



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**

The Loss and Needs Assessment Module

Deliverable No.	D3.3		
Workpackage No.	3	Workpackage Title	Damage, Loss and Needs Assessment
Author(s)	Corrado Sanna (TECNIC)		
Status	Final		
Version No.	V1.00		
File Name	'RECONASS_D3.3_The_Loss_and_Needs_Assessment_Module_v.1.00'		
Delivery Date	29 02, 2016		
Project First Start and Duration	Dec. 1, 2013; 42 months		



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

DOCUMENT CONTROL PAGE

Title		
Authors	Name	Partner
	Corrado Sanna	TECNIC
Contributors	Name	Partner
Peer Reviewers	Name	Partner
	Dimitrios Bairaktaris	DBA
	Mata Frondistou	RISA
Format	Text-MS Word	
Language	en-UK	
Work Package	WP3	
Deliverable Number	D3.3	
Due Date of Delivery	29/02/2016	
Actual Date of Delivery	10/03/2016	
Dissemination Level	PP	
Rights	RECONASS Consortium	
Audience	<input type="checkbox"/> public <input checked="" type="checkbox"/> restricted <input type="checkbox"/> internal	
Revision	(none)	
Edited by		
Status	<input type="checkbox"/> draft <input checked="" type="checkbox"/> Consortium reviewed <input checked="" type="checkbox"/> WP leader accepted <input checked="" type="checkbox"/> Project coordinator accepted	

REVISION LOG

Version	Date	Reason	Name and Company
V 0.01	20/01/2016	First draft	Corrado Sanna (TECNIC)
V 0.02	25/02/2016	Draft for review	Corrado Sanna (TECNIC)
V 1.00	09/03/2016	Revision for submission	Corrado Sanna (TECNIC)

TABLE OF CONTENTS

DOCUMENT CONTROL PAGE	2
REVISION LOG	3
TABLE OF CONTENTS	4
LIST OF FIGURES	7
LIST OF TABLES	8
ABBREVIATIONS AND ACRONYMS	10
GLOSSARY OF TERMS	11
EXECUTIVE SUMMARY	14
INTRODUCTION	16
1. TAXONOMY AND CODING	18
2. ASSESSMENT OF DAMAGE (LIMIT) STATES AND THEIR REPERCUSSIONS	20
2.1. RUGGED COMPONENTS IN REGARDS TO SHAKING-INDUCED DAMAGE	21
2.2. A10 FOUNDATIONS, A20 BASEMENT, B10 SUPERSTRUCTURE: STRUCTURAL LIMIT STATES FOR SEISMIC LOADING, DAMAGE AND REPERCUSSIONS	21
2.3. STRUCTURAL COMPONENTS SUBJECTED TO IN-PLANE OR OUT-OF-PLANE LOADING DUE TO BLAST EFFECTS INDUCED BY AN EXPLOSION.....	26
2.4. STRUCTURAL COMPONENTS EXPOSED TO FIRE.....	26
2.5. B20 EXTERIOR ENCLOSURE.....	28
2.5.1. B201 Exterior non-structural walls	28
2.5.1.1. B2010 Precast Concrete Wall Panels	28
2.5.1.1.1. B2010.001a and B2010.001b (Precast Concrete Wall Panels and Other Brittle Cladding Systems): seismic/shaking induced damage and its repercussions	28
2.5.1.1.2. B2010.001c Precast Concrete Wall Panels and Other Brittle Cladding Systems: Fire Induced Damage and its Repercussions	30
2.5.1.2. B2011 Non Load Bearing Unreinforced Masonry Walls (UMW).....	30
2.5.1.2.1. B2011.001 UMW subjected to seismic excitation; Failure Mechanism: In-Plane Failure; Damage (Limit) States And Their Repercussions	30
2.5.1.2.2. B2011.002 UMW subjected to seismic excitation: Failure Mechanism: Out-Of-Plane Failure; B2012.001 Unreinforced Masonry Parapet (Cantilever): Failure Mechanism: Out - Of -Plane - Failure.....	31
2.5.1.2.3. B2011.003 Non Load Bearing UMW: Fire Damage And Its Repercussions	36
2.5.1.3. B2013 Aluminum Panels	38
2.5.1.3.1. B2013.001 Aluminum Panels: Fire Damage and its Repercussions.....	38
2.5.2. B202 Exterior Window Systems.....	40
2.5.2.1. B2022 and B2023 Exterior Window Systems Subjected To Seismic Loading.....	40
2.5.2.2. B2024 Exterior Window Systems Subjected To Fire	47
2.5.3. B203 Exterior Doors.....	49
2.5.3.1. B2030 Exterior Doors Subjected to Fire	49
2.6. B30 ROOF ELEMENTS	51

