WHITE PAPER AP16
SMART CITY

EXECUTIVE SUMMARY

CNR DIITET AP Smart Cities deals with the sustainability of urban services and improvement of the quality of living of the citizens by collecting data from citizens, places and urban assets, processing and analysing this data to enhance the city services.

At the core of this vision there is the Smart City IoT Platform, a system that enable the collection of data from connected sensors integrated with real-time monitoring systems, crowdsourced personal devices of citizens and various types of everyday objects that are deployed in the city. The information and knowledge that can be acquired from this data is essential to improve city operations and services. Key barriers for the successful deployment of such smart city IoT platform are interoperability, scalability, economic viability, user trust and adoptation. HORIZON 2020 Programme identify four main areas:

- Energy, where a first priority is to develop new technologies, approaches and tools to manage and control urban energy systems and grids;
- Transport, where the key priority is to design efficient, safe and sustainable urban mobility systems by reducing the dependence on inefficient private motorized transport while mitigating traffic congestion and other transport-related costs;
- Building, not only to optimise energy consuming, but also, according to the perspective of cognitive building, to offer to people personalized solutions with the aim of improving the quality of life in their living environments, receiving feedbacks and providing recommendations;
- Communities of Citizens, because citizens play a key role in the development of smart cities and represent final users of all the services. Engaging citizen's means doing everything in an open, inclusive, and participatory way. It also means increasing citizen's collaboration and participation in smart city governance, with citizens contributing to data collection and the definition, execution and evaluation of smart city programs.

Each of these main topics is briefly discussed in the document and linked to the current activities of CNR research groups in AP SC. The impact, in terms of working groups, joint laboratories, personnel efforts and main projects of the area, is also described. A list of the specific challenges is then presented.

1. STATE OF THE ART OF THE RELEVANT SCIENTIFIC AREA

Cities and urban communities in Europe and around the world are undergoing profound socio-economic transformations as a result of global demographic, social and economic trends, as well as technological innovations. The United Nations estimates that 54% of the population lives in urban areas today, but this trend is expected to continue and by 2050 more than 80% of the population will live in cities. Cleary, the speed and scale of urbanization brings huge challenges in terms of resource consumption, transportation needs and economic development. Cities are responsible for more than 75% of a country's GDP but they also consume about 75 per cent of global primary energy and emit between 50 and 60 per cent of the world's total greenhouse gases. Urban areas need to manage their development, supporting economic competitiveness, while enhancing social cohesion, environmental sustainability and an increased quality of life of their citizens.

Given the above context, the Horizon 2020 action is promoting a set of initiative to contribute to the "Sustainable Cities and Communities" goal, which is one of the 17 Sustainable Development Goals (SDGs) agreed by the UN member states in 2012. The key challenge is "*to significantly increase the overall energy*

and resource efficiency as well as climate-resilience of Europe's cities in a holistic fashion, targeting the building stock, energy systems, mobility, climate change, as well as water, air quality, waste and noise”.

Smart City technologies optimize the sustainability of urban services and improve the quality of living of the citizens by collecting data from citizens, places and urban assets, processing and analysing this data to improve the city services. At the core of this vision there is the **Smart City IoT Platform**, a system that enable the collection of data from connected sensors integrated with real-time monitoring systems, crowdsourced personal devices of citizens and various types of everyday objects that are deployed in the city. The information and knowledge that can be acquired from this data is essential to improve city operations and services. Key barriers for the successful deployment of such smart city IoT platform are interoperability, scalability, economic viability, user trust and adoption. The volume, variety and velocity of the smart city data bring also huge challenges for knowledge discovery and intelligent decision making. Thus, data-related technological innovations, such as big data analytics, edge computing, artificial intelligence and learning approaches are key to cope with the highly dynamic nature of smart cities and learn from real-time data.

In the following we present the key areas of interventions for a Smart City that are identified in the H2020 Programme, and we discuss the open issues.

