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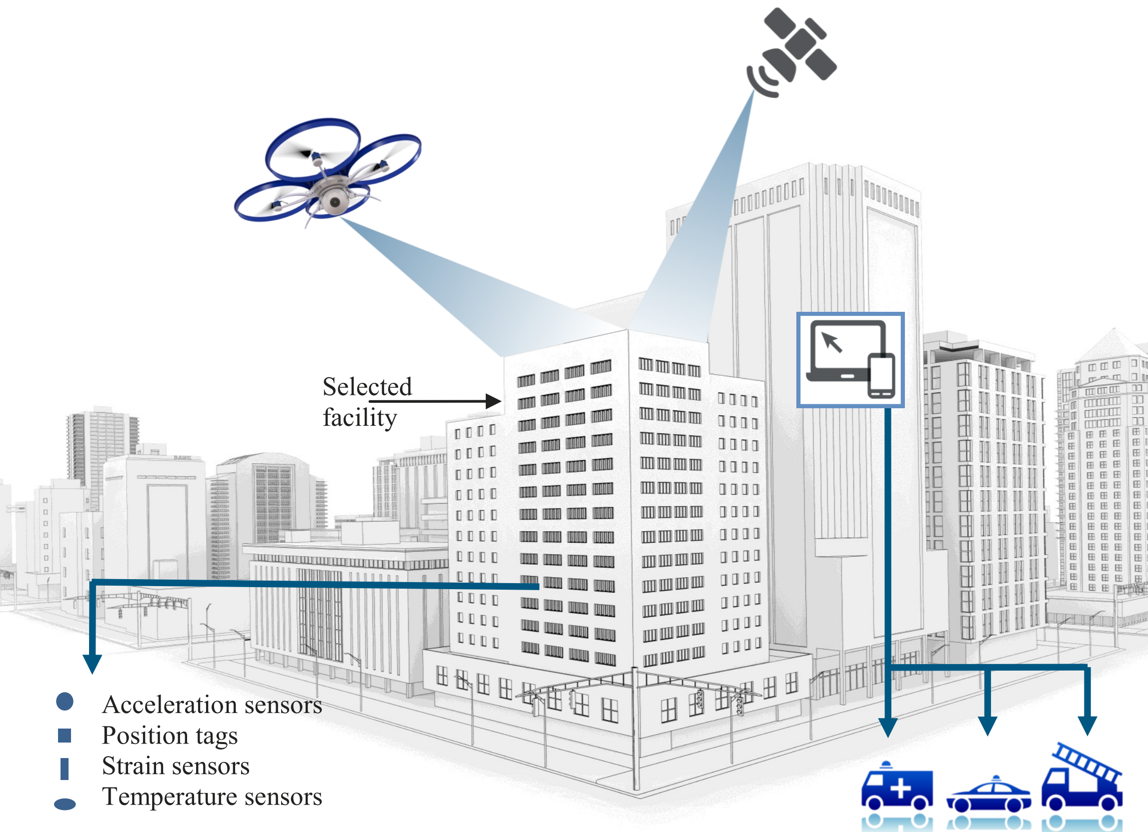
RECONASS Newsletter

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

RECONASS



In this issue

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

Editorial

Dear readers,

Welcome to the first newsletter of the RECONASS project!
RECONASS is a European 7th Framework project funded under the SEC programme (grant agreement No. 312718).
The main objective of the project consortium is to provide a 'smart' structural monitoring system, permitting a reliable and ongoing assessment of the state of structures hit by earthquakes, explosions and other causes.
The project officially launched its activities in December 2013. During the first eleven months of the project the partners indentified an extended group of end-users, derived user requirements and based on these determined the system architecture. Subsequently, the development process has recently initiated where the RECONASS components, namely the assessment modules (i.e. structural, non-structural and remote sensing) hosted by a damage assessment tool that provides a usable GUI and the sensor devices designed to instrument uninterruptedly a given structure utilizing robust communication means are subjected to the preliminary coding and assembly.
Inside this issue you will find what are the problems spanned across various domains of structural health monitoring (e.g., optimisation of structural/non-structural assessment, resilient communications towards sensors' data gathering and subsequent processing, etc.), that this project attempts to solve, what the end users need from RECONASS, an overview of the RECONASS monitoring system and partners' participation in conferences and workshops.
To stay tuned with the RECONASS developments you may subscribe to this newsletter.