2.6.1.	B301 Roof Coverings	51
2.6.2.	B302 Roof Openings.....	52
2.6.3.	B303 Masonry Chimneys (Residential).....	52
2.7.	C10: INTERIOR CONSTRUCTION.....	54
2.7.1.	C101 Interior Non Load Bearing Walls (Partitions)	54
2.7.1.1.	C1011 Gypsum Wall Board Partitions	54
2.7.1.1.1.	C1011.001 Gypsum Wall Board Partitions on Metal and Wood Studs Exposed to Seismic Damage	54
2.7.1.1.2.	C1011.012 Gypsum Wall Board Partitions on Metal and Wood Studs Exposed to Fire.....	57
2.7.1.2.	C1012 Unreinforced Masonry Walls (UMWs).....	57
2.7.1.2.1.	C1012.001 UMWs Exposed to Seismic Damage. In-Plane Failure.....	57
2.7.1.2.2.	C1012.002 UMWs Exposed to Seismic Damage. Out-of-Plane Failure.....	57
2.7.1.2.3.	C1012.002 UMWs Fire Damage and its Repercussions.....	57
2.7.2.	C102 Interior Doors.....	58
2.7.2.1.	C1021 Interior Doors Fire Damage and its Repercussions	58
2.7.3.	C201 Stairs	58
2.7.3.1.	Stairs (C201) Exposed To Seismic Shaking.....	58
2.7.3.2.	Stairs (C201) Exposed to Fire	60
2.7.4.	C301 Wall Finishes Other Than Paint.....	60
2.7.4.1.	C301 Wall Finishes Other Than Paint Exposed to Seismic Shaking.....	60
2.8.	REQUIRED INPUT FROM.....	64
	THE STRUCTURAL MODEL:	64
3.	ASSESSMENT OF THE BUILDING FUNCTIONALITY	65
4.	ASSESSMENT OF THE DEBRIS.....	67
5.	LOSS AND NEEDS ASSESSMENT	69
5.1.	THE BUILDING MODEL	69
5.2.	THE ARCHITECTURE OF THE LOSS AND NEEDS ASSESSMENT MODULE.....	71
5.3.	THE DATA DICTIONARY	71
5.4.	COST AND NEEDS ESTIMATIONS	72
5.4.1.	Shoring Needs.....	72
5.4.2.	Repair costs and repair time	72
5.4.2.1.	Structural Elements.....	73
5.4.2.2.	Non- Structural Elements.....	73
5.5.	THE IMPLEMENTED MODULE	74
	CONCLUSIONS	76
	REFERENCES.....	77
	ANNEX I – RECONASS TAXONOMY AND CODING	81
	ANNEX II – RUGGED COMPONENTS IN REGARDS TO SHAKING-INDUCED DAMAGE	86
	ANNEX III COMMON REHABILITATION TECHNIQUES CONSIDERED IN THIS WORK.....	87
	ANNEX IV – LIMIT STATE DETERMINATION OF ANCHORED NONSTRUCTURAL COMPONENTS (AFTER FEMA, 2012B).....	88

