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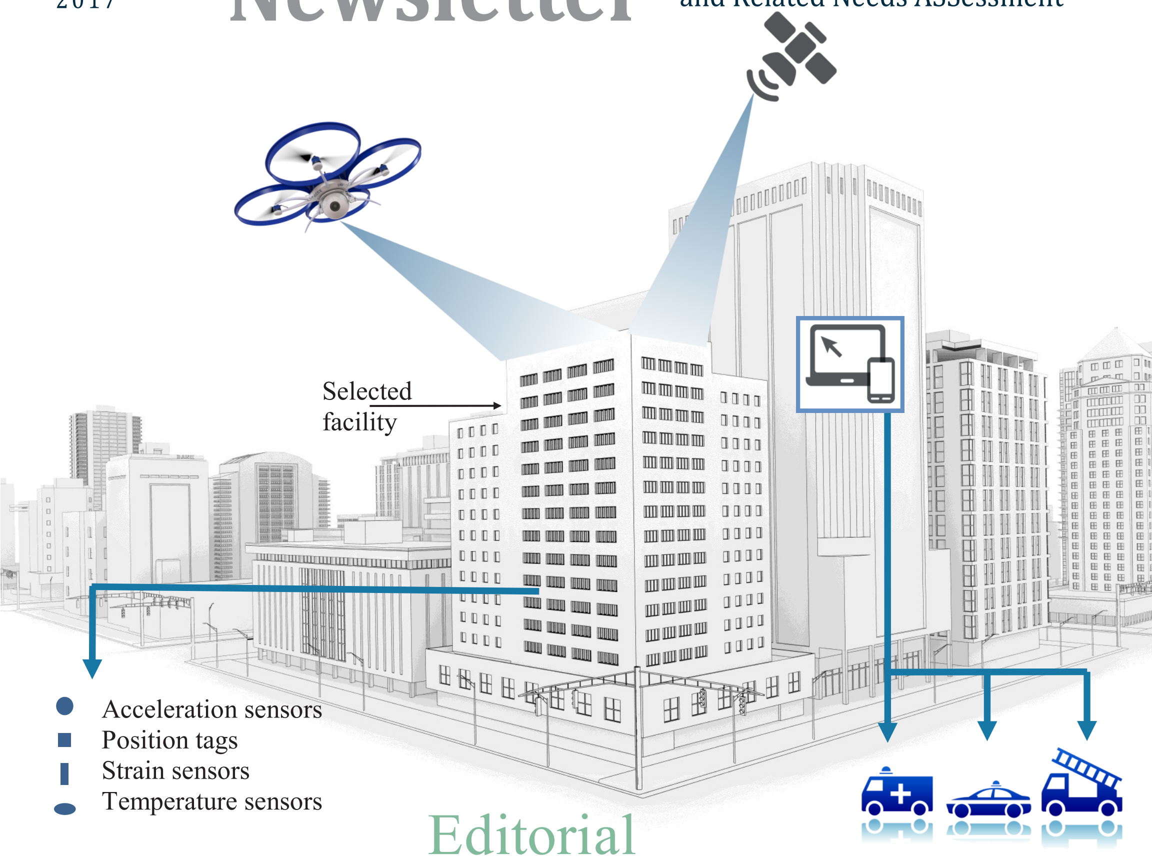
RECONASS Newsletter

Reconstruction and REcovery Planning:
Rapid and Continuously Updated
COnstruction Damage
and Related Needs ASSessment



In this issue

Editorial

Welcome to the 6th newsletter of the RECONASS project.

RECONASS is a European 7th Framework project funded under the SEC programme (grant agreement no. 312718).

The main objectives of the project are (a) to provide a monitoring system for critical buildings that will provide a near real time reliable and continuously updated assessment of the structural condition of the monitored building after a disaster, (b) in case of spatially extended events, e.g., a strong earth-quake, to use the above assessment of the monitored facilities for the speedy calibration of satellite and oblique aerial photography of the damaged area and (c) to provide a post-crisis needs assessment tool in regards to construction damage and related needs that will be based on input from (a) and (b) above.