Kind Regards,
Dr. Angelos Amditis
Project Coordinator

The Need

Terrorist actions often strike building and civil critical infrastructures of strategic interest, such as government buildings, airports, harbors, bridges, head offices of large corporations

The same buildings and critical infrastructure are often among the facilities damaged in a natural disaster. During such events the above facilities may exceed their functional or structural limits and this can be visible. On the other hand, they can also suffer enormous damage to their capacity without producing any apparent visible signs. Such damage, for instance, in the case of an earthquake, can render the facility incapable of surviving consecutive aftershocks.

The post-crisis damage assessment process for constructed facilities is based mainly on on-site inspection by experienced engineers. When the visible signs of damage are not of the kind that points to a definitive damage or non damage state, further analysis is necessary. The problem is compounded by the shortage of experienced inspectors and the inevitable time delay caused by an in-depth structural analysis during which time a conservative position has to be taken and the facility stays closed. This is extremely painful in the case 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.

Advances in Information and Communication Technologies

In case of large scale events (e.g., an earthquake or regional conflict), recent advances in Information and Communication Technologies, including Earth Observation, can shorten the time for an initial inspection to identify damaged constructed facilities. For instance, following the 2010 Haiti earthquake, vertical aerial imagery of 0.15 m resolution allowed damage delineation that was an order of magnitude more accurate than that generated based on 0.5 m satellite imagery. Still, this is information that is based exclusively on what can be seen from outside the facility and can replace a first, rapid inspection, to quickly screen out the obviously safe and the obviously unsafe facilities, that usually takes some days. Following the Haiti earthquake also the utility of multi-view oblique aerial imagery from the Pictometry system to detect and quantify structural damage of buildings was assessed. This work has shown that physical damage to roofs and facades can be identified (visual signs of damage, as well as damage revealed by geometric deformation such as tilting). Systems such as Pictometry, but in principle any airborne imaging system that permits controlled oblique image acquisition, allow a building to be imaged from all four sides (barring occlusion by vegetation or closely-spaced buildings) and from above. While this potentially allows a comprehensive appraisal of the state of a buildings, it cannot replace the detailed inspection that follows to provide a more reliable estimate of the structural condition of the facility that takes some weeks.

The RECONASS Objectives

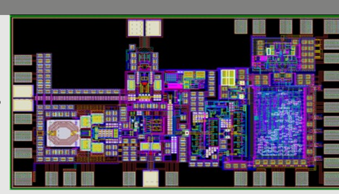
RECONASS aims at providing a monitoring system for constructed facilities that will provide a near real time, reliable, and continuously updated assessment of the structural condition of the monitored facilities after a disaster, with enough detail to be useful for early and full recovery planning.

The above assessment will be seamlessly integrated with automated, near real-time and continuously updated assessment of physical damage, loss of functionality, direct economic loss and needs of the monitored facilities and will provide the required input for the prioritization of their repair.

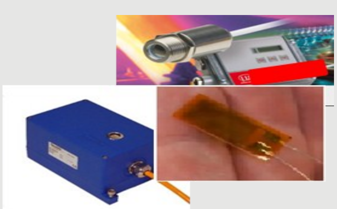
Such detailed monitoring is only economical for selected facilities that are essential for response and recovery or facilities that have a high value as a target for terrorist attacks. In case of spatially extended events, in order to assess the physical damage in the whole affected area, the detailed assessment of damage in the monitored facilities will be used for the speedy local calibration of satellite and oblique aerial photography dramatically reducing the required time to inform the post disaster/crisis needs assessment process and provide base data for reconstruction efforts.

The above will be part of the RECONASS next generation Post-Crisis needs assessment tool in regards to Construction Damage and related Needs (PCCDN). This tool will enable fusion of external information, allow for future expansion of the system, provide international interoperability between the involved units for reconstruction and recovery planning and support the collaborative work between these actors.