ANNEX V – L&NAM DATA DICTIONARY 90
ANNEX VI – L&NAM IMPLEMENTED FUNCTIONS..... 97

LIST OF FIGURES

Figure 0.1 Typical Investments in Building Construction (Please note that 'Contents' are out of scope of RECONASS) From FEMA E-74/January 2011.....	16
Figure 0.2 Overview of the Estimation of Repair Needs Debris and Functionality in the Case of Structural Components under Seismic Loading.....	17
Figure 0.3. Overview of the Estimation of Repair Needs, Debris and Functionality in the Case of Non-structural Components.....	17
Figure 1.1 Tree Shaped Classification of Components (after Taghavi and Miranda, 2003).....	19
Figure 2.1 Plastic Hinges in a R.C. Building after Earthquake Loading.....	22
Figure 2.2. Deflection of Rocking Walls (Melis, 2002).....	31
Figure 2.3. Simply Supported Wall at Incipient Rocking and at Point of Instability (Melis, 2002).....	32
Figure 2.4. Parapet Wall at Incipient Rocking and at Point Instability (Melis, 2002).....	33
Figure 2.5. Tri-Linear, Bi-Linear and Real 'Semi-Rigid' $F - \Delta$ Relationship (Melis, 2002).	33
Figure 2.6. SDOF Idealisation (Melis, 2002).....	34
Figure 2.7. Multi-Wythe Wall Assemblies (Masonry Advisory Council)	38
Figure 5.1 The nodes in the building model.....	69
Figure 5.2 – L&NAM Process.....	71
Figure 5.3 –The L&NAM Data flow.....	72
Figure 5.4 The Architecture of the L&NAM.....	74
Figure 5.5 The first prototype of the L&NAM – Main results.....	75
Figure 5.6 The first prototype of the L&NAM – Detailed results	75

LIST OF TABLES

Table 0.1 Post Earthquake Structural Damage Assessments.....	17
Table 2.1. Example of Demand Parameters.....	20
Table 2.2. Classes of Structural Components in R.C. Buildings Considered in This Work.....	21
Table 2.3. Common Rehabilitation Techniques at the Component Level.....	22
Table 2.4. Damage States and Likely Consequences for R.C. Columns (After Williams et al. (1997)).....	23
Table 2.5. Damage States and Likely Consequences for R.C. Columns (After Stone and Taylor (1993)).....	23
Table 2.6 Damage States as Functions of Damage Indices Used in This Work.	23
Table 2.7. Common Rehabilitation Techniques at the Component Level.....	24
Table 2.8. Frequency of Usage of Different Repair Techniques in R.C. Moment Frame Buildings After the 1985 Mexico City Earthquake (After Beck et al. (2002)).....	24
Table 2.9. Characteristics of Repair Techniques (After Beck et al. (2002)).....	24
Table 2.10. Proposed Relation Between Damage States and Repair Techniques (Beck et al., 2002)	25
Table 2.11. Damage States as Functions of S.F.s Use in this Work	26
Table 2.12. Rehabilitation as a Function of Deflection at the Midspan of Beams.....	26
Table 2.13. Effect of High Temperature on Concrete Properties (After Yehia and Kashwami, 2013)	26
Table 2.14. Minimum Thickness for Cast In Place Floor and Roof Slabs, in inches (After Bilow and Kamara, 2008).....	27
Table 2.15. Minimum Concrete Column Dimensions, in inches (After Bilow and Kamara, 2008)	27
Table 2.16. Minimum Cover for Floor and Roof Slabs, in inches (After Bilow and Kamara, 2008).....	27
Table 2.17. Minimum Cover Requirements to Main Reinforcement in Beams (All types), in Inches (After Bilow and Kamara, 2008).....	27
Table 2.18. Drift Accommodation Ratio $\delta\alpha$ for Precast Concrete Cladding and Other Brittle Cladding Systems (after FEMA, 2012a).....	28
Table 2.19. Damage State and Its Repercussions for Precast Concrete Wall for In-Plane Damage (B2010.001a)	29
Table 2.20. Damage State and Its Repercussions for Precast Concrete Wall for Out-of-Plane Damage (B2010.001b).....	29
Table 2.21. Minimum Equivalent Thickness of Cast-In-Place or Precast Concrete Walls, Loadbearing or Nonloadbearing	30
Table 2.22. Damage State and Its Repercussions for Precast Concrete Wall for Fire Damage (B2010.201c).....	30
Table 2.23. B2011.001 (Brick Wall) and B2012.001 (Brick Parapet): Limit States for Simply Supported and Cantilever UMWs Subjected to Out of Plane Demands and their Repercussions (Repair actions, damage consequences, functionality and loss after Taghavi and Miranda, 2003). In-Plane Failure.	30
Table 2.24 Non- Load Bearing Solid Brick Wall. Empirically Derived Displacement Ratios for the Tri-Linear Model (Griffith et al., 2003).....	33
Table 2.25. B2011.002 and B2012.001 (Brick Wall): Limit States for Simply Supported and Cantilever UMWs Subjected to Out of Plane Demands and their Repercussions (Repair actions, damage consequences, functionality and loss after Taghavi and Miranda, 2003). Out-of-Plane Failure.....	35
Table 2.26. Fire Resistance Periods as a Function of Thickness of Clay Walls	36
Table 2.27. Thickness Coefficient of Sanded Gypsum Plaster.....	37
Table 2.28. Min. Required Thickness of the Concrete Masonry Assembly (in inches) to Achieve the Indicated Rating.....	37
Table 2.29. B2011.003 (Non Load Bearing UMW): Fire Damage and Its Repercussions	38
Table 2.30. B2013.001 Aluminum Panels: Fire Limit State and Its Repercussions.....	39
Table 2.31 Seismic Damage States for Exterior Windows. In Plane Failure (FEMA, 2012b).....	42
Table 2.32 Tested Window Pane Sizes (FEMA, 2012b)	47
Table 2.33 Window Systems: Damage States, Repair Actions and Building Functionality.	47
Table 2.34 Single Pane Glass: Room Temperature and Time for Occurrence of the First Crack in a Room Fire. 48	48
Table 2.35 Windows: Damage States, Repair Actions and Building Functionality	48
Table 2.36 Resistance of Doors to Fire Exposure (after US Dept. of Housing and Urban Development, 2000). 49	49