The project officially launched its activities in December 2013. Since then the partners have developed (a) a first prototype of the monitoring system that consists of local positioning tags to determine the position of selected points of the structural system before and after a catastrophe and thus determine the structure that has emerged from the disaster, strain sensors attached to the columns at the ground level to determine the distribution of loads and accelerometers to assess the structural condi-tion under vibrations, e.g., in the case of seismic loading, (b) a methodology and coding for assess-ment of the status of structural and non-structural elements and (c) a damage methodology for multi-view oblique airborne imagery and (d) have successfully performed two separate tests of components and a large pilot in which the whole integrated system was evaluated and demonstrated.

In this issue you will find a description of the final integrated system, future extensions & refinements before the system reaches the market, a brief description of the project's final workshop, and the market search results in brief. This is the last newsletter of project RECONASS as the project ends in June 2017. Interested readers can communicate with the project coordinator, Dr A. Amditis (a.amditis@mail.ntua.gr), or the dissemination manager, Mr S. Camarinopoulos (s.camarinopoulos@risa.de), to be informed on future extensions and upgrading of the system.

Angelos Amditis
Project coordinator

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no [312718]

Project facts

DURATION
42 months

TOTAL COST
5,48 million euro

REQUESTED EU CONTRIBUTION
4,26 million euro

The set-up for the pilot demonstration in Sweden

The Final Integrated RECONASS System

As RECONASS aims to provide a monitoring system for constructed facilities that will provide a near real time, reliable, and continuously updated assessment of the structural condition of the monitored facilities after a natural or manmade disaster, a sophisticated and seamlessly integrated system is required.

RECONASS has developed small, inexpensive, wireless, **local positioning tags** that are embedded in the structural elements of the monitored buildings to report their position to the base station. The wireless local positioning tags measure the displacement of structural elements using radio frequency signals. They are connected to the RECONASS Data Collection Hubs via a **Zigbee** module. Following a disaster, comparison of the original position of the tags – in the undamaged state – with the final position of the tags – in the damaged state – is used in order to hypothesize the structural system that has emerged from the disaster. The system can then be used to assess the structural response, damage and loss.

At elevated temperatures the properties of the materials used to construct the building can be begin to degrade. For this reason **temperature sensors** are embedded into the structure of the building. The temperatures within the building are monitored by the system. The temperature sensor provides analogue voltage output proportional to the temperature it measures. The temperature is converted from analogue to digital and then passed to the data hubs via Zigbee. In testing, battery powered temperature sensors were used since during blast scenarios independent power system should actively support sensor operation. Two types, physically wired and wireless types have been tested.

During a collapse event structural members of the

building may be subject to excessive loads. To monitor these loads during and after such an event, the building is equipped with embedded **strain gauge sensors**. These strain gauges will indicate the changes in strain that the structural members have been subjected to. ARU modules essentially consists of excitation voltage supply, bridge completion modules with strain gauges. These provide analogue voltage proportional to the strain a structure undergoes. ICCS modules are waspmotes that communicates with GS's data hub. The structural strain is converted from analogue to digital and then passed to the data hubs via Zigbee. The modules of both ARU and ICCS act as a wireless strain sensor node that remotely communicate with GS's data hub. This arrangement particularly suits to RECONASS pilot as each strain node works independently thereby making it possible to mimic events such as earth quake or blast or fire scenarios. This is relatively low cost option to assess building integrity. The wireless sensor nodes are mounted in an ABS box, which can be attached to any wall, beams or columns of the building. The scope of this design is to allow ease of assembly of modules from ARU and ICCS.

Acceleration sensors are embedded within the system to assess the magnitude and direction of any movement caused by an event. The **Accelerometers** measure the acceleration at the various parts of the building or structure subjected during an event. The acceleration magnitude is passed to the data hubs.

To ensure that the positioning, acceleration, strain and temperature information from the monitored buildings can reach the base station, a gateway-tool for communication provides redundancy at situations of access network

unavailability by utilizing multiple and different access interfaces, e.g., GSM, UMTS, ADSL connections etc.

Data Collection Hubs connect the sensors to the Communication Gateway. All of the information from all of the sensors is passed through these hubs to the Gateway.

The Communication Gateway holds a central position in the

The Final Integrated RECONASS System

system architecture of RECONASS being one of its core modules. The primary functionalities that the gateway has to conform with can be seen below:

· Reception of sensor related information (metadata and measurements) from the heterogeneous sensor networks. This information is collected via the data hubs.

· Management of the heterogeneous sensor networks for optimum performance and intermittent operation (sensor network status, automated and on demand measurements collection, reconfiguration of sensors, tec.) This function is realised via exchanging commands with the data hubs.

