

Small or medium-scale focused research project (STREP)

Short proposal

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ICT FET Open Call

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[Combined and Responsive Environmental Sensing Technologies]

[CREST]

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Type of funding scheme: Small or medium-scale focused research project (STREP), short proposal

Work programme topics addressed:

ICT-2011.9.1 Challenging Current Thinking

Proposal Abstract:

The global market for environmental sensing and monitoring technologies is huge, estimated at \$10.1 billion in 2009 and predicted to grow by an annual rate of 5.2% reaching a value of \$13 billion in 2014. City Managers and built-environmental professionals currently rely on a vast array of different technologies and hardware for monitoring a range of different environmental aspects including factors such as air and water quality, noise and lighting levels as well as human and vehicular movement and behaviour. CREST will explore opportunities to bring together such technologies with the aim of increasing energy and cost efficiency in daily environmental monitoring, also facilitating linkages between varying types of sensory information, combining situation awareness of the systems with the long term build up of machine/system learning. Ultimately, CREST will produce technologies used to improve built environmental design and management, with the system also potentially used in other settings. This will be the first such research involving development of an integrated feature in the built environment. CREST has technological novelty centring upon information transmission, energy use and new propagation models developed for wireless signals in the built environment to not include buildings, but for also for the first time, vehicles. Explicitly, this project will (1) produce new hardware solutions combining existing and new sensing technologies (2) facilitate efficient communications for environmental sensing and monitoring equipment (3) facilitate more detailed consideration of synergies between different types of sensory information (4) explore potential for such technologies to facilitate responses to

sensory information (5) Inform related urban policy and decision making at a variety of spatial levels. Furthermore, this project will strengthen the European knowledge base and competitive position in this growing market.

Proposal

Section 1: Scientific and/or technical quality, relevant to the topics addressed by the call

1.1 Targeted breakthrough and its relevance towards a long-term vision

The integration of different forms of environmental sensors and sensory information is the key novelty and targeted breakthrough in terms of technology in this application, with these new technologies supporting better design, monitoring and management of the built environment. This project proposes to bring together different forms of environmental sensing equipment, information, technical knowledge and the needs of the end-users. However, this is not a simple adding together of technologies. Rather, it will involve significant challenges in balancing the accuracy requirements between the various component parts, for example the transmission of the acoustic signal will be very different to that of temperature. The project will also significantly progress the scope of the technology through delivery of new propagation models developed for wireless signals in the built environment and including buildings and also, for the first time, vehicles. This project will produce new integrated sensor technologies and new models by which more resource efficient (energy and people resources), effective and responsive environmental monitoring can be achieved.

The balance between usage of memory and sensor energy supply is an important part of this project investigation, requiring new technologies to be developed. This will also incorporate investigation of the accuracy requirements of such technologies and use of resources in the sense system where the integration of sensors will lead to the simplification of the wireless monitoring process and significantly reduce energy consumption.

1.2 Novelty and foundational character

The ability to detect, measure and respond to a vast array of different environment features via technological means has in recent years, grown exponentially supported by advances in wireless infrastructure, data compatibility and modelling and simulation of a variety of scenarios relevant to modern life. As a result, the built environment today, is home to a plethora of different devices monitoring air, water, sound, temperature, lighting and movement as well as the behaviours of inhabitants, sanctioned or otherwise. Chemical and electronic air quality monitors, systems for measuring sound levels and identifying type of sound signals, and footfall counting cameras are examples of such devices.

Projects such as the RUNES project have considered the role of embedded sensors in a range of applications, whilst the FireGrid consortium, funded by the UK based Technology Strategy Board, has made further progress investigating use of the Grid as a means of more effectively responding to emergency situations. FireGrid both considers use of data collected from sensing equipment in an emergency situation, such as that monitoring temperature and smoke, and explores opportunities to use wirelessly-enabled devices such as sprinkler systems, alarms, fans and ventilation systems as a first means of response.

Concurrently, city managers and built-environmental professionals (including planners, urban designers, architects and engineers) have become increasingly reliant upon environmental sensors as part of their day to day operations and decision-making processes. They draw from data such as CCTV images, pedestrian footfall figures, real-time parking information, noise and air quality figures in both short-term responses through to much longer-term strategic planning. Alike the FireGrid project, technology is increasingly used by such actors to not only collect information, but also facilitate action. This includes older technologies such as audio equipment that enables CCTV camera control operators to speak directly to people in

the street and electronic signage that directs vehicular movement, through to more sophisticated pre-programmed responsive hardware such as sound-enhancing equipment used in Florence, Italy used as a means of masking unwanted noise and improving the overall quality of urban life and experiences.