Table 2.37 Doors: Damage States, Repair Actions and Building Functionality	50
Table 2.38 Roof Coverings Exposed to Seismic/Shaking Damage: Damage States, Repair Actions and Building Functionality (columns 1 to 5 after FEMA, 2012b).....	51
Table 2.39 Unreinforced Masonry Non-Industrial Chimneys (B303): Damage States, Repair Actions and Building Functionality (columns 1 to 5 after FEMA, 2012b).....	52
Table 2.40 Gypsum Wall Board Partitions (C101): Damage States, Repair Actions and Building Functionality (columns 1 to 5 are after FEMA, 2012b).....	55
Table 2.41 Gypsum Wall Board Partitions on metal or Wood Studs Exposed to Fire (C1012): Damage States, Repair Actions and Building Functionality	57
Table 2.42 Stairs (C201): Damage States, Repair Actions and Building Functionality (columns 1 to 5 are after FEMA, 2012b)	59
Table 2.43 Stairs Exposed to Fire (C201): Damage States, Repair Actions and Building Functionality.....	60
Table 2.44 Wall Finishes other than Paint (C301): Damage States, Repair Actions and Building Functionality (columns 1 to 5 are after FEMA, 2012b).....	61
Table 3.1 Levels of Functionality in Regards to the Structural or Overall Building Part (Including Structural and Non-Structural Components).....	65
Table 3.2 LoF as a Function of S.F.s or Damage Indices	65
Table 3.3. Lof of the Building Part Including Structural and Non-Structural Components	66
Table 4.1. Percentage of main construction components with respect to the volume of a reinforced concrete building.....	68
Table 5.1 Normative quantities for buildings of different occupancies (after FEMA 2012)	74
Table I. 1.RECONASS Damage (Limit) State Menu Categories	81
Table II.1. Rugged Components in Regards to Shaking-Induced Damage (after FEMA, 2012a).....	86

ABBREVIATIONS AND ACRONYMS

ABBREVIATION/ACRONYM	DESCRIPTION
ALFED	Aluminium Federation (UK)
AN	Annealed Glass
ASTM	American Society for Testing and Materials
ASCE	American Society of Civil Engineers
ATC	Applied Technology Council (US)
BRI	Building Research Institute (Japan)
CFRP	Carbon Fiber Reinforced Plastic
D	Damage Index
FEMA	Federal Emergency Management Agency
GEM	Global Earthquake Model
IBC	International Building Code
ICC	International Code Council
IGU	Insulating Glass Units
L&NAM	Loss and Needs Assessment Module
LAM	Laminated Glass
LoF	Level of Functionality
NIST	National Institute of Standards and Technology
NISTIR	National Institute of Standards and Technology Interagency Report
NZSEE	New Zealand Society for Earthquake Engineering
PEER	Pacific Earthquake Engineering Research Center
PVB	Polyvinyl Butyval (a resin)
r.c.	Reinforced concrete
SDOF	Single-Degree-Of-Freedom
SEI	Structural Engineering Institute (US)
S.F.	Safety Factor
UBC	Uniform Building Code
UMW	Unreinforced Masonry Walls