Energy: A first priority is to develop new technologies, approaches and tools to manage and control urban energy systems and grids. Several trends, such as the massive development of renewable energy technologies and distributed generation; the shift towards more electric cooling, heating and transport systems; the key role of energy storage to improve network capacity; the deployment of integrated communication and control systems in the power grid; the active participation of consumers to load balancing in critical situations, are contributing to radically transform the way energy is produced, distributed, and consumed. The goal is to develop integrated approaches to match renewable energy production and consumption at local level enabling *community-level microgrids* and *positive energy districts*.

Transport: The key priority is to design efficient, safe and sustainable urban mobility systems by reducing the dependence on inefficient private motorized transport while mitigating traffic congestion and other transport-related costs. A combination of factors will contribute to achieve this goal. First of all, information and data communication capabilities will play a key role in the design of next generation traffic management systems supporting new *door-to-door mobility services* by means of integrated multimodal transport systems. In addition, a new generation of *shared mobility services* are being designed and seamlessly integrated in the urban mobility landscape to increase the transport efficiency by moving more people in fewer cars. Thus, the design of optimised approaches to foster the growth of real-time ride sharing and promote more sustainable and social-aware travel models are of particular relevance. A third factor that is expected to revolutionize urban mobility, for instance making travel more accessible and safer, is the integration of connected, autonomous and cooperative technologies in the overall transport system. Clearly, cooperation, connectivity, and automation are not only complementary technologies, they reinforce each other and will over time merge completely. Key challenges are to increase the safety of automated vehicles (AVs), allow the coexistence between vehicles with no active control systems and varying levels of automated vehicles, embed shared AVs within the public transportation system, and rethink urban planning accounting for the decline of private cars. Finally, electrification of transport systems will significantly contribute to reduce the impact of transport on the environment and human health. Furthermore, electric vehicles (EVs) will also open the way to innovative uses and services as EVs could play the role of producer-consumers of energy services, through vehicle-to-grid (V2G) and smart charging.

Building: A large share of energy in the EU is consumed by buildings (around 40%). Thus, buildings play a key role in the EU sustainability policies and strategic energy plans. All new buildings constructed after 2020 are required to adopt “Nearly Energy Zero Building” (NZEB) standards. Furthermore, buildings are expected to be integrated as active elements of wider energy networks, and to foster innovative mobility solutions. However, building management can go beyond its physical structure, and the monitoring and optimisation of energy performance. A building can contain a variety of sensors and can exploit data retrieved from them to learn the behaviours and daily habits of building inhabitants and users so that it can diagnose and mitigate unwanted events, thus becoming a *cognitive building*. A cognitive building is able to offer to people, which

are geo-spatially tracked, personalized solutions with the aim of improving the quality of life in their living environments, receiving feedbacks and providing recommendations.

Communities of citizens: Citizens play a key role in the development of smart cities. Engaging citizens means doing everything in an open, inclusive, and participatory way. It also means increasing citizens’ collaboration and participation in smart city governance, with citizens contributing to data collection and the definition, execution and evaluation of smart city programs. Clearly, Internet technologies will have a radical effect on cities’ organization and relationship with their citizens by changing the way productive processes are organized, how economic transactions take place, and even how citizens consume culture and leisure service for instance. In addition, online and mobile social networking (MSN) services will be fundamental tools to empower the citizens. Finally, to increase the resilience of urban communities to disasters, the concept of smart city should be embedded within a broader framework of resilient city. For instance, technologies and capabilities for first responders for emergency operations in crisis and disaster situations are needed. Furthermore, cybersecurity should be improved substantially, to ensure the protection of the huge number of IoT devices that will be deployed in the city.