Functionalities



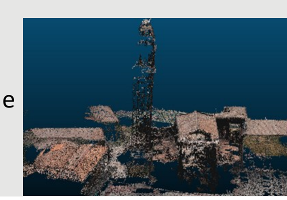
- Precise (<10cm) structural components' measurements derived from a Local Positioning System (LPS) to feed the assessment modules with data related to displacements, collapses and residual capacities.



- Measurement of strains and accelerations required for the assessment of the condition of structural members and measurement of temperature deviations that affect the materials' structural characteristics.

- Seamless interoperability among heterogeneous networks to secure that the required information from the monitored facility can reach, in near real-time, the base station even after difficult conditions, such as post-crisis situations

- Civil engineering algorithms for the automatic and reliable near real-time assessment of the structural condition and damage of the structural and non-structural components and the monitored building as a whole after a disaster.



- Novel structural/nonstructural assessment completeness by analyzing the exterior of a structure utilizing photogrammetry methods

ENSURE SYSTEM RELIABILITY

Testing and validation

All functionalities and the overall assessment process and results will be preliminary tested on a **component basis within a laboratory environment** to be ultimately validated and benchmarked **on the field** after detonating several **blasts on a ½ scale pilot building**.

The last test is expected to prove the **RECONASS concept as a reliable and innovative structural health monitoring system** capable of being used in both earthquakes and explosions providing at the stakeholders a rich set of assessment data in regards to the affected structure's condition.

Expected Impact

- Relief organizations, insurers and banks can begin funding restoration efforts at a much earlier date.

- Emergency response crews will be provided with critical and timely information on damage in monitored facilities so that danger can be pinpointed and emergency response directed with precision.

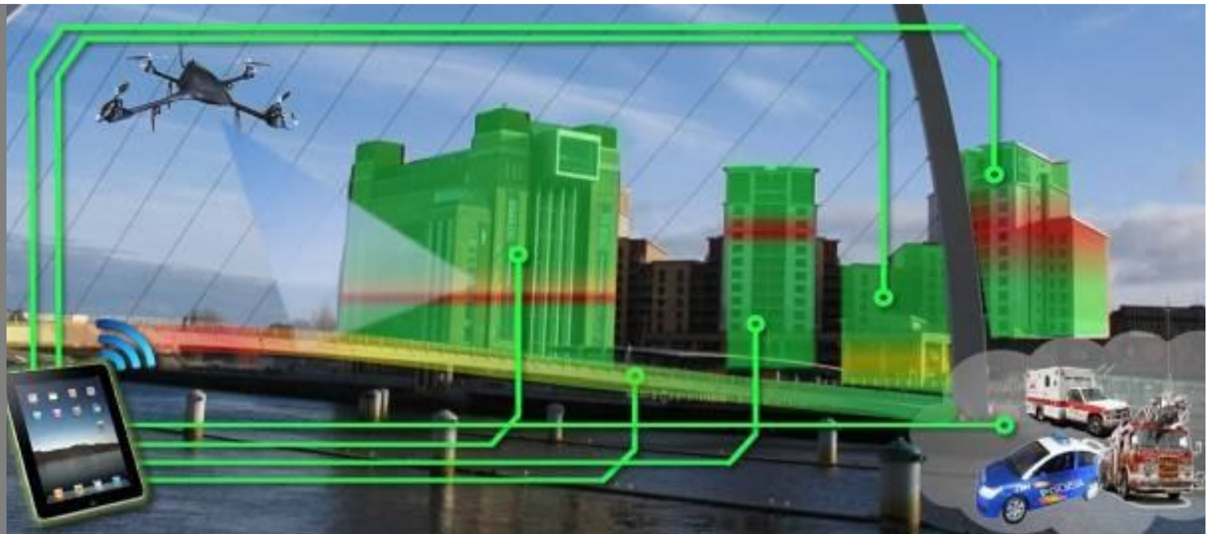
- Disaster cost will be reduced by preventing monitored structures from collapsing to limit damage to adjacent structures and additional loss of life when explosive devices impact highly populated urban centers.

- Knowing the functionality of hospitals immediately after the disaster will help the government direct injured victims to available hospital capacity.

- RECONASS information to all major recovery stakeholders (in the form that they need it) will help them acquire a common picture of the situation.