In recent decades, these same built environment professions have been identified as pre-occupied with visual aesthetics at the expense of other sensory modes by which people can come to know and understand the world. As such, potentially valuable opportunities are being missed to enhance environmental experience and quality of life, ultimately leading to more sustainable towns and cities of the future. One frequently cited reason for such oversights are difficulties faced when attempting to quantify and respond to sensory environmental information. What research has been carried out on sensory experiences of the environment has generally been undertaken within specific professional fields (acoustics, vibration measurement, olfactometry etc.) with studies on sensory interactivity only just starting to emerge. As a result, the vast majority of the different pieces of sensing equipment have each been developed within specific disciplines and for particular purposes. However by focusing upon limited aspects of the environment, it is likely that this has led to biased solutions. Furthermore, without there being an integrated sensor system, no integrated solution will be provided and without this, many technologies will struggle to move forward in significant terms. For example, acousticians will continue to focus upon traditional microphone systems with very high accuracy but expensive and difficult to achieve in terms of what is needed in practice.

CREST sets out to challenge current thinking and seeks to overcome these limitations by facilitating the integration of technologies, increasing synergies between the different types of sensory information and simplify wireless monitoring processes and thus providing opportunities to radically challenge current thinking with regards to each of these currently separate technologies. This has implications both in delivery of more sustainable environments and much wider policy and disciplinary fields.

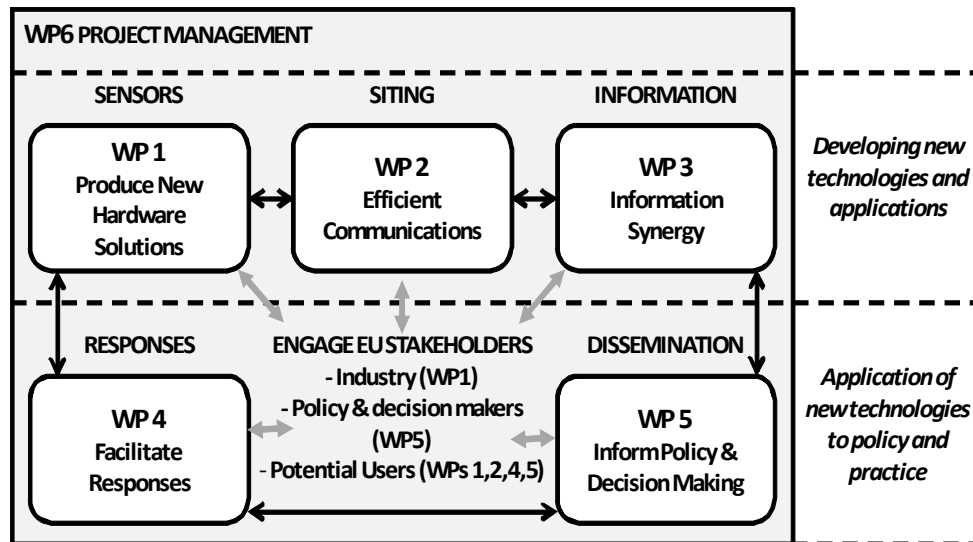
These ambitious project goals can only be delivered through a highly interdisciplinary, exploratory and experimental approach, facilitating linkages between different specialist fields and connecting a variety of stakeholders including academic and industry experts, policy makers and end users.

1.3 S/T methodology

This project will bring together specialists from a range of disciplines from within the five lead project organisations and audiences and stakeholders targeted as part of the project's day to day development and dissemination activities. Project partners include specialists from architecture and acoustics, electronic and electrical engineering, mechanical engineering and urban and spatial policy, with a mix of both public and private organisations included. CREST includes five full partner organisations, each situated in different member state and covering between them, four different European regions.

A number of different work themes are identified, each detailed below within distinct work packages. Close links will be developed between each of these work packages, considered critical in ensuring successful delivery of overall project aims. Each partner will lead on one work package each, with the lead partner also leading on overall project management.

The work packages and relationships between them are summarised as follows:



WP1: Produce new hardware solutions that combine existing and new sensing technologies

Environmental monitoring in the presented context will rely on the implementation of a variety of sensors in a wireless system, reaching high standards in reliability and stability. The project proposes delivery of new hardware via development of a miniaturised system of electronics modules, designed to incorporate different sensors and capable of handling the sensor-based signal analysis, the wireless data transmitting and the sensor controls. Single sensor (nodes) will feature integrated diagnosis and will be tailored to operate in unpredictable environments. Distributed detection schemes will use and will fuse information of neighbouring nodes or pre-imposed network structures to infer the status of themselves and/or neighbours to reduce the communication demand.

WP2: Efficient communications for environmental sensing and monitoring equipment

Environmental sensors and monitors are deployed in the built environment in increasing numbers. The data collected must be streamed back to monitoring stations located at fixed points in the built environment. However the positioning of the sensing equipment must be flexible and collecting their output is most conveniently carried out via wireless radio signals. The propagation of wireless signals in the built environment is not well understood and changes depending on the construction materials used on the building exteriors (walls, facades, windows), the size and shape of buildings, their relation to each other, external factors such as vehicles, etc. This work package will investigate the electromagnetic properties of the building exteriors and develop a suitable model for the whole built environment including for the first time vehicles and validate the model with measurements. This model will produce a breakthrough and make it possible to recommend optimum siting positions for the base stations and the monitors/sensors, determine the best wireless protocols and diversity systems for communication and eliminate wireless blind spots which are common in the built environment by specifying materials on facades (reflecting metals or absorbers such as wood) and introducing novel frequency selective structures to isolate wireless channels.