GLOSSARY OF TERMS

Acceleration-sensitive non-structural component	A non-structural component sensitive to and subject to damage from inertial loading. Once inertial loads are generated within the component, the deformation of the component may be significant; this is separate from the issue of deformation imposed on the component by structural deflections (see deformation-sensitive non-structural components)
ATC – 58 Project	The Applied Technology Council (ATC) – US -has entered into a contract with the Federal Emergency Management Agency (FEMA) –US- to develop a next generation of performance-based seismic design guidelines for buildings (project ATC-58). The work includes a building taxonomy and damage states for several structural and non-structural components.
Bending moment	It exists in a structural or non-structural component when a moment is applied to this component so that it bends. It can be calculated by multiplying vector forces (loads or reactions) by the vector distance at which they are applied.
Building downtime	In this work the estimated downtime is limited to the downtime required to complete the repair work.
Component	One of the many parts, both structural and non-structural, that together comprise a building.
Concrete masonry	Masonry constructed with solid or hollow units made of concrete.
Consequences	The consequences covered in this work are the losses resulting from earthquake, blast/impact or fire damage in terms of repair and replacement costs, repair time and construction manpower and material needs.
Curtain wall system	An outer covering of a building in which the outer walls are non-structural.
Damage Index (related to seismic or blast/impact loading)	Released internal bound energy over initially available internal bound energy.
Damage – or limit - state	For a particular component, or the building as a whole, a range of damage conditions associated with unique consequences.
Deformation-sensitive non-structural component	A non-structural component sensitive to deformation imposed on it by the drift or deformation of the structure, including deflection or deformation of diaphragms.
Demand	A parameter that is predictive of component or building damage states, including peak floor acceleration, peak story drift, peak floor velocity or peak component force (or stress).
Displacement	The total movement, typically horizontal, of a component or node.
Economic loss ¹	In this work the assessment of economic loss is limited to the direct cost of rehabilitating or replacing structural and non-structural earthquake, blast/impact or fire damage.
Fire resistance rating	The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by tests or the methods listed in ICC, 2000 (chapter 7 on fire resistance) that are based on

¹ This is synonymous to economic impact defined in SEC (2010) 1626 Final. In this work the assessment of the economic impact is limited to the cost of rehabilitation of buildings.

	fore exposure and criteria specified in ASTM 119.
Floor acceleration	At a floor level, the acceleration of the centre of mass relative to a fixed point in space.
Floor velocity	At a floor level, the velocity of the centre of mass relative to a fixed point in space.
GEM (Global Earthquake Model)	In the GEM project researchers from different countries are developing a physical earthquake risk estimation model of global use. In it a common terminology or taxonomy is critical to document variations in building design and construction practices around the world
In-Plane Behaviour	Behaviour that occurs in the direction parallel to the orientation of the element, which is typically a wall. The term is often used to describe failure, where for instance door and window openings in a wall may no longer have right angle corners.
Instability global	Total failure of the building.
Instability local	Failure of a building component.
Inter-story drift	The relative horizontal displacement of two adjacent floors in a building. Inter-story drift can also be expressed as a percentage of the story height separating the adjacent floors.
Intumescent	A substance that swells as a result of heat exposure, thus increasing in volume and decreasing in density. Intumescent are typically used in passive fire protection.
Load	Any type of force exerted on an object.
Non-structural components	In this work these are components that are a permanent part of the building and are not part of the structural system.
Operating loads	Loads under normal service conditions
Out-of-Plane Behaviour	Behaviour that occurs in the direction perpendicular to the orientation of the structural element, which is typically a wall. The term is often used to describe failure, where for instance a wall may deform outwards or completely collapse into the adjacent street or valley.
Rebar	Steel reinforcing bar.
Rehabilitation	This term is taken in this work to include repair, retrofit, restoration and replacement and is used interchangeably with these words.
Reinforced concrete	Concrete in which steel reinforcement bars (rebars) have been incorporated.
Repair cost	The cost, in present Euros, necessary to restore a building to its pre-damage condition, or in the case of total loss, to replace the building with a new structure of similar construction.
Repair time	The time, in weeks, necessary to repair a damaged building to its pre-damaged condition.
Replacement cost	The cost, in present Euros, necessary to replace a building that has been damaged beyond the point of practicable repair, including costs associated with demolition and removal.
Replacement time	The time, in weeks, necessary to replace a building that has been damaged beyond the point of practicable repair, including time associated with demolition and removal of debris.
Strength	The maximum axial force, shear force, or moment that can be resisted by a component.
Structural components	Building components that are part of the intended gravity, seismic, blast/impact or fire forces resisting system, or that provide measurable resistance to these forces.
Structural system	An assemblage of structural components that are joint together to