2. CONTRIBUTION TO THE RELEVANT SCIENTIFIC AREA

In the “MOBILITY” thematic area the research lines that are currently active can be grouped as follows:

- *Design of Demand Responsive Transportation (DRT) systems*: One focus is to develop optimised tools for the DRT operational planning, based on Dial-a-Ride models, both for the booking and travel phase of the service. Moreover, innovative algorithms have been studied to support car-sharing systems, bike-sharing and car-pooling in urban and extra-urban context. This activity is also dedicated to the development of new models and tools to promote multimodality and the integration of DRT systems with conventional modes of transport. Involved Institutes: **IAC, IASI, IIT**
- *Mobility models*: We have developed forecasting models of traffic flows on large-scale road networks by combining integrating fluid-dynamic macroscopic models with cross-over dynamics models, which allows simulating in real-time the traffic status. We also have developed new methodologies for providing real-time information about mobility-related phenomena, e.g. mobility demand models, individual mobility patterns from various mobility-related data sources, including mobile phone data, geo-located media on social networks. These data provide useful real-time insights for transport users and traffic operators, and can help to tackle a vast variety of mobility situations, i.e., congestion, safety, tolling, navigation support. Involved Institutes: **IAC, ISTI.**
- *Optimisation methods for logistic and transportation service. Logistics and fleet management*: We have developed advanced optimisation methods and tools for planning and real-time operation of smart city logistics and transportation services. We focused on: i) distribution of goods and the management of fleets at different territorial scales, ii) vehicle routing and orienteering problems, and iii) door-to-door waste collection. Involved Institutes: **IAC, IASI**
- *Virtual Traffic Lights*: This activity focuses on the development of a cooperative and autonomous system for the management of road intersections to reduce traffic congestion and improve road safety. Involved Institutes: **IEIIT**.
- *Communication systems for vehicular environments*: Our focus is to investigate the hybrid cooperation of different wireless access technologies for ultra-reliable and low-latency communications for connected and autonomous vehicles. In particular, we have developed models and algorithms of D2D communications supporting automotive services. Another aspect is the optimization of V2X communications for rural environments characterized by low vehicle density and natural obstacles. Involved Institutes: **IEIIT**, **IIT**, **ITAE**.
- *Intelligent Transportation Systems*: We have designed platforms and tools for efficient traffic management. One focus is on how to integrate geo-referenced data in the context of smart and sustainable mobility, dealing with data interoperability and standards, crowdsourcing, data visualization and analysis. Another fundamental aspect is to design solutions to reduce emissions

and optimize journey times. Furthermore, we have developed smart cameras with cooperative sensing functionalities for real-time and capillary traffic monitoring. Involved Institutes: **IMATI**, **ITAE, ISTI**.

- *Low-emission vehicles*: The activities are focused on the development of long-range hydrogen vehicles equipped with fuel cells and batteries. Involved Institutes: **ITAE**.
- *Electrical mobility*: We have developed short to mid-term models of electric mobility diffusion to assess the relative infrastructure requirements, to design management tools for smart charging infrastructures, and to evaluate the impact on renewable energy production/storage systems. Involved Institutes: **ITAE**, **IM, IIT**.

In the “ENERGY” thematic area the research lines that are currently active can be grouped as follows:

- *Vehicle-to-Grid (V2G) services*: We have developed optimisation methods for energy management of vehicle battery packs to support smart micro-grids through V2G services, through vehicle to grid services. Another aspect is the development of multi-agent aggregation schemes for private vehicles and public/corporate fleets, leveraging the knowledge of users’ charging behaviours. Involved Institutes: **IM, ITAE**.
- *Power-to-Gas (P2G) systems*: We have developed P2G systems using electrolysis and CO2 recovery for storage or methane network integration. Involved Institutes: **ITAE**.
- *Resiliency in SGs*: We have developed methodologies and tools to increase the resiliency of smart grids against both cyberattacks and faults. Involved Institutes: **IEIIT**.
- *Communication and control of SGs*: We have developed technologies and system to enable distributed communication, measurement and control capabilities within nest-generation power grids. Our focus is on design of: i) reliable, scalable and interoperable communication systems and networks for SGs, using both wireless and PLC technologies; ii) new cooperative or hierarchical methodologies for reliable estimate of SG state; iii) new smart meters; iv) IED technologies for remote management of distributed generators and storage systems; and v) new polyhedral formulations for the problem of the Unit Commitment for thermal power plants. Involved Institutes: **IEIIT, INM, IASI**.