· Connection and information exchange (sensor, interface and alerts related) with the PCCDN tool using a dedicated virtual private network (VPN).

The UAV performs a detailed damage assessment along exterior elements of the building using remote sensing images. These images will be fed as an input for the RECONASS system. Remote sensing-based damage maps are provided, using both air- and space-borne imagery. Near real-time construction damage data from the monitored buildings are used in order to effectively calibrate and evaluate these maps. The needs of the monitored buildings are continuously updated with space-borne and airborne damage maps (calibrated and validated for the buildings monitored) in a much reduced time, fused and integrated with relevant external data and information.

Based on this, a **PCCDN Tool** provides the recovery stakeholders with near real-time, detailed and reliable data and information on the construction damage and loss. This Tool will provide international interoperability to allow for customization, expansion and permit collaborative work between the civil agencies/ authorities and the relief units. The PCCDN tool takes all sensor and UAV information which has been stored in the cloud (remote database) by the gateway tool and combines it other information to determine the structural damage and deduce the post crisis needs. Disparate application components, independent of programming languages and running platforms need to be independently developed, yet easily integrated into to the PCCDN. External sources include the monitoring system, the structural assessment module, the positioning tag correlation, the loss and needs assessment module, the remote sensing assessment module, external alerts/ information. Sensors' information and observations are inserted/ retrieved in/from the PCCDN database with the use of OGC compliant Sensor Observation Services (SOS) services. Special procedures are followed to store and retrieve information from each of the calculation modules

Wireless network interfaces and Ethernet wires are the final components required for the system to be integrated and fully operational.

FUTURE EXTENSIONS & REFINEMENTS

The RECONASS system can be extended to cover additional thread scenarios, e.g., via chemical or biological agents. In this case the RECONASS system can be extended to allow monitoring within the structure itself for such contamination in real time. In addition, in a situation where several RECONASS-equipped buildings are scattered throughout an urban area, they can form a sensor network. In case a sensor network comprising several RECONASS buildings is used, then readings from those sensor nodes (i.e. individual buildings) can be coupled with weather information, such as wind speed and direction, to allow constraining potential contamination origins or the aerial extent affected.

Potential enhancements with regards to the accelerometer could be development of a dual-range accelerometer suitable for both weak and strong motion.

Cooperative positioning with multiband LPS tags based on frequency-modulated continuous-wave (FMCW) radar was used to measure the indoor deformations, which are hard to evaluate from outside of the building. The resolution of the measurement is directly related to the available frequency bandwidth. Extending the system bandwidth, e.g. by using a dedicated frequency band, may allow the system to operate in practical and complex scenarios that have more reflective obstacles, such as heavily reinforced concrete. Furthermore, to allow the system to operate in a near real-time, special consideration need to be taken on the measurements' update rate. Optimizing the number of the required nodes to focus on the crucial structural elements has a direct influence on the final update rate. It can be investigated, if the Zigbee network which was used during the pilot can be replaced by a low-latency high-performance wireless sensor network.

The RECONASS Communication Module comprises the various systems and networks (i.e. the wireless sensor networks, the local area (in building network) and the wide area (internet) network), platforms (the RECONASS Gateway) and nodes (sensor nodes, data hubs, switches, routers and coordinators) responsible to realise the challenge of ubiquitous, secure, reliable and real-time communications of the sensors and users of the overall system towards the disaster management platform of RECONASS, namely the PCCDN tool. As the RECONASS Communication System is considered a solution for monitoring buildings in regards to damages, extensions and refinements consider the inclusion of additional functionalities, sensors and networking concepts that enhance the system and make it suitable in a wide range of applications, operational environments and underlying networks.

