RECONASS

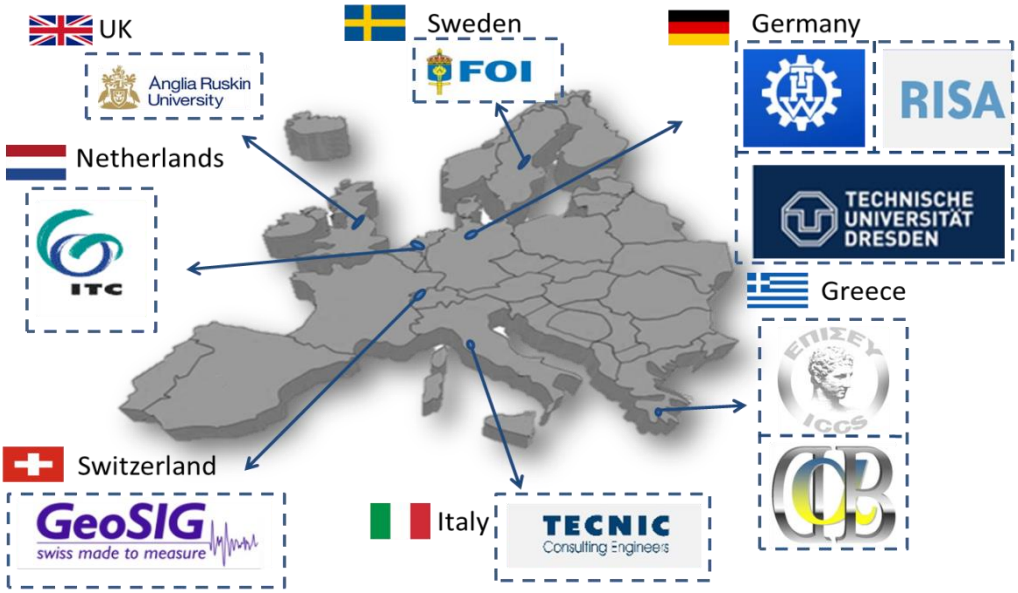
7th Framework Programme

FP7-SEC-2012.4.3-1

Next Generation Damage and Post-Crisis Needs Assessment Tool for Reconstruction and Recovery Planning

Capability Project

RECONASS – The Pilot Test
Where: Älvdalen, Sweden
When: 25th and 30th of August 2016
Who: RECONASS Consortium



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EXECUTIVE SUMMARY

On 25th and 30th of August 2016 in Älvdalen, Sweden a large demonstration was successfully set up by the RECONASS Consortium towards materialising almost 3 years of research, implementation and integration efforts to stress the RECONASS system in real conditions and experimentally validate the system's functionality.

In brief, RECONASS project creates 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. The system uses inputs from in-building sensors; accelerometers, local positioning tags, strain and temperature sensors and the assessment picture is complemented by oblique aerial photography of the damaged building and surrounding area.

The demonstrator concept was basically the instrumentation of a 3 storey building of reinforced concrete, with the RECONASS sensors and prototypes and the execution of massive blasts from its exterior (400 Kg of TNT) and its interior (16 KG of TNT) to evaluate the RECONASS system in a live experiment, as close as possible to realistic conditions.

The RECONASS demonstrator showcased how the RECONASS system as a whole assesses rapidly the structural condition of the monitored building after a disastrous event. Moreover, the behaviour of the individual prototypes has been put into stress (i.e. the sensors and their casings, the communication nodes, the structural assessment algorithms, the UAV assessment process, and the disaster management tool at the service of the end users that visualises the condition of the building post event).