In the “PLATFORMS” thematic area the research lines that are currently active can be grouped as follows:

- *Smart IoT platforms*: We have developed a Swarm-Edge IoT platform that allows dynamic addition of processors/devices for uninterrupted distributed processing, connectivity and protocol-agnostic heterogeneous by means of using proactive, self-emergent dynamic configurable, software-defined autonomous agents that learn and share data at the edge of the network. The architecture uses Swarm Intelligence (SI) techniques to enable multi-agent artificial intelligence, facilitated collective machine learning, and to provide an AI-based decentralized self-forming intelligence at a high scale. Finally, the SioT paradigm has been integrated to realize a social network of objects. Involved Institutes: **ICAR**.
- *Urban monitoring:* This research activity concerns with the development of sensing technologies, tools, and models for monitoring urban phenomena and knowledge discovery from urban data collected locally. Several aspects are addressed. We have developed reliable, low-cost sensors for obtaining data about weather dynamics, noise levels, atmospheric pollution, environmental indicators, etc. We have also developed sensing technologies for activity recognition and behavioural assessment. Another focus is the development of intelligent cameras for objects and people identification with the use of artificial intelligence technologies based on deep learning. Integration of drone technology and cameras is also investigated. Furthermore, we design new methodologies and service for spatiotemporal monitoring of urban areas by processing remote sensing images, and generating semantic meaningful information, such as flooded areas, burned areas, displacement maps. Finally, we have developed models of the spatiotemporal dynamics of the demands for mobile services in urban areas, as well as land use detection and population density estimation techniques, by leveraging mobile network metadata. Involved Institutes: **ICAR**, **IEIIT**, **INAMOTER, IMEM**, **IRC, ISTI.**

In the “BUILDING” thematic area the research lines that are currently active can be grouped as follows:

- *Building monitoring and control*: Our focus is to design services that make the building intelligent by acting on parameters such as lighting, thermal comfort, air quality, physical safety, etc. We develop sensor networks that are able to monitor both the energy consumption of building environments and users, as well as various environmental parameters (temperature, humidity, air quality, etc.). Moreover, smart cameras can produce images and video to detect danger situations (thefts, aggressions, etc.). The collected data, crossed with each other through appropriate algorithms, allow the development of virtual sensors (intrusion, climatic well-being, energy saving, etc.), and services that assist users in tuning their habits (i) for reducing power consumption; (ii) for safety and comfort issues. Involved Institutes: **ITAE, ISTI, ICAR, ITC.**
- *NZEB technologies*: One focus is the development of standardized panels for ventilated façades or roofs combining PV, solar thermal, insulation, PCM and batteries. The general objective is to innovate the building process considering the advantages associated with using renewable energy generation, storage and energy management in façade. The second focus is the development of hybrid thermal/electric storage based on PCM and batteries, and integrated with renewable energy sources in order to increase the overall energy efficiency of air conditioning systems for residential application. Involved Institutes: **ITAE**.
- *Cognitive buildings:* The goal of the research is to combine IoT technology, cognitive computing, big data, machine learning and reasoning to help people live and work better in buildings, as well as maintain and manage the building itself by providing it with the capabilities to learn over time how to improve building management. Involved Institutes: **ICAR**

In the “COMMUNITIES OF CITIZENS” thematic area the research lines that are currently active can be grouped as follows:

- *Open Data, Linked Data and semantic technologies*: We have developed methodologies for data publication as Open Data and data integration as Linked Data for e-Government applications. Involved Institutes: **IMATI**.
- *Social networking applications*: One focus is to develop applications and tools for connecting citizens with the social context in which they live to strengthen their links with their neighbourhood thus enabling the volunteering for neighbourhood welfare services. We also design social networking applications to facilitate human interactions and to enable users to share data within temporary and localised social communities based on common interests. Involved Institutes: **IREA**, **IIT**.
- *Applications for tourism and use of cultural heritage*: We have developed web-based services and mobile apps for facilitating users to plan their visit tours, but also to get detailed and contextualised information about the cultural contents of tourist sites, while they are visiting them. Another activity concerns the design of optimized models for the creation of car sharing and bike-sharing systems for tourism or to choose the optimal pedestrian route. Involved Institutes: **IAC, ISTI**.
- *Applications for a safer and more accessible city*: We have developed algorithms for the optimal management of rescue vehicles in emergency situations. We have also developed models of crowd dynamics and methods for the management of pedestrian flows. Involved Institutes: **IAC**.
- *Water management system*: We have developed a smart system for real-time detection of the saturation of the urban drainage network, the overloading of the sewage treatment plants, and to regulate the flow and water flow in the pipeline. Involved Institutes: **ICAR**.