- Communication in case of disaster, such as guaranteed by the proposed communication gateway, in addition to helping the recovery efforts, can save lives.

- Early, effective handling of the reconstruction and recovery process will have long term financial repercussions.



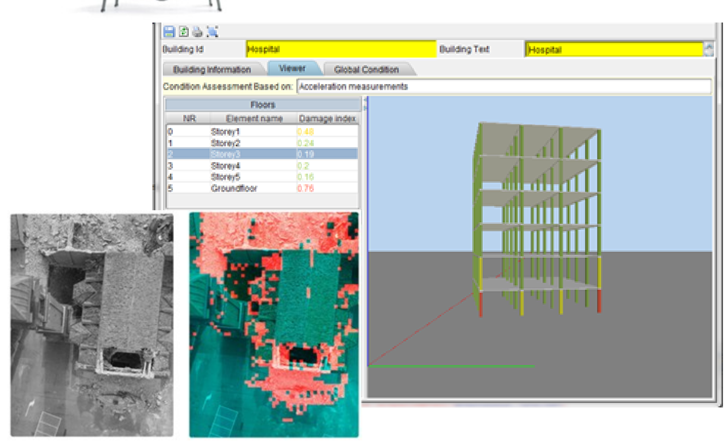
The RECONASS Methodology

In order to achieve its objectives, **RECONASS will develop small, inexpensive, wireless, local positioning tags** that will be embedded in the structural elements of the monitored buildings and report their position to the base station. 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 – will be used in order to hypothesize the structural system that has emerged from the disaster. This latter system, then, will be used to assess the structural response, damage and loss.

To ensure that the **positioning**, and also information from other gauges recording **acceleration, strain and temperature** from the monitored buildings can reach the base station, a **gateway-PCCDN tool for communication will be developed** in this work that will provide redundancy at situations of access network unavailability by utilizing multiple and different access interfaces, e.g., GSM, UMTS.

Our own **Unmanned Aerial Vehicle (UAV-drone)** will be operated around the monitored building after the event and the 3D model of the building will be generated using the images and a detailed 3D damage assessment will be carried out. In case of extensive events like earthquake, the local UAV based3D damage assessment on monitored and neighboring buildings will be used to calibrate and validate the air-and-space -borne imagery based damage maps provided for extensive area.

A **PCCDN Tool** will be developed that will provide the recovery stakeholders with near real-time, continuously updated, detailed and reliable data and information on the construction damage, loss and needs of monitored buildings. Space borne and airborne damage map, fused and integrated with relevant external data and information will in a much reduced time support the involved decision makers. Furthermore, the PCCDN Tool will allow for customization and future expansion of the system, provide international interoperability and allow for collaborative work between the civil agencies/authorities and the relief units.



End-Users' Involvement

In order to create a system that is needed and accepted by the users, **the first step has been to collect, analyse and document user requirements.**

Consequently the following **diverse user types** were defined:

- *Governmental Emergency / Disaster Response Organisations*
- *Non-Governmental Emergency / Disaster Response Organisations*
- *Public Operators of Critical Buildings*
- *Private Operators of Critical Buildings*
- *Organisations involved in the development of remote sensing based damage maps.*
- *Organisations involved in synoptic damage prediction based on acceleration measurements, insurance companies, etc.*

With the help of these user types, the relevant (or respective) user requirements and the user group members are classified.

In order to generate first user requirements and to prepare the first RECONASS end user workshop, **a questionnaire** was created in cooperation with all RECONASS consortium members and sent out to the first organisations that were invited to join the user group in accordance with the classification mentioned above.

During **the first end user workshop** it was explored how potential end users proceed with damage and needs assessment. Additionally the preliminary user requirements were evaluated. The central objective was to obtain as much input as possible from potential end users of all user types.

The user requirements state the services, which the system is expected provide to system users and the constraints, under which it must operate.

The **overall goal** of a close involvement of end users is to ensure that the RECONASS system complies with the user requirements. This will lead to a system, which will be user friendly and does, what the user expects from such a system.