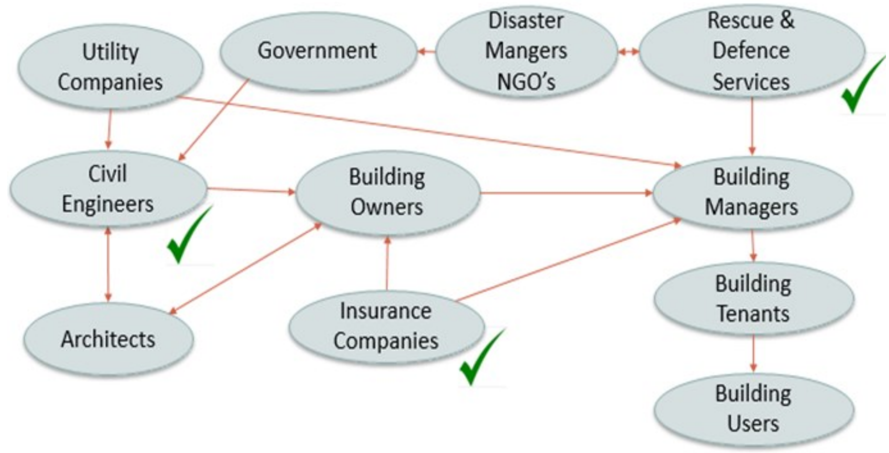
FUTURE EXTENSIONS

IoT enablement:

Modern societies tend to enable hyper-connectivity with the concept of the “Internet of Things” in which monitoring and actuation functions are central to various IoT deployments. RECONASS Communication Module which facilitates monitoring and connectivity of built infrastructure may exploit such momentum by refining and adapting its communication protocols for transmission of sensor data and control functions so that the same system can be re-used within different monitoring environments, such as of transport, smart homes and retail to name a few. In this context, uptake of IoT application protocols such as CoAP and MQTT are closely considered in future implementations.

Mobility Concepts and Edge Computing:

The RECONASS Communication Module is based on a ruggedized and fixed gateway that acts as the main platform (server and storage unit) for the whole system and is installed within the building/monitoring facility of interest. In recent years, new mobility concepts and the rise of edge computing have emerged that introduce new concepts of operations for data transmission and relevant processing. Such deployments necessitate utilization of mobile nodes and distributed processing of application data that are ultimately aggregated at the final user interface. In that sense, an envisaged extension for the RECONASS Communication Module is the re-design of the overall architecture to facilitate deployment of mobile processing units which will increase system resilience and application/processing speed, hence making the RECONASS system a high quality communication solution for monitoring applications.



Market search results in brief

This system is beneficial for a multitude of public buildings and infrastructure, as well as large, private buildings such as office headquarters or apartment blocks.

In times of emergency, it can assess damage and help prevent the unnecessary closure of critical facilities, such as, for instance, buildings necessary for the planning and management of early and full recovery (e.g., the Ministry of the Interior, or civil protection agencies), or hospitals, police and fire stations, bridges and tunnels essential for the passage of emergency vehicles. RECONASS, as a modular state of art monitoring system, will have a wide and varied appeal to many potential users. Civil protection agencies who have a full overview of critical buildings in a given geographic area would see RECONASS as an invaluable tool to help them achieve their highly demanding objectives. Individual building owners, in particular those of high net value, will see a huge benefit in installing this highly-advanced system to monitor their assets. Insurance companies providing cover for many buildings may specify installing RECONASS as a precondition.

However, there is a difference between buyers and users of the system. The expected market is complex and diverse. Buyers of the system include governments, utility companies, disaster managers for NGO's, building owners, and rescue and defense services. The end-users could also include civil engineers, building managers, architects, insurance companies, building tenants and building users. Building owners/managers are key market actors. Certification and standardisation of the system are facilitators and catalysts to reach the market.

GeoSIG have made a market study and business analysis of the expected market. The RECONASS (SHOX) sales and financial forecast 10 years post-project projects a steady increase in sales, from 2 units sold the first year, up to 34 sold in Year 5 and up to 74 in Year 10. GeoSIG projects RECONASS could have more than 90 percent of the market share by Year 10 post-project.

News and Events from February to May 2017

Presentations/Publications in Conferences and Congresses

Vetrivel, A., Duarte, D., Nex, F.C., Gerke, M., Kerle, N. and Vosselman, G. (2016) Potential of multi-temporal oblique airborne imagery for structural damage assessment. In: Proceedings of the XXIII ISPRS Congress: From human history to the future with spatial information, 12-19 July 2016, Prague, Czech Republic. Peer reviewed Annals, Volume III-3, 2016 / edited by L. Halounova, ... [et al.]. ISPRS, 2016. ISSN: 2194-9050. pp. 355-362.

D. Fritsche, S. Li, N. Joram, C. Carta and F. Ellinger, 'Design and Characterization of a 190-GHz Voltage-Controlled Oscillator,' 46th European Microwave Conference, Oct. 4-6, 2016, London, UK, published by IEEE.