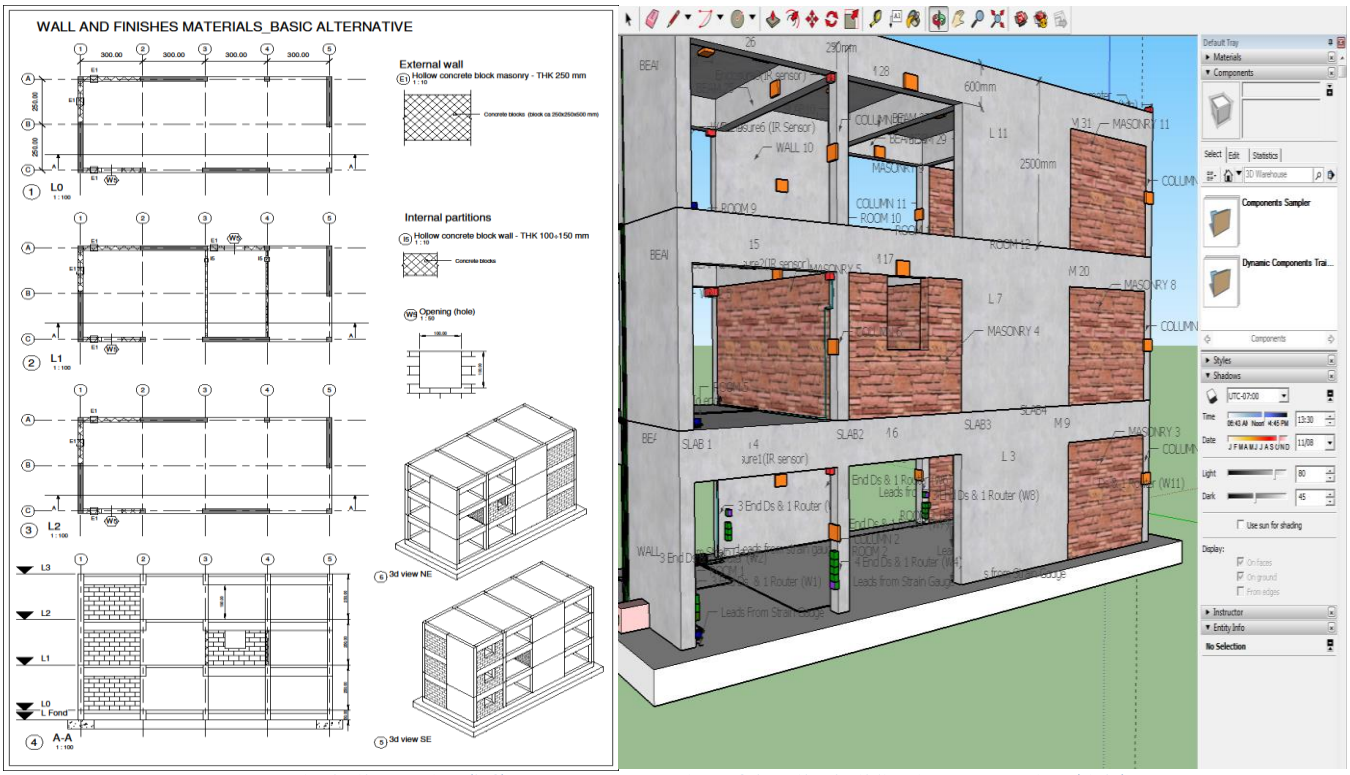
The images below depict the pilot area (left) and the RECONASS instrumented building (right) designed, constructed and monitored by the collaborative efforts of the consortium's partners.

In overall, the demonstrator was proved of outmost success as the system's merits and functionalities have been experimentally validated, revealing at the same time where room for optimisation exists. At the following sections, the pilot test storyline is described along with the experiment's highlights.

1 THE PILOT TEST STORYLINE

1.1 The Design Phase (September 2015 – March 2016)

First and foremost the consortium's partners have designed the pilot building that suits the RECONASS purposes and represents a typical structure of reinforced concrete. The RECONASS building was a 3-storey one of 1:1 scale allowing for the experiment to be as realistic as possible. Moreover, the design has been further enhanced by annotating the appropriate placement decisions made, for its effective and efficient instrumentation and monitoring. The below images provide snapshots of the design process.