DAMAGE ASSESSMENT

In case of a **seismic event** to assess the residual structural capacity of the structural members and the whole building, use will be made of the history of acceleration during the seismic loading, while input from the strain sensors will be used in order to assess the axial forces on the columns at the ground level and from these the structural condition under operating loads.

As non-structural members, unlike structural members, are not directly affected by the ground shaking in an earthquake, but rather are affected by motion or shaking of the structure to which they are attached or upon which they are supported, the structural condition of the non-structural members will be assessed as a function of the response of the building structure at the points of attachment of the structural elements.

In case of **blast loading**, as mentioned above, the position of the local positioning tags before and after an extreme event, the part of the structural system together with the associated non-structural components that will be beyond the point of practicable repair will be determined. Damage to the remaining components (structural and non-structural) will be due to blast induced vibrations and, thus, the damage states developed for, the similar, seismic vibrations are appropriate and have been used for this type of blast damage as well.

In the case of fire, input from the temperature sensors will be used to assess material properties and based on these, the structural condition at a local and global level.

Follow-up RECONASS

The end user group is invited to follow-up the RECONASS process during the project's lifetime via the RECONASS homepage (www.reconass.eu) as well as via twitter and LinkedIN and to contribute within all in all three RECONASS end-user workshops.

www.reconass.eu

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System Specifications

The RECONASS system comprises of the following sub-systems:

RECONASS Monitoring System

The **Sensors Network** comprises of acceleration, temperature and strain sensors.

- The **acceleration sensors** (installed at two extreme points on the overall slab of every building floor) will provide data that will be processed to find the additional amount of energy that has been dissipated during a disaster event and the resulting, diminished, residual capacity of the structure.
- The **strain sensors** (attached on the reinforcing bars) will be used to verify that the right structure condition before the event is used to perform the analysis and to determine the condition after the event.
- The **temperature sensors** (installed within each open space area of the building) will provide data on the history of temperature exposure of the structural members in order to assess the properties of materials for structural analysis.

The **Local Positioning System** (LPS) uses positioning tags and base stations installed in building structures to monitor the location of structural elements within the structures. The LPS consists of the following:

- **Sensor node or tag**: small locatable device to be embedded at crucial points such as beams and columns in the structure. Certain external nodes will be provided with access to GPS. Once those sensor nodes have the capability to knowing their accurate locations they become anchors.
- **Anchor** (GPS-enabled sensor node): any sensor node with known reference position (by GPS or by direct measurement of distance) that communicates with other nodes to give them reference location data.
- **Coordinator/Base Station**: connected to a certain number of LPS sensor nodes, coordinates positioning signals, calculation of position of each node relative to anchor, interface to the rest of the monitoring system. The coordinator has a fixed position and acts as an anchor.

In case of blast and/or impact loading of the structure, comparison of the tags' position in the undamaged and damaged state will be used in order to estimate the structural system that has emerged from the disaster event.

The **Communication Gateway Module** is a communication platform that acts as an aggregation point for the sensor data as a means of interconnecting the various parts of the sensor network (including the LPS) and then provide a resilient gateway for the transmission of sensor data to a remote analysis module (PCCDN TOOL) of the RECONASS system. The Gateway Module aims to ensure the integrity, maximum possible availability, secure transmission, "longevity" and reliability of the sensor data. The Gateway Module will incorporate a number of processes and technologies, which include:

