out in RELYonIT are of interest in the context of waste water management.

4.3.4 Arrowhead Project

RELYonIT was presented to the project members of Arrowhead (ARTEMIS call 2012, 77 partners, 67.7 MM€ budget), among them are Airbus, Infineon, and INDRA. The presentations were given in the meeting series that were held in Luleå (Sweden) on September 16, 17 and 18th in their General Assembly (with almost all partners present).

4.3.5 IREEN Project

RELYonIT use cases and requirements were discussed with members of the IREEN project. IREEN examines the ways that ICT for energy efficiency and performance can be extended

beyond individual homes and buildings to the wider context of neighbourhoods and communities, by establishing a common strategy for its members. In that context, RELYonIT results could give us the reliability that we need from the WSN technology, which is very important in order to determine a realistic development plan.

4.3.6 VINN Excellence Center for Wireless Sensor Networks WISENET

RELYonIT was introduced to members of the "Large-scale industrial monitoring and control" project that has a task on robust networking for industrial environments. RELYonIT might be of interest for industrial partners including the Swedish companies Marnatech, Upwis, and SensiNet.

5 Conclusions

In deliverable D-5.1 we summarized all collaboration, dissemination, and exploitation activities conducted in the first year of the RELYonIT project.

The implementation of the dissemination strategy outlined in the description of work enabled the RELYonIT project to receive good visibility within the scientific and industrial community, as well as with the general public. This has been manifested by a significant number of publications at scientific conferences and workshops and by substantial media coverage. Internal and external cooperation activities enabled a fruitful exchanges of ideas and allowed us to secure access to required resources and facilities.

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