3. IMPACT

DIITET Institutes are participating to several working groups and research alliances, both at the European and Italian level, where emerging research challenges, solutions, strategies and policies relevant to the Smart City domain are discussed. The most relevant are the following:

- European Energy Research Alliance – **EERA**, with special focus on the Joint Programmes Smart Cities, Energy Storage, and Smart Grid (ITAE)
- Distretto Tecnologico Nazionale sull’Energia – **Di.T.N.E.** (ITAE)
- Distretto Tecnologico Nazionale sulle Tecnologie Ambienti di Vita – **TAV** (ICAR)

- Associazione Nazionale per la Telematica per i Trasporti e la Sicurezza – **TTS** (ITAE)
- Mobilità Idrogeno Italia – **MH2IT** (ITAE)
- Cluster Tecnologici Nazionali
    - Energia (ITAE)
    - Trasporti (ITAE, IIT, IEIIT)
        - Coordinator of the “Intelligent Transportation System” Woking Group – **ITS** (IAC)
    - Smart Cities (ITAE)
- Polo di Ricerca e Innovazione “Tecnologie e Ricerca Network Sicurezza ed Intermodalità nei Trasporti” – **T.R.A.N.S.I.T.** (INM, IMATI)
- European Innovation Partnership on Smart Cities and Community – **EIP-SCC** (ITC)
- Cluster “smart cities and communities” – Regione Lombardia (IREA)
- Cluster “aerospazio” – Regione Lombardia (IREA)
- Tuscan Rail Technological District – **DITECFER** (ISTI)

Joint laboratories have been established with universities and public authorities, such as:

- “Intelligent Transportation Systems” Lab, between INM and the Department of Mechanical, Energy, Management and Transportation Engineering (DIME) of the University of Genova.
- “Smart Distributed and Pervasive Systems” – (SPEEDY LAB), **ICAR** in collaboration with the Department of Mechanical, Energy and Management (DIMEG) of the University of Calabria
- Measurement and Communication for Smart Grids” Lab, between INM and the Department of Energy, Information Engineering and Mathematical Models (DEIM) of the University of Palermo
- “Centro di Ricerca per l'Analisi delle Informazioni Multimediali” – **CRAIM**, IIT and ISTI in collaboration with Department of Public Safety, Ministry of Internal Affairs
- “European Laboratory on Big Data Analytics and Social Mining” – **SoBigData.it** Lab, between ISTI, IIT and the Department of Computer Science, University of Pisa

A summary of the CNR personnel efforts contributing to Smart City-related research is reported below

INSTITUTE	# RESEACHERS	# TECHNOLOGITS	FTE (RESEARCH)	FT (TECHNOLOG.)
IAC	3	2	2,3	1,1
IASI				
ICAR	8	1	8,0	0,4
IDASC				
IEIIT	9	0	3,4	0
IFAC				
IIT	9	0	4,8	0
IM				
IMAMOTER	4	0	0,75	0
IMATI	3	0	0,5	0
IMEM	7	0	1,2	0
IRC				
IREA	8	3	1	0,4
INM	7	0	4	0
ISTI	17	0	4,4	0
ITAE	34	2	7,75	0,8
ITC	2	2	0,8	0,35

ITIA				
(TOTAL)				

Details about major active projects (overall budget > 1ME):