Final Pilot Design (left) & 3D Representation of the pilot building instrumentation (right)

1.2 The Instrumentation Phase A – Strain sensors installation (May 2016)

Since the start of the pilot building's erection, Phase A of the instrumentation began. During that time and when the foundations were constructed the strain sensors have been installed in the rebars so that the building's loadings are monitored both during its erection (dead load) but during operations as well. For the latter, the strain values provide assessment to the buildings fatigue. The images below present the placement of strain sensors during May 2016.

Strain sensors installation to the building's rebars

1.3 The Building Construction (April 2016 – July 2016)

The RECONASS building took its final shape, from setting the foundations to final construction after a 3.5–month process. The building was ready to be fully instrumented by the RECONASS monitoring system around end of July 2016. The images below provide snapshots of the erection process.

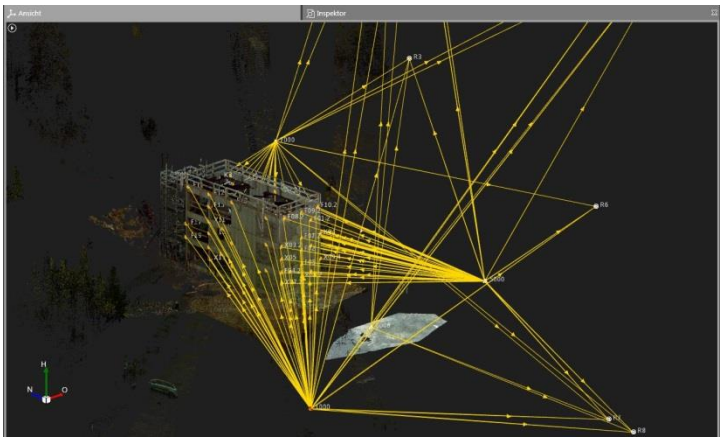







1.4 The Instrumentation Phase B – Tags, Accelerometers, Temperature Sensors and the RECONASS Integrated System - incl. additional means of instrumentation - (August and September 2016)

The building construction phase was followed by the instrumentation one. As such a resource-efficient calendar was set in place and in August 2016 the consortium partners have gradually instrumented the entire building with the RECONASS monitoring system. Together with the installations, several tests have been performed to the individual components and prototypes to validate their functionalities and performance in the experimental environment. Last but not least a 3-day full integrated system testing has been performed successfully.



Laser scanning (an additional evaluation metric of the assessment process)

Furthermore, additional instrumentation means[1] have been deployed: a) A laser scanning/total GPS base station system has been set in place so as to measure the building's reactions to blast with mm accuracy; providing an additional evaluation metric for the RECONASS system. And b) high-frequency accelerometers and pressure gauges have been also installed so as to measure the pressure wave and the blast impact subjected to the building.
The former has been brought by THW (RECONASS partner) and the latter has been offered by the Norwegian Defence Estate Agency (NDEA) that showed special interest on clustering[2] with RECONASS and exchanging knowledge on building monitoring tools as well as the process to be followed for "building back better" resilient structures that are capable of withstanding high-stress events.

The images below provide snapshots of the instrumentation phase B.

Ready to cable high frequency sensors (left) & the strain wireless module (right)

[1] The additional instrumentation means have been funded by the individual entities that liaised with RECONASS project for knowledge exchange purposes

[2] The most important clustering activities occurred during the pilot implementation have been: 1) NDEA additional instrumentation and agreement for exchanging relevant results, 2) ASI experiment simulations and interfacing with RECONASS' disaster management platform, the PCCDN tool

Set up of data hubs, temperature sensors and accelerometers at ground floor (left) & the positioning tag at the mid-span of a wall (right)

Busy day on site - all RECONASS partners are instrumenting the building in preparation for 1st explosion

2 EXTERNAL EXPLOSION – 25TH OF AUGUST 2016

On 25th of August everything was ready for the 1st test, a 400 Kg of TNT external blast was to be executed. This test was open to the public and the demonstrator attracted many stakeholders (approx. 20 persons[3] from civil protection agencies, building owners, defence agencies and experts in damage assessment) that were highly interested to watch the live stress test of the RECONASS system. The visitors arrived on site early in the morning to be briefed on security & safety instructions and to get introduced to the RECONASS system and the scope of the experiment. The visitors were given the opportunity to have a tour in the building and the consortium explained in more detail the instrumentation rationale and the technical decisions made for the RECONASS monitoring system. After the blast event the RECONASS consortium presented the assessment results produced by the RECONASS monitoring system in a round-table.

