



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**

Full specification set for the RECONASS system

Deliverable No.	D1.4		
Workpackage No.	1	Workpackage Title	User Requirements and System Architecture
Author(s)	Isaiah Saibu (GS); Jonathan Naundrup (GS)		
Status	Final		
Version No.	V1.00		
File Name	RECONASS_D1.4_Full_Specification_set_for_the_RECONASS_system_v1.00		
Delivery Date	09/10/2014		
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
	Isaiah Saibu	GS
	Jonathan Naundrup	GS
Contributors	Name	Partner
	Evangelos Sdongos	ICCS
	Nikos Georgakopoulos	ICCS
	Ezzaldeen Edwan	TUD
	Rickard Forsén	FOI
	Roger Berglund	FOI
	Stephanos Camarinopoulos	RISA
	Corrado Sanna	TECNIC
	Emmanuel Bairaktaris	DBA
	Markus Gerke	ITC
	Anand Vetrivel	ITC
	Hassan Shirvani	ARU
Peer Reviewers	Name	Partner
	Stephanos Camarinopoulos	RISA
	Niko Joram	TUD
	Evangelos Sdongos	ICCS
Format	Text-MS Word	
Language	en-UK	
Work Package	WP1	
Deliverable Number	D1.4	
Due Date of Delivery	30/06/2014	
Actual Date of Delivery	09/10/2014	
Dissemination Level	PP	
Rights	RECONASS Consortium	
Audience	<input type="checkbox"/> public <input checked="" type="checkbox"/> restricted <input type="checkbox"/> internal	
Revision	none	
Edited by	Isaiah Saibu (GS)	
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
V0.01	14/04/2014	First draft	Isaiah Saibu (GS)
V0.02	06/05/2014	Revision to the structure, headings and numbering of the first draft	Jonathan Naundrup (GS); Isaiah Saibu (GS)
V0.03	13/05/2014	Revision to the structure and headings based on feedback from ICCS	Isaiah Saibu (GS); Evangelos Sdongos (ICCS)
V0.04	26/05/2014	Including inputs from FOI and ICCS	Isaiah Saibu (GS); Evangelos Sdongos (ICCS); Rickard Forsén (FOI), Roger Berglund (FOI); Nikos Georgakopoulos (ICCS)
V0.05	01/06/2014	Includes inputs from ICCS; TUD; TECNIC	Isaiah Saibu (GS); Ezzaldeen Edwan (TUD); Corrado Sanna (TECNIC); Nikos Georgakopoulos (ICCS)
V0.06	01/07/2014	Include revisions by GS and input of information from some partners' presentations from the 2 nd Plenary Meeting on their technology	Jonathan Naundrup (GS); Isaiah Saibu (GS); Nikos Georgakopoulos (ICCS); Ezzaldeen Edwan (TUD);
V0.07	15/07/2014	Includes inputs from TUD; TECNIC; ITC	Isaiah Saibu (GS); Ezzaldeen Edwan (TUD); Corrado Sanna (TECNIC); Markus Gerke (ITC); Anand Vetrivel (ITC)
V0.08	15/08/2014	Includes inputs from RISA, DBA, ICCS and ARU. Also internal review within GS.	Jonathan Naundrup (GS); Isaiah Saibu (GS); Stephanos Camarinopoulos (RISA); Evangelos Sdongos (ICCS); Nikos Georgakopoulos (ICCS); Emmanuel Bairaktaris (DBA); Hassan Shirvani (ARU)
V0.09	11/09/2014	Include inputs from ICCS on the Abbreviation, Acronym and Glossary table and GS on the Executive Summary and Conclusion section.	Evangelos Sdongos (ICCS); Jonathan Naundrup (GS); Isaiah Saibu (GS)
V0.10	24/09/2014	With feedback from the peer review process	Stephanos Camarinopoulos (RISA); Niko Joram (TUD); Evangelos Sdongos (ICCS);
V1.00	09/10/2014	Changes based on the feedback from the peer review process – Quality Review and PC Review	Isaiah Saibu (GS); Stephanos Camarinopoulos (RISA); Evangelos Sdongos (ICCS); Angelos Amditis (ICCS)