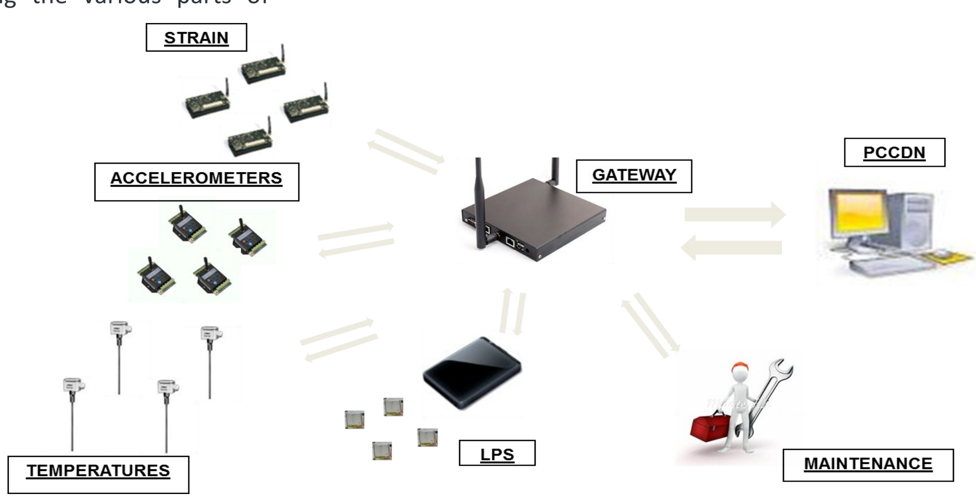
- Multiple WAN access technologies operating in parallel both wired and wireless
- Adaptive routing protocol for optimal routing path selection
- Transmission through secure tunneling
- Local sensor data aggregation
- Sensor network management features
- Two layers of data aggregation datahubs – gateway
- Power redundancy features - backup power support
- Event logging
- Sensor network fault tolerance – multiple paths for data routing
- Sensor network power management features – triggering of sleeping nodes
- "Top to bottom" security architecture
- Local storage of "most recent" sensor data

The Datahubs will be used to locally collect all the data from the acceleration, temperature and strain sensors within the Sensors Network and the Local Positioning System. The datahubs provide the link between sensors and the central gateway.

Assessment Module

The **Assessment Module** based on the records of the sensor data will conduct an analysis that will provide in near real-time the end user with information about the structural integrity of the building and its structural elements. The Assessment Module consists of the following subsystems:

The Deterministic Structural Assessment module, based on a combination of numerical data received from sensors (acceleration, strain, temperature and LPS tags) and the use of preparatory and/or commercially available software by which the actual state and the damage indices or the safety factors of the structural



elements are estimated.

The **Economic Loss and Needs Assessment Module**, which receives input from the Structural Assessment Module (damage index of the structural components, interstory drifts and peak floor accelerations) and Temperature sensors in order to assess the damage state of every structural and non-structural component; building functionality; demolition needs; amount of debris; repair costs and duration; construction manpower and material cost required.

The **PCCDN Tool**, which embodies both the 'Structural' and 'Economic Loss and Needs' Assessment Module, collects information from all the monitored facilities in the affected region (e.g., the parliament, the Ministry of the Interior, hospitals, bridges) and process it in order to provide recovery stakeholders with near real-time, reliable, continuously updated information, in the form that each one of the stakeholders' needs it, on structural and non-structural damage, shoring and demolition needs, loss of functionality, direct economic loss and the resulting needs in construction labour and materials for the monitored buildings.