Additionally, the RECONASS experiment was lively covered by two national Swedish TV channels (SVT and TV4) promoting the EC work and the RECONASS project to the public at large and the below interviews were given:

- RECONASS Pilot Test on TV4 News 25-08-2016 @ 22:00 pm
- RECONASS Pilot Test on STV Channel News (25-08-2016)

In the following videos and images the process of the external explosion experiment can be seen.

- RECONASS External Blast – Aerial view
- RECONASS External Blast – View from interior
- RECONASS External blast – point cloud view after the explosion

RECONASS briefing session to guests

[3] The persons attending represented the following organisations: FOI, SECRAB, CESIUM AB, Swedish Fortifications Agency, Swedish Defence Agency (FRA and FM departments), Norwegian Defence Estate Agency (NDEA), SSAB and PEAB AB.

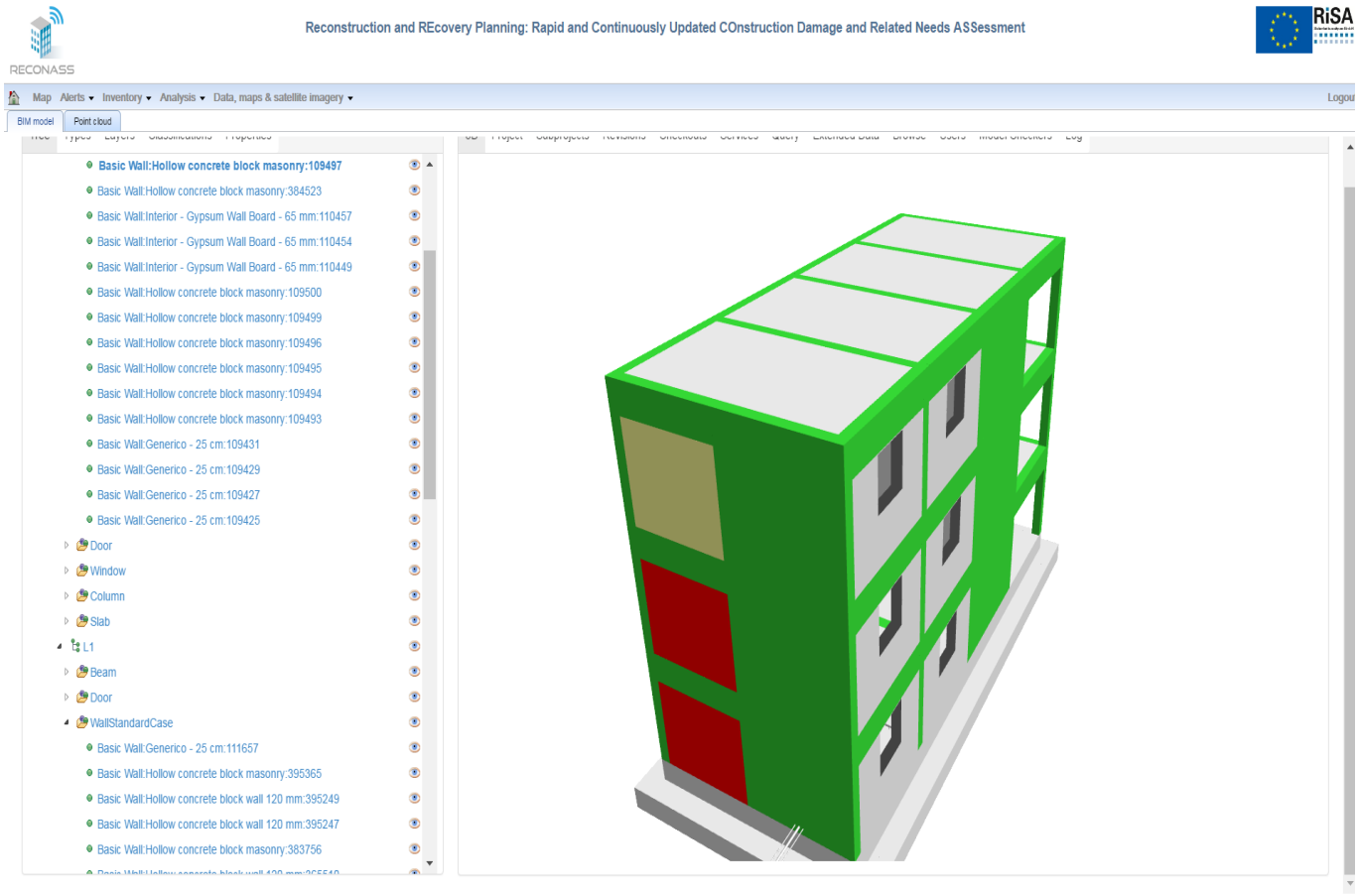
Guests tour in the RECONASS building

RECONASS Building is ready to be subjected to external blast and UAVs to record

Group photo (RECONASS consortium and guests) some minutes before the 1st blast

After External Explosion and the RECONASS Results

After the external blast the RECONASS system remained operational with minor losses of components that did not affect the assessment process. The images below depict the building and the instruments' status as well as the first results visualised by the RECONASS platform (PCCDN). The building remained safe!



PCCDN Tool Results after 1st Explosion (combination of manual/automatic/aerial data)

3 INTERNAL EXPLOSION – 30TH OF AUGUST 2016

On 30th of August the 2nd test, this time an internal blast with 16 Kg of TNT, was executed. Between the two tests the system remained operational and minor equipment failures from the first test were corrected. Furthermore a "hot" evaluation of the individual components of RECONASS system as well as of the assessment results has been performed by the partners. The 2nd explosion was closed to the public and only the consortium attended the test. The images below depict the preparation process for the internal explosion as well as the post-event conditions.