TABLE OF CONTENTS

DOCUMENT CONTROL PAGE	2
REVISION LOG	3
TABLE OF CONTENTS	4
LIST OF FIGURES	6
LIST OF TABLES	7
ABBREVIATIONS AND ACRONYMS	8
GLOSSARY OF TERMS	12
EXECUTIVE SUMMARY	15
1. INTRODUCTION	16
1.1. RECONASS PROJECT OVERVIEW	16
1.2. BUILDING DESIGN AND SCENARIO CASE STUDY	17
2. RECONASS MONITORING SYSTEM	19
2.1. MONITORING SYSTEM DESCRIPTION.....	19
2.1.1. Overview	19
2.1.2. Sub-systems/Components	19
2.1.3. Constraints and Dependencies	20
2.2. ACCELERATION SENSOR REQUIREMENT SPECIFICATION.....	22
2.2.1. Technical Requirement	22
2.2.2. Technical and Design Specifications.....	23
2.2.3. Component Diagram	25
2.2.4. Compliance to Standards and Best Practice	26
2.3. STRAIN AND TEMPERATURE SENSOR REQUIREMENT SPECIFICATION	26
2.3.1. Technical Requirement	26
2.3.2. Technical and Design Specifications.....	28
2.3.3. Strain and Temperature Sensors' Component Diagram	30
2.3.4. Compliance to Standards and Best Practice	31
2.4. LPS REQUIREMENT SPECIFICATION.....	31
2.4.1. Technical Requirement	31
2.4.2. Technical and Design Specifications.....	33
2.4.3. LPS System Architecture and Distributed Nodes Configuration.....	34
2.4.4. Compliance to Standards and Best Practice	35
2.5. DATA-HUB REQUIREMENT SPECIFICATION	36
2.5.1. Technical Requirement	36
2.5.2. Technical and Design Specifications.....	37
2.5.3. System Diagram/Architecture.....	41
2.5.4. Compliance to Standards and Best Practice	42

2.6.	COMMUNICATION GATEWAY MODULE REQUIREMENT SPECIFICATION.....	42
2.6.1.	Technical Requirements.....	42
2.6.2.	Technical and Design Specifications.....	47
2.6.3.	Communication Module Architecture and Interface/Integration with other Subsystems.....	53
2.6.4.	Compliance to Standards and Best Practice	59
3.	RECONASS STRUCTURAL, ECONOMIC LOSS AND NEEDS ASSESSMENT MODULE	60
3.1.	ASSESSMENT MODULE DESCRIPTION	60
3.1.1.	Overview	60
3.1.2.	Sub-systems/Components	61
3.1.3.	Constraints and Dependencies	61
3.2.	STRUCTURAL ASSESSMENT MODULE REQUIREMENT SPECIFICATION	62
3.2.1.	Technical Requirement	62
3.2.2.	Technical and Design Specifications.....	64
3.2.3.	System Diagram/Architecture.....	65
3.3.	ECONOMIC LOSS & NEEDS ASSESSMENT MODULE REQUIREMENT SPECIFICATION.....	66
3.3.1.	Technical Requirement	66
3.3.2.	Technical and Design Specifications.....	67
3.3.3.	System Diagram/Architecture.....	71
3.4.	PCCDN SOFTWARE TOOL REQUIREMENT SPECIFICATION	72
3.4.1.	Technical Requirement	72
3.4.2.	Technical and Design Specifications.....	73
3.4.3.	System Diagram/Architecture.....	75
3.4.4.	Compliance to Standards and Best Practice	75
4.	UAV DAMAGE MAPPING SYSTEM.....	76
4.1.	UAV SYSTEM DESCRIPTION.....	76
4.1.1.	Overview	76
4.1.2.	Sub-systems/Components	76
4.1.3.	Scope of System and Relevant Scenarios	76
4.1.4.	Constraints and Dependencies	76
4.2.	UAV SYSTEM REQUIREMENT SPECIFICATION.....	76
4.2.1.	Technical Requirement	76
4.2.2.	Technical and Design Specifications.....	80
4.2.3.	System Diagram/Architecture.....	82
4.2.4.	Compliance to Standards and Best Practice	83
	CONCLUSIONS	84
	REFERENCES	85
	ANNEXES	87