UAV System

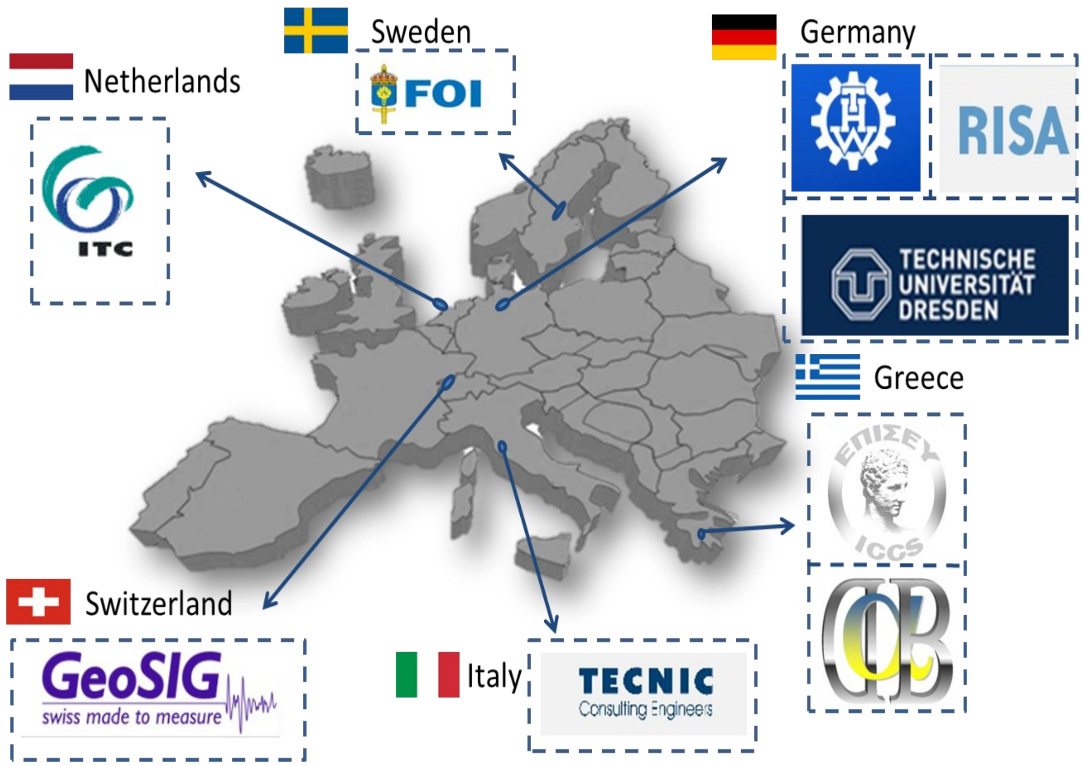
The UAV system's primary functionality is to perform a detailed damage assessment along exterior elements of the building using remote sensing images. In RECONASS, a UAV-drone will be operated around the monitored building after the event to capture the images of the building in all possible viewing directions (oblique and vertical views). These images will be fed as an input for this subsystem. From the set of captured images, the products like 3D point clouds, orthophoto, Digital Surface Modelling (DSM) will be generated by adopting existing technologies. Using these products and our own RECONASS developed methods, a 3D model of the monitored building will be generated and a detailed 3D damage assessment will be carried out along every exterior element of the building. The resultant image based damage assessment will be used along with sensor data based damage assessment for improving the assessment level and, for calibration and validation of both image and sensor data based assessment. The calibrated UAV images based assessment of monitored and neighbouring buildings will be used to validate and calibrate the satellite based damage maps produced in case of extensive events. The UAV system based assessment will consist of four components:

- *Element specific exterior structural damage assessment module*
- *Synergistic use of remote sensing and WSN for improved structural damage assessment*
- *Calibration and validation of satellite damage maps produced for an extensive area*
- *Prototype for sensor network extension with relevant hazard monitoring sensors*

News and Events

- The **official kick-off meeting** of the RECONASS project was held in Athens (Greece) at the ICCS premises from 13th to 14th of February 2014.
- The RECONASS **2nd plenary meeting** took place in Enschede, Netherlands, from June 11 to June 13, 2014.
- The RECONASS **3rd plenary meeting** took place in Santorini, Greece, from September 29 to September 30, 2014.
- The first **end-user workshop** on the RECONASS system user requirements, took place in Berlin, Germany, from March 24 to March 25, 2014. It was organized by the German Federal Agency for Technical Relief.
- A **joint paper by all RECONASS partners** titled ' A Novel and Practical Approach to Structural Health Monitoring - The RECONASS Vision/Local Positioning, Sensor Networks, Secure Communications and Remote Sensing at the Service of Structural Monitoring to Assess Construction Damage and Related Needs,' has been presented at the 2014 Workshop on Environmental, Energy, and Structural Monitoring Systems (EESMS 2014).
- The RECONASS project participated in the **European Symposium on Border Surveillance & Search and Rescue Operations Technology** (BSSAR '14) in Heraklion, Crete-Greece on November 27th – 28th 2014, organized by the Center for Security Studies (KEMEA) of the Hellenic Ministry of Public Order and Citizen Protection. The RECONASS Project was presented by ICCS through a roll-up banner entitled "URBAN & CRITICAL INFRASTRUCTURE SECURITY-Search and Rescue Operations".
- A **paper** by N. Joram, R. Wolf, B. Lindner and F. Ellinger on 'Concurrent 2.4 and 5.8GHz Dual Band Power Amplifier for FMCW Radar Systems' was accepted for publication at the IEEE International Symposium on Intelligent Signal Processing & Communication Systems, in Kuching, Malaysia.

Consortium



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