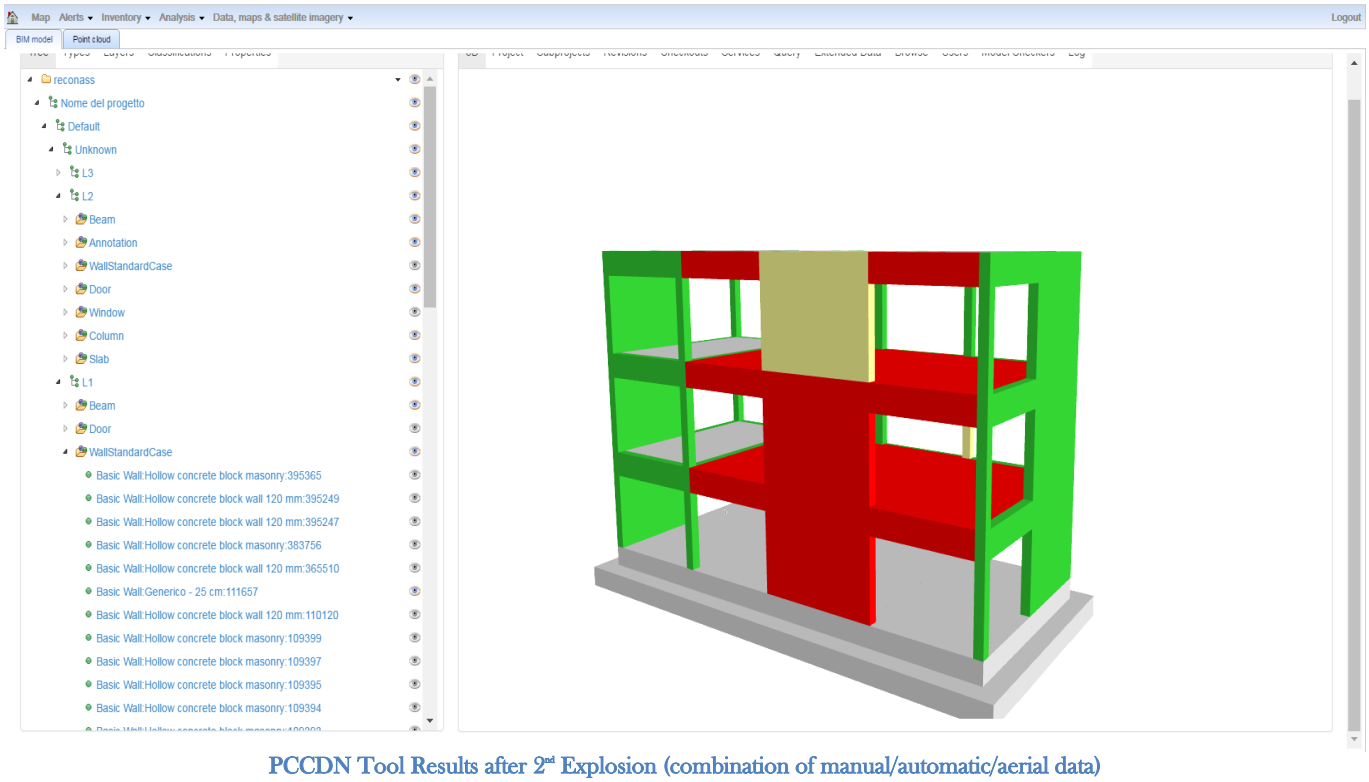
After Internal Explosion and the RECONASS Results

The internal blast was severe to the building (as anticipated/simulated) and some losses of components occurred. However, the system remained (partially) operational as individual sensors failed and it was able to provide, via the absence of data from particular sensors, the assessment that the building was not in a structurally safe condition for certain areas.

In the following link (videos) and images, the event, post-event conditions and the PCCDN tool visualisation/assessment can be seen.

- RECONASS Pilot – Internal Explosion
- RECONASS Internal Blast – GoPro high frame rate
- RECONASS Internal Blast – Aerial View
- RECONASS Internal Explosion – GoPro camera
- RECONASS Internal Blast – Aerial view

Pilot building's condition after internal blast (floor collapsed and external walls/columns were severely displaced)



PCCDN Tool Results after 2nd Explosion (combination of manual/automatic/aerial data)

4 WHAT'S NEXT

In overall, the RECONASS Pilot tests have been a very successful conclusion of the research, implementation and integration efforts of the entire consortium. Not only the project's scope (tools and assessment algorithms) was experimentally validated, but the pilot has been a unique experience for benchmarking and validating the system, allowing at the same time to clearly identify where room for optimisation exists. For the period to come the consortium is focused exactly on the latter by implementing the below activities:

- Evaluation of the RECONASS system and its components from a functional/technical perspective (compliance to functional and technical requirements based on evaluation metrics already established)
- Evaluation of the RECONASS system and its components from a non- functional/end-user perspective (compliance to non-functional user requirements)
- Based on preliminary evaluation results to optimise the system where needed
- Further end-user evaluation of the system and presentation of results to the Final RECONASS Workshop, scheduled for the end of the project.
- Further exploitation of the RECONASS system, based on the experimental validation and the subsequent evaluation. This includes mainly the following steps:
    - RECONASS manual of operations
    - Cost – benefit analysis
    - Push standardisation activities
    - Benefit from clustering activities established (knowledge exchange and expansion of the RECONASS platform)
- Continue the dissemination of the project based on the achievements made and the results obtained from pilot tests

After pilot conclusion (building was demolished and functional equipment retrieved)