LIST OF FIGURES

Figure 1-Sketch of building structures and location of high explosive charges to be used in the two project pilot tests	17
Figure 2-Overview of the Local Positioning System (LPS)	19
Figure 3-Component Diagram of the AC-4x Series Force Balance Accelerometer	26
Figure 4-‘Embedment’ and ‘Surface Mount’ Vibrating Wire Strain Sensors	30
Figure 5-Component Diagram of the thermoMETER CTlaserFAST High Speed IR Temperature Sensor with Laser Marking.....	31
Figure 6-Possible LPS node distribution in Structural Health Monitoring application (locatable nodes in red, reference nodes in green, coordinator in grey).....	35
Figure 7-High level architecture and processes of the Data-hubs in the RECONASS Monitoring System	41
Figure 8-Component Diagram of the Data-hub Hardware for the RECONASS Monitoring System	41
Figure 9-High level Communication Gateway Module Architecture.....	55
Figure 10-Flow diagram for WAN (Internet Access)	56
Figure 11-Sensor data flow diagram	57
Figure 12-Management data flow diagram	57
Figure 13-Aggregation network architecture.....	58
Figure 14-Aggregation network architecture.....	59
Figure 15-The process for assessing damage, required repair, cost and duration of repair, manpower/material needs, debris and building functionality.....	70
Figure 16-Required Input for the ‘Structural’ and ‘Economic Loss and Needs’ Assessment Module	71
Figure 17-System Architecture showing Interdependencies of the PCCDN tool	75
Figure 18-System/Process Flow Architecture of UAV System	82

LIST OF TABLES

Table 1-Table showing the translation of the general user requirements into technical requirements for the Acceleration Sensors.....	23
Table 2-General Specification Table for the Acceleration Sensors	25
Table 3-Interface/Integration of Acceleration Sensors with other Subsystems.....	26
Table 4-Table showing the translation of the general user requirements into technical requirements for the Strain and Temperature Sensors.....	28
Table 5-General Specification Table for the Strain and Temperature Sensors	29
Table 6-Interface/Integration of Strain and Temperature Sensors with other Subsystems.....	31
Table 7-Table showing the alignment of the general user requirements to the proposed Local Positioning System	33
Table 8-Interface/Integration of Local Positioning System with other Subsystems	35
Table 9-Table showing the translation of the general user requirements into technical requirements for the Data-hubs.....	37
Table 10-General Specification Table for the Data-hubs.....	39
Table 11-Interface/Integration of Data-hubs with other Subsystems	42
Table 12 -Table showing the translation of the general user requirements into technical requirements for the Communication Gateway Module of the RECONASS system	47
Table 13-Table showing the alignment of the general user requirements to the proposed Structural Assessment Module.....	64
Table 14-Table showing the translation of the general user requirements into technical requirements for the Economic Loss & Needs Assessment Module	67
Table 15-General Specification Table for Economic Loss & Needs Assessment Module	68
Table 16-Functional Specification Table for Economic Loss & Needs Assessment Module	70
Table 17-Interface/Integration of Economic Loss & Needs Assessment Module with other Subsystems	72
Table 18-Table showing the translation of the general user requirements into technical requirements for the PCCDN tool	73
Table 19-Functional Specification Table for PCCDN tool.....	74
Table 20-Table showing the translation into technical requirements of the general user requirements for the UAV Damage Mapping System solely related to ITC	77
Table 21-Table showing the translation into technical requirements of the general user requirements for the UAV Damage Mapping System related to ITC collaboration with other partners.....	78
Table 22-Table showing the translation of the general user requirements related to Data Acquisition into technical requirements for the UAV Damage Mapping System.....	79
Table 23-Table showing the general user requirements not relevant or out of scope for the UAV Damage Mapping System.....	79
Table 24-Functional Specification Table for UAV Damage Mapping System.....	80
Table 25-Interface/Integration of the UAV Damage Mapping System with other Subsystems	83
Table 26-Table showing the rephrasing of the general user requirements relating to the Communication Gateway Module aspect of the RECONASS system.....	88