Publications in Refereed Journals

Vetrivel, A., Gerke, M., Kerle, N., Nex, F.C. and Vosselman, G. (2017) Disaster damage detection through synergistic use of deep learning and 3D point cloud features derived from very high resolution oblique aerial images, and multiple-kernel-learning. In: ISPRS Journal of Photogrammetry and Remote Sensing, (2017- IN PRESS) 15 p

RECONASS Final Workshop

RECONASS (together with project INACHUS) have chaired a track and organized a Workshop on 'Post-Crisis Damage and Needs Assessment of Buildings for Response, Reconstruction and Recovery Planning' under ISCRAM 2017 (https://iscram2017.mines-albi.fr/).

ISCRAM (Information Systems for Crisis Response and Management) is an international community of researchers, practitioners and policy makers involved in or concerned with the design, development, deployment, use and evaluation of information systems for crisis response and management.

The aims of this workshop were to:

- present the project results after the successful pilot in Sweden
- receive user feedback on the approaches followed
- help identify useful refinements/ extensions of the system and its components
- discuss the importance and trends in Structural Health Monitoring in buildings as a means to avoid partial or total collapse when disastrous events take place (e.g., earthquakes, explosions).

The workshop was a success including 19 people outside the RECONASS consortium that came from civil protection, disaster risk management, situation monitoring, red cross, fire brigades, research groups, industries and users.

The participants commented that it is very useful that the RECONASS system is interoperable and that provides the capability of integration with first responders' applications.

The conference proceedings can be found in public deliverable D9.4.

Follow-up RECONASS

RECONASS Project is ending as of June 2017, however the RECONASS End-User Group is encouraged to follow post-project activities by visiting RECONASS' on-line presence (www.reconass.eu, Twitter and Linked IN accounts). Additionally, all interested users are welcomed to contact the project coordinator, Dr A. Amditis (a.amditis@mail.ntua.gr), or the dissemination manager, Mr S. Camarinopoulos (s.camarinopoulos@risa.de), to remain updated on future activities of the RECONASS Consortium .

www.reconass.eu

#Reconass

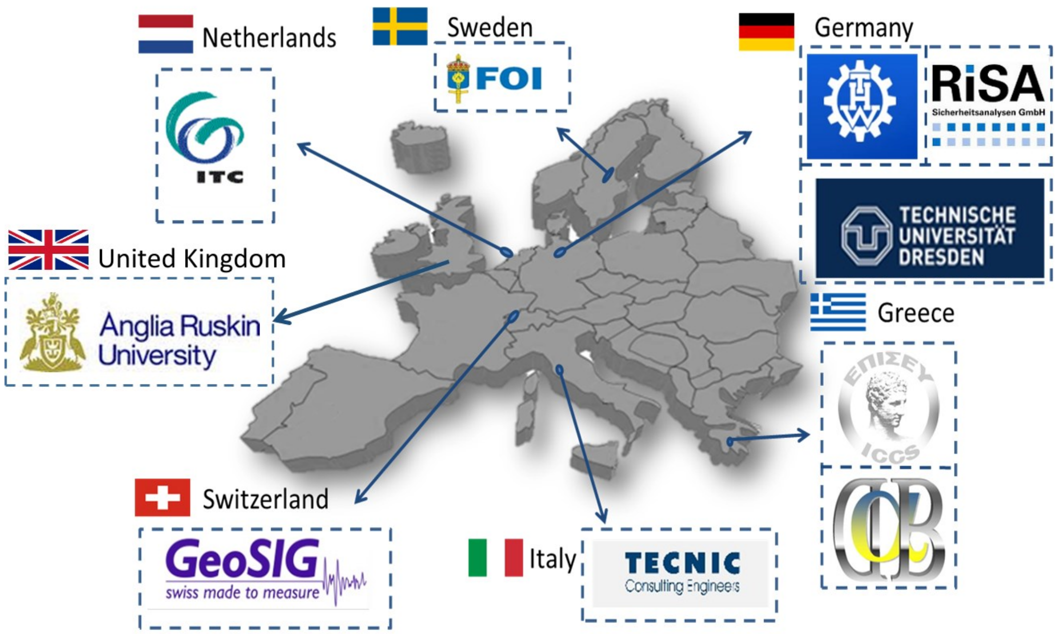
RECONASS group

Contact Us

Project Coordinator:
Dr. Angelos Amditis
(a.amditis@iccs.gr)

Dissemination Manager:
Stephanos Camarinopoulos
(s.camarinopoulos@risa.de)

Consortium



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