	provide regular interaction or interdependence in resisting the intended forces.
Taxonomy	A hierarchical classification system.
Two-Way Walls	Any class of walls supported on at least one vertical and one horizontal edge (Vaculik and Griffith, 2007)
Unreinforced Masonry Wall (UMW)	Clay brick or concrete or natural stone units bound together using lime or cement mortar to form a wall, without any reinforcing elements such as steel reinforcing bars.
Wythe	A continuous vertical section of a wall, one masonry unit in thickness

EXECUTIVE SUMMARY

The objective in Task 3.3 is to develop a Module that will determine the repair needs of the structural and nonstructural components of a monitored reinforced concrete building subjected to operational, seismic, blast/impact or fire loading, in terms of repair cost, construction manpower, construction materials and repair duration. Additionally, this Module will determine the amount of debris and building functionality.

These objectives are focused to the needs of the building owners, the construction and insurance industry and reconstruction and recovery planners.

This report presents the developed methodology for the above Module.

The developed methodology:

- Is a unified methodology for the assessment of economic loss and needs resulting from any of the extreme events under consideration (earthquake, blast/impact, fire) that can be extended to include additional extreme events.
- Is based on the assessment of physical damage at the component and global level due to the extreme events under consideration and the assessment of the direct economic consequences of such damage.
- Provides a detailed taxonomy of all structural and nonstructural components of a reinforced concrete building. This taxonomy provides naming of all components that are consistently used throughout the set of WP3 reports.
- Facilitates global collaboration by being consistent, as much as possible, with existing building taxonomies developed for national use (e.g., in the (US) ATC – 58 project) or for international use (e.g., the GEM building taxonomy).

In this work the partners elaborated appropriate damage states² for all structural and nonstructural components for all extreme events under consideration and, based on these, estimated the economic loss and needs of all structural and nonstructural components for all extreme events under consideration.

For **structural components**:

(a) in the case of seismic loading, the damage states are based on the damage index for the component, an input from the Structural Model in Task 3.2. The damage index of structural members is the ratio of the released internal bound energy over the available internal bound energy. This index and the resulting damage state are far more credible than present methods as they are based on the results of a detailed structural analysis permitted by sensor measurements in the monitored building.

(b) In case of explosion there is an initial state where the air pressure generated by the explosion exerts on the structural members, mainly those lying in the vicinity of the explosive charge, a sudden transversal blast loading with a duration of some milliseconds. As a result of this some of the structural members together with the associated nonstructural components might reach a point beyond practicable repair. These structural members will be an input to this model. The no longer functioning structural members, together with all the nonstructural members attached to them, will be part of the debris calculation in this work. Damage to the remaining components (structural and nonstructural) 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.

(c) In case of fire the input from the structural model will be in the form of safety factors (S.F.s) for each structural component that will determine the need for intervention. Additional input from the structural model will include the midspan deflection in beams and temperatures that will determine the type of intervention.

² Used terms are defined in the Glossary.

(d) In the case of operating loads the input from the structural model is in the form of S.F.s that determine the need for intervention.

For **nonstructural components**, in the case of seismic or blast damage, the damage states are based on input (e.g., interstory drift, peak floor acceleration) from the Structural Model in Task 3.2. In case of fire, the damage states are based on input from the temperature sensors on time of exposure and maximum temperature.

Emphasis has been placed on exterior, non load bearing, masonry walls, prevalent in r.c. buildings in the seismic prone countries of Europe and elsewhere (e.g., in Australia or New Zealand), because the assessed damage of these walls will be used to calibrate satellite based damage maps after an earthquake (WP4). Here, based on published experimental and analytical work on seismically damaged masonry walls and using input from the structural assessment in Task 3.2, the partners were able to assess, the seismic damage of these walls.

The estimates of nonstructural damage, economic loss and needs are continuously updated as estimates of physical damage of the structural system change with time (e.g., due to seismic aftershocks).