ABBREVIATIONS AND ACRONYMS

ABBREVIATION	DESCRIPTION
(m)PCI	(mini) Peripheral Component Interconnect
2G	2nd Generation
3 GPPP	3rd Generation Partnership Project
3G	3rd Generation
AC	Alternating Current
ADC	Analogue to Digital Converter
ADSL	Asymmetric Digital Subscriber Line
AES	Advanced Encryption Standard
ATM	Asynchronous Transfer Mode
B.A.T.M.A.N	Better Approach To Mobile Adhoc Networking
CAD	Computer-Aided Design
CAN	Controller Area Network
CBC	Cipher Block Chaining
CO	Central Office
CPE	Customer Premises Equipment
CPU	Central Processing Unit
DB	DataBase
DBMS	DataBase Management System
DC	Direct Current
DFS	Dynamic Frequency Selection
DH	Diffie–Hellman
E/M	Electro-Mechanical
EC	European Commission
EDGE	Enhanced Data rates for GSM Evolution
EIRP	Equivalent Isotropically Radiated Power
EMS-98	European Macro-seismic Scale-98
EPON	Ethernet Passive Optical Network
ETABS	Software package for the structural analysis and design of buildings
EU	European Union
FDD	Frequency-Division Duplexing
FDM	Frequency Division Multiplexing
FDSN	International Federation of Digital Seismograph Networks

FNAVR	Functional Requirement-Availability
FNCNR	Functional Requirement-Connectivity
FNDTR	Functional Requirement-Data and Information
FNIPR	Functional Requirement-Interoperability
FNMDR	Functional Requirement-Modularity
FNPFR	Functional Requirement-Performance
FNRCR	Functional Requirement-Recovery
FNRLR	Functional Requirement-Reliability
FNSCR	Functional Requirement-Security
FNTLR	Functional Requirement-Tools
FPGA	Field Programmable Gate Array
FR	Functional requirement
GB	Giga Byte
GDOP	Geometric Dilution of Precision
GF	Gauge Factor
GIS	Geographic Information System
GND	Ground
GPON	Gigabit-capable Passive Optical Network
GPRS	General Packet Radio Service
GPS	Global positioning System
GSM	Global System for Mobile communications
HSPA	High Speed Packet Access
HTTP	Hypertext Transfer Protocol
HW	Hardware
IEC Code	International Standard
IEEE	Institute of Electrical and Electronics Engineers
IMU	Inertial Measurement Unit
IP	Internet Protocol
IP Code	International Protection Marking
ISDN	Integrated Services Digital Network
ISM	Industrial, Scientific and Medical
J2EE	Java 2 Platform-Enterprise Edition
JTAG	Joint Test Action Group
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode

LOS	Line-of-Sight
LPS	Local Positioning System
LTE	Long Term Evolution
MEMS	Micro-Electro Mechanical Systems
MID	Measuring Instruments Directive
NFCMR	Functional Requirement-Compliance
NFR	Non Functional Requirement
NFUBR	Functional Requirement-Usability
NIC	Network Interface Controller
NMEA	National Marine Electronics Association
NS	Non-Structural
NTP	Network Time Protocol
OFDM	Orthogonal Frequency-Division Multiplexing
OGS	Open Geospatial Consortium
OLSR	Optimized Link State Routing Protocol
PAN	Personal Area Network
PCCDN	Post Crisis Needs Assessment Tool in regards to Construction Damage and related Needs
POTS	Plain Old Telephone Service
QoS	Quality of Service
RAM	Random Access Memory
RECONASS	Reconstruction and REcovery Planning: Rapid and Continuously Updated CONstruction Damage, and Related Needs ASSessment
RF	Radio Frequency
RTLS	Real Time Location System
SEED	Standard for the Exchange of Earthquake Data
SPI	Serial Peripheral Interface
SQL	Structured Query Language
SSID	Service Set Identifier
SSL	Secure Socket layer
SW	Software
SWE	Sensor Web Enablement
TCP	Transmission Control Protocol
TDD	Time-Division Duplexing
TDM	Time Division Multiplexing
TLS	Transport Layer Security
UART	Universal Asynchronous Receiver/Transmitter