Project name	***Funding institution***	***Budget***	***Start year, duration***	***CNR Institutes/Role***
PoWER – Ports as driving Wheels of Enterpreneurial Realm	EU Interreg ADRION, Innovative and Smart Region	1.436 k€	01/01/2018, 24 months	**ITC**, Coordinator,
HAPPEN – Holistic APproach and Platform for the deep renovation of the Med residential built ENvironment	H2020-EE-2017-CSA-PPI	2.108 k€	01/04/2017, 36 months	**ITC**, Coordinator
STAGE – Streaming of Theatre and Arts for old aGe Entertainment	AAL-2015-1-014	1.304 k€	01/03/2016, 35 months	**ITC**, legal representative ITABC, coordinator
PROGRESSIVE – Progressive standards around ICT for active and healthy aging	H2020-SC1-2016-CNECT	905 k€	01/10/2016, 24 months	**ITC**, Partner
HYBUILD – Innovative compact HYbrid electrical/thermal storage systems for low energy BUILDings	H2020-EEB-2017	5.995 k€	01/10/2017, 48 months	**ITAE**, Partner
CHEAPH2 – Combined HEAt, Power, and Hydrogen generation system integrated in a hydrogen filling station	PONMISE HORIZON 2020	3.798 k€	01/01/2017, 36 months	**ITAE**, Partner
E-BRICK – Componente edilizio per uso residenziale a supporto dell’efficientamento e produzione di energia da fonte rinnovabile fotovoltaica	PONMISE HORIZON 2020	1.680 k€	01/04/2017, 36 months	**ITAE**, sub-contractor
HPEM2GAS – High Performance PEM Electrolyser for Cost-effective Grid Balancing Applications	H2020-JTI-FCH-2015-1	2.654 k€	01/04/2016, 36 months	**ITAE**, Coordinator
NEPTUNE – Next Generation PEM electrolysers under new extremes	H2020-JTI-FCH-2017-1	1.927 k€	01/02/2018, 36 months	**ITAE**, Partner
Track and Know	H2020	4.848k€	01/01/2018, 36 months	**ISTI**
SoBigData: Social Mining and Big Data Ecosystem	H2020-INFRAIA-2014-2015	5.917k€	09/01/2015, 48 months	**ISTI**, Coordinator, **IIT**, Partner
MOSCARDO – Tecnologie ICT per il MOnitoraggio Strutturale di Costruzioni Antiche basato su Reti di sensori wireless e DrOni	PAR FAR FAS 2014 – Regione Toscana	2.444k€	26/04/2016, 30 months	**ISTI**, Partner
SIGS – Sistema integrato geotermico solare di riscaldamento e raffrescamento in logica Smart grid	PAR FAR FAS 2014 – Regione Toscana	4.707 k€	10/05/2017, 24 months	**ISTI, IIT**, Partner
SCIADRO	PAR FAS – Regione Toscana	4.803k€	08/09/2006, 30 months	**ISTI**, Partner