The risks for this WP include the complexity of the model and its computational requirements and potential interference between other wireless networks and a consequent reduction in the data rate.

WP3: Data Fusion and Machine Learning for Visualisation and Optimisation of the Built Environment

The increasing numbers of environmental sensors in use in the built environment means that there is an opportunity to adapt and optimise the environment for 'feel'. The opportunity to fuse information from sensors of potentially (very) different modalities, means that it will be possible to visualise overall summary information in terms of sound, smell, lighting etc. This can be combined with survey/questionnaire information in order to quantify or rank 'feel' and thus construct a map between measurements in the physical environment and perceptible measures. This would mark a return to the original concept of data fusion which originated in the need to assess military threat situations; in that framework, the 'sensor' had a very broad interpretation and could refer to a human messenger etc. Once such a map is established, using techniques developed for ranking company fitness, one can visualise a 'feel' landscape and position individual buildings within this landscape in terms of their perceived acceptability. Further, one can then use optimisation techniques in order to determine different scenarios for the built environment and by reverse engineering establish smell, sound, lighting conditions etc. in order to achieve different models. Although there are existing techniques for fusion and visualisation, experience has shown that there is always a need to tailor and extend algorithms in new contexts, and the current context is very novel and will be complex and demanding. Optimisation methods as a rule cannot be guaranteed to return a global optimum and indeed built environments are related to their spatial and cultural contexts - the perceived acceptability of or tolerance towards light, sound and smell for example is very different in a southern European or Mediterranean context, to that in a Scandinavian context. The objective of the WP will therefore be to provide methods for systematically driving the environment to improved 'feel' with regards to their specific environmental and social contexts.

WP4: Explore the potential for such technologies to facilitate responses to sensory information

It is of great significance to explore current gaps in information and future potential requirements of sensing systems, with respect to built environmental research, design and improvements. Details on the accuracy, format and level of details are also required. For example, in terms of sound information, it is important to identify whether overall levels or spectra, or sound signals are required, and at what decibel accuracy and in what format such information is needed. To systematically establish such a system, in addition to a systematic literature review of current knowledge, two work tasks are planned: (1) Integrated surveys and case studies in typical built environments, considering various types of spaces such as urban streets, squares, large indoor public spaces. Both objective measurements and subjective evaluation will be made within a well designed framework, so that correlation between them can be obtained. (2) Interviews and surveys among relevant experts, including practitioners and researchers will also be undertaken. With the above results a framework on information requirements can be established.

WP5: Inform related urban policy and decision making at a variety of spatial levels

The dissemination of the project findings forms a crucial strand of activity within this project proposal and is thus included as a dedicated work package. The lead organisation for this work package will co-ordinate Europe-wide dissemination of findings, as well as utilise the strength of having the other project partners situated within different regions of Europe, but having each of those partners assisting with dissemination at a regional, and national level. Target audiences will include European and national policy makers in technology and urban policy fields, private businesses, academics and practitioners.

WP6: Project Management

The provision of sound project management is critical to a project of this size and scope and a dedicated post will be recruited, situated with the lead partner, working in co-operation with all other project partners. High standards of project management will be achieved through regular project planning, communication, reporting, risk management and the adhering to existing high organisational standards and underpinned by recognised industry standards such as PRINCE II. Financial co-ordination will also be provided by the lead partner, ensuring accurate and up-to-date monitoring and reporting of financial information.

Measuring success

Ultimately, the success of this project will be measured through development and progression of new environmental sensing technologies. These will operate more effectively and efficiently than those in place today, meeting and potentially surpassing environmental monitoring needs of end-users. They will offer new opportunities for use of environmental sensors in responding to incidences and challenges, and will be widely known about within target groups such as policy makers at a range of spatial levels. The project might, for example, facilitate communication with motorists advising them to switch off engines to reduce air pollution or noise.

Regardless of the level of success achieved in delivering truly integrated sensing technologies and synergies, it is believed that significant progress and new knowledge will nevertheless be delivered in identifying limitations or mismatches between different types of sensory information, the technologies available and needs of the end-users.

Risks

A detailed risk identification and management strategy will be developed by partners to remediate risk. Given the exploratory and experimental nature of this project in developing new and emerging technologies, key identified risks centre upon the potential for difficulties to be experienced in linking together the variety of different sensing technologies and synergising sensory communications. Integrating sensors will reduce risks of signal interference while allowing sophisticated smart antenna systems to be used to overcome potential signal propagation problems in the built environment. Another risk is presented by different sites potentially having very different requirements. This will be overcome through the early identification and focussing of activities upon typical sites in the first instance. These risks will be overcome through the establishment of a management panel including specialist industrial partners who will advise on risk mitigation and project direction.