UAV	Unmanned Aerial Vehicle
UMTS	Universal Mobile Telecommunications System
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
VDSL	Very high bit rate Digital Subscriber Line
VLAN	Virtual Local Area Network
VTOL	Vertical Take-Off and Landing
WAN	Wide Area Network
W-CDMA	Wide Code Division Multiple Access
WDM	Wavelength Division Multiplexing
WGS84	World Geodetic System
WLAN	Wireless Local Area Network
WP	Work Package
WSN	Wireless Sensor Network

GLOSSARY OF TERMS

Case Study	A case study is a descriptive, exploratory or explanatory analysis of an event.
Communication Gateway Module	In this work the Communication gateway Module refers to the overall communication means utilised to exchange information from the sensors and LPS to the assessment tool (PCCDN).
Early recovery	A multidimensional process of recovery that begins in a humanitarian setting. It is guided by development principles that seek to build on humanitarian programs and to catalyse sustainable development opportunities. It aims to generate self-sustaining, nationally owned, resilient processes for post crisis recovery. It encompasses the restoration of basic services, livelihoods, shelter, governance, security and rule of law, environment and social dimensions, including the reintegration of displaced populations (CWGER, 2008).
Fragility Functions for non-structural components	In this work they show the probability of the non-structural component experiencing or exceeding a certain damage state conditioned on the level of acceleration in the case of acceleration-sensitive non-structural components or the level of drift in the case of drift sensitive non-structural components.
Functional Requirement (FR)	An FR is a statement of an action or expectation of what the system will take or do. It is measured by concrete means like data values, decision making logic and algorithms.
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
GSM, GPRS, UMTS, HSPA, LTE	GSM, GPRS, UMTS, HSPA, LTE refer to a holistic package of public mobile communication solutions with capabilities to transmit data.
Interstory 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.
Magnitude	Size of an earthquake measured on the open ended scale of moment magnitude, sometimes called Richter magnitude.
Miniseed	A stripped down version of SEED (Standard for the Exchange of Earthquake Data) which only contains waveform data. SEED is a data format intended primarily for the archival and exchange of seismological time series data and related metadata.
Non-functional Requirement (NR)	An NR is a low-level requirement that focuses on the specific characteristics that must be addressed in order to be acceptable as an end product. NRs have a focus on messaging, security, and system interaction.

Non-structural Components	All items in a building other than the building structural system and its foundation. Included are all architectural elements such as cladding, glazing, ceiling systems and interior partitions that are permanently attached to the building; all mechanical and electrical equipment such as fire sprinkler systems, water and sewer piping, HVAC (Heating, Ventilating and Air Conditioning) systems and electrical distribution and lighting systems that are permanently attached to the building. For the purposes of this deliverable non-structural components do not include building contents.
Point Cloud	A point cloud is a set of data points in some coordinate system. In a three-dimensional coordinate system, these points are usually defined by X, Y, and Z coordinates, and often are intended to represent the external surface of an object.
Rehabilitation	This term is used to include repair, retrofit and replacement and is used interchangeably with these words.
Remote-Sensing	Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to in situ observation. In this work by using such term we refer to the procedure of obtaining data through aerial or satellite photos regarding the condition of a building as seen from its exterior.
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.
System Architecture	A system architecture or systems architecture is the conceptual model that defines the structure, behaviour, and more views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviours of the system. A system architecture can comprise system components, the externally visible properties of those components, the relationships (e.g. the behaviour) between them. It can provide a plan from which products can be procured, and systems developed, that will work together to implement the overall system.
Taxonomy	Categorization system
Technical Requirement (TR)	A technical requirement pertains to the technical aspects that a system must fulfil, such as performance-related issues, reliability issues, and availability issues etc.
Technical Specification	Specification (often abbreviated as spec) may refer to an explicit set of requirements to be satisfied by a material, design, product, or service.
User Requirement (UR)	A UR is a statement of what users need to accomplish. It is a mid-level requirement describing specific operations for a user (e.g., a business user, system administrator, or the system itself). They are usually written in the user's language and define what the user expects from the end product.
Wi-Fi	The Wi-Fi Alliance, the organization that owns the Wi-Fi (registered trademark) term specifically defines Wi-Fi as any 'wireless local area network (WLAN) products that