Visual Deep Engines For Monitoring (VIDEMO)	Regione Toscana		01/08/2016, 30 months	**ISTI**, Coordinator,
Visual Engines for Cultural Heritage (VISECH)	Regione Toscana		01/03/2018, 30 months	**ISTI**, Coordinator,
CRAIM - Centro di Ricerca per l'Analisi delle Informazioni Multimediali	Ministero degli Interni		05/08/2015, 36 months	**IIT**, Coordinator **ISTI**
Renaissance in Places with Innovative Citizenship And Technology (REPLICATE)	H2020 SC-2015	29.250k€	01/06/2016, 60 months	**IIT**, **ITC, IM**, Partners
RES NOVAE - Networks Buildings Roads New Objectives Virtuous for the Environment and Energy	PON - MIUR	24.000 k€	60 months	ICAR, Parner
DOMUS- District of infOrmatic technologies and coMunication for the development of intelligent and sustainable environments	PON - MIUR	10.000 k€	60 months	ICAR, Partner
COGITO – A COGnItive dynamic SysTem to allOw buildings to learn and adapt	PON - MIUR	8.850 k€	30/09/2018 36 months	ICAR, Partner
Genova Smart Mobility 2.0	Regione Liguria	1.715 k€	Late 2018, 24 months	**INM**, Partner
URBAN GEO BIG DATA “URBAN GEOmatics for bulk information generation, data assessment and technology awareness	PRIN-2015 MIUR		05/02/2017, 36 months	**IREA**, Partner
SIMULATOR-ADS:Sistema Integrato ModULAre per la gesTione e prevenziOne dei Rischi Arricchito con Dati Satellitari	POR FESR 2014 – 2020	1.200 k€	01/12/2016, 24 months	**IREA, IDPA**, Partner
FHfFC – Future Home for Future Communities	Accordo Quadro CNR Regione Lombardia	2.850 k€	01/01/2017, 24 months	**ITIA**, Coodinator, **IREA, ICMATE, IPCB, IBFM, INO, IFN, IBBA, IMATI, ITC** Partners,
MIE – Mobilità Intelligente Ecosostenibile	MIUR - Bando PON-CTN	10.770 k€	30/09/2017, 36 mesi prorogato al 2018	**IASI, IAC, ISTI, IMATI, IIT**, Partners
La città educante	MIUR - Bando PON-CTN	9.637 k€	01/01/2014, 48 months	**IEIIT, IIT, ITD, ISTC, IRPPS, ILC**, Partners
DAWN4IoE – Data Aware Wireless Networks for Internet of Everything	H2020 MSCA RISE 2017	850 k€	01/12/2017, 48 months	**IEIIT**, Coordinator
V2X – Communication Module and System Technology & Communication service and plug test technology	Korea Institute Advancement Technology (KIAT)	1.600 k€	01/12/2016, 36 months	**IEIIT**, Partner
PLUG-IN – Piattaforma per la mobilità Urbana con Gestione delle	MIUR	3.408 k€		**IMATI**, Partner

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4. EMERGING RESEARCH CHALLENGES

For the above thematic areas, a (incomplete) list of emerging research challenges:

- Integration of thermal storage and hybrid storage with electrical batteries in building management.
- Development of building integrated photovoltaic technologies
- Improve autonomy of hybrid electric vehicles, low-carbon hydrogen including fuel cells
- Connected, cooperative and automated mobility systems
- Data and video analytics for security applications in city environments
- Enabling cognitive smart cities using big data analytics, machine learning and artificial intelligence
- Technologies and tools for positive energy districts and zero-emission mobility and logistics
- Better management of responsive transport systems, fleets and logistic services
- Traffic forecasting models.
- Algorithms and applications for tourism and the use of cultural heritage.
- Identification and use of appropriate data analytics platforms that allow both historical data analysis and predictive analysis.
- Security applications by computer vision methods, such as i) automatic monitoring of strategic targets and infrastructures, ii) real time data acquisition for remote surveillance iii) multimodal survey and mapping of urban areas

5. CONCLUSIONS

Even if there is no single generally acceptable definition for the concept of Smart Cities, it is emerging worldwide a prototype of an urban environment provided with a new generation of innovative services for transportation, energy distribution, environmental monitoring, emergency response, and social activities, which frequently interact with each other thanks to ICT solutions. These networks of relationships lead smart cities to become a system-of-systems, with global missions. This multidimensional and multidisciplinary nature of the Smart City concept implies and requires at level of CNR a strong synergy and a partial overlapping of the current activities with other APs’ such as Future Internet, Healthcare and well-being, Sustainable buildings, Society security. The main difference with each of them is represented by the highly integrated approach which is required in this sector, where each aspect is strictly connected to the others.
The 18 CNR Institutes, which work and/or have showed interest in this AP, cover the main areas of activity, and exactly Mobility, Energy, platforms, Buildings and Communities of Citizens. The fields of activity cover:

- participation in several working groups, both at the European and Italian level, in order to discuss emerging research challenges, solutions, strategies and policies;
- joint laboratories with universities and public authorities, as a tangible example of integrated and integrated approach to the problem;
- participation in several national and international projects (only the most relevant in term of funding are listed in the IMPACT section), in order to study and realize a number of solutions to specific problems.

PROJECT AREA 16: SMART CITIES

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