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Capability Project

LPS and sensor node

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ABBREVIATIONS AND ACRONYMS

ABBREVIATION	DESCRIPTION
AC	Alternating Current
ADC	Analogue to Digital Converter
AES	Advanced Encryption Standard
AODV	Ad hoc On-Demand Distance Vector
ASIC	Application-specific Integrated Circuit
BCM	Bridge Completion Module
CAN	Controller area network
CPU	Central Processing Unit
FMCW	Frequency Modulated Continuous Wave
FPGA	Field Programmable Gate Array
GPRS	General Packet Radio Service
GPS	Global Positioning System
HTTP	Hypertext transfer Protocol
HW	Hardware
HWMP	Hybrid Wireless Mesh Protocol
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IR	Infrared
LAN	Local Area Network
LNA	Low Noise Amplifier
LSN	Local Sensor Network
LOS	Line-of-Sight
LPS	Local Positioning System
LPS	Local Positioning System
MAC	Medium Access Control
MEMS	Microelectromechanical Systems
MODBUS	A serial communications protocol
NTP	Network Time Protocol
PCCDN	Post Crisis Needs Assessment Tool in regards to Construction Damage and related Needs
PLL	Phase Locked Loop
RECONASS	Reconstruction and Recovery Planning: Rapid and Continuously Updated Construction

ABBREVIATION	DESCRIPTION
	Damage, and Related Needs ASSessment
RF	Radio Frequency
RF	Radio Frequency
RFD	Reduced-function device
RS485	Serial interface standard in which data is sent in a differential pair
SRAM	Static random-access memory
SRD	Short range device
SSID	Service Set Identifier
SSL	Secure Socket layer
SW	Software
TCP	Transmission Control Protocol
USB	Universal Serial Bus
VCO	Voltage Controlled Oscillator
VLAN	Virtual Local Area Network
WAN	Wide Area Network
WDS	Wireless distribution system
WEP	Wired Equivalent Privacy
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access
WSN	Wireless Sensor Network
xDSL	Symmetric digital subscriber line
ZC	ZigBee Coordinator
ZED	ZigBee End Device
ZR	ZigBee Router

GLOSSARY OF TERMS

Accelerometer	A sensor that measures the specific force (i.e. acceleration).
Accuracy	Deviation of a measured value to a reference value.
Anchor	Any sensor node with known reference position that communicates with other nodes to give them reference location data.
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).
Coordinator or 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.
Data hub	Data hubs will be used to locally collect all data from the different sensors (acceleration, strain, temperature, position), then transfer this data to the gateway.
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.
Gateway	The communication's module central unit where sensor collected data is aggregated, formatted, classified, validated and finally transmitted to the PCCDN tool for further processing and subsequently overall structural and non-structural assessment. Furthermore, the underlying sensor network is monitored and managed through the RECONASS gateway in a way that ensures the network is operating efficiently mainly in terms of availability, reliability and power consumption.
LAN	Local Area Network – LAN access specifies the various interfaces between the gateway and the data-hubs and the communication means deployed between the data-hubs and the sensors.
LSN	Local Sensor Network – LSN access specifies the interfaces and the network deployed between the wireless/wired sensor nodes and the data hubs.
Magnitude	Size of an earthquake measured on the open ended scale of moment magnitude, sometimes called Richter magnitude.
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.
Precision	The repeatability of a distance or position measurement in an unchanged scenario.
Resolution	The ability of the LPS to separate targets (i.e. tags) in close proximity.
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.

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.
Strain gauge	A strain gauge is a device used to measure strain on an object.
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

The requirements of Local Positioning System (LPS), and sensors were established in D1.4 and D2.1. This deliverable presents the results of initial evaluation of RECONASS sensors and data-acquisition systems with physical prototypes. In order to provide prototypes of the LPS and sensors, TUD, ARU and GS defined sensor design criteria as well as their interfaces. LPS and the sensors were evaluated in the laboratory, tested inter alia, for accuracy and reliability to meet RECONASS requirements. It is intended to place local positioning tags of accuracy under 65 cm in the mid-span of the structural elements to monitor relevant displacements according to structural engineers' requirements. Strain-gauges of measuring range (-25000με to +25000με) are intended to be bonded on steel-rebars that act as reinforcements in concrete. The temperature sensors with measuring range of 40°-1030°C and accuracy of ±10°C to be installed on building walls with steel adjustable brackets. Acceleration sensors of full scale input ±5g and power consumption ≤1W are intended to be placed flat on the floor of level 0, level 1, level 2 and on the roof of the building as specified by structural engineers (DBA).

The tests conducted were based on both the end user requirements and the input to satisfy WP3 on the structural and non-structural assessment. TUD, ARU and GS tested hardware, prototypes and the output signals that feed in to data-acquisition system. Relevant hardware to accept sensor signals and firmware were developed for data-acquisition and communication systems. To minimise the cost, off-the-shelf hardware was used where possible. Partners have interconnected, adjusted and configured the relevant hardware to create a customised solution. Hardware was configured in-line with the needs of the project.

In brief, the LPS prototype module consists of a stack-up of 3 printed circuit boards (PCBs) and a 12V battery supplying the unit. The strain sensors are the 1-LY41-20/120 ones and they are coupled with a Bridge Completion Module that features several precision resistors to balance the strain resistance, hence it provides accurate readings of strain. The temperature sensors are off the shelf pyrometers (““CSmi-SF15-C6/3 Miniature Pyrometer”) whilst the accelerometers are the state of the art in structural monitoring devices, and are developed by GeoSIG (“Type AC-43” accelerometers).

Last but not least and as the prototyping of the overall RECONASS communication module evolves (to be reported in D2.3), the appropriate hardware to support all sensors' interfaces and the data acquisition, management and transmission process were selected. The communication module consists of an off the shelf wireless sensor network solution to support the LPS and the strain sensors. To this end, a proprietary software and custom configuration is to be implemented in RECONASS. A local area network interconnects the remaining sensors as well as provides the overall bridging of all the sensing components (via the data hubs) to the RECONASS gateway. The latter is an embedded high processing unit with custom implementations (both software and hardware) to process and manage the sensors' data and subsequently provide them to the PCCDN tool in the way the end users request them. The interconnection with the PCCDN tool is performed over a custom wide area network solution with multiple interfaces to support heterogeneous networks towards a resilient and robust communication of the monitored building with the outside world and the end users.