	are based on the IEEE 802.11 standards.'
WiMAX	WiMAX (Worldwide Interoperability for Microwave Access) is a wireless communications standard designed to provide 30 to 40 megabit-per-second data rates, with the 2011 update providing up to 1 Gbit/s for fixed stations. The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL"
Wireless Sensor Network (WSN)	Spatially distributed autonomous devices (nodes) using sensors to cooperatively monitor physical (such as, acceleration, strain) or environmental conditions

EXECUTIVE SUMMARY

This document is the fourth deliverable 'D1.4' of work package 1 in the RECONASS project and it consists of the "Full specification set for the RECONASS system". This deliverable is capitalising on the work performed in D1.3 ("User requirements") where functional, operational and performance requirements have been produced from the consortium and the end-users group. More specifically the above requirements have been used as a benchmark to assist the specifications' definition process undertaken by the RECONASS consortium. On top of this, the RECONASS partners depending on their expertise have produced additional specifications for the RECONASS system after elaborating on their own technical requirements.

This deliverable document includes the technical specifications of the RECONASS system and components including the:

- network of sensors (acceleration, temperature and strain),
- local positioning tags,
- data-hubs (for collecting the sensors and tag data),
- communication gateway module (to gather all the data in the appropriate format),
- PCCDN tool (consisting of the structural, economic loss and needs assessment modules) and
- UAV system.

The different technology domain/system components were represented in each chapter of the deliverable (each representing a system component).

The RECONASS partners derived the technical specification for the whole system on a system component basis after extensively studying the user needs i.e. user requirements and in correlation with the expected work to be performed as defined in the DoW. Their respective expertise mainly drove the overall system specifications' guidelines. Further to this and due to the multidisciplinary nature of the RECONASS system, biweekly teleconference meetings were held over a period of 4 months (with a face-to-face project meeting occurring in the middle) to discuss the possible system specification and architecture. Each project partner contributed following a proposed structure as follows:

- Review the user requirement deliverable document (D1.3) to identify which requirements were relevant to our technology domain.
- Then, if applicable, translate/rephrase the requirements; of which some were very general and broadly defined, into more technical descriptions.
- Then for each technical requirement, define specifications for our technology domain (system component) that can meet the requirements.
- Then go beyond the requirements and define any additional and relevant specifications/characteristics of the sub-systems.
- As part of the exercise, we also highlighted in the appropriate section the areas where there were constraints and dependencies with each other's technology
- Each partner contribution was then consolidated into the deliverable 'D1.4: Full specification set for the RECONASS system'.

The current document presents the system specifications derived for RECONASS in this early phase of design. However, the specifications are rather extensive and are covering a plethora of aspects of the RECONASS system. Since RECONASS is a research project and taking into account that specific design and planning activities are expected during the actual development of each subsystem it is possible that additional specifications emerge during such effort. The same applies for the architectural considerations of the RECONASS system as a whole. Such additions will be thoroughly documented and reported in the relevant deliverables in which each specific subsystem is presented in a final form in terms of development and operation.