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TRIMESTRALE
ANNO IV - N. 4/2017

Ing. Francesco Marinuzzi, Ph. D.

World Engineering Forum

Dal 27 al 29 novembre 2017 si è svolto a Roma il World Engineering Forum. L'evento, come si è potuto evincere dal suo titolo, "Salvaguardare l'eredità dell'umanità: una grande sfida per gli ingegneri", ha rappresentato un momento di riflessione su quello che sarà il mondo dell'ingegneria nel prossimo futuro, delineando il possibile ruolo dell'ingegnere. L'ingegneria e l'ingegnere contemporanei, infatti, devono cogliere le sfide che la modernità impone, con particolare attenzione al tema dell'innovazione tecnologica e dello sviluppo sostenibile. Le sessioni sono state arricchite dal contributo di relatori di spicco provenienti sia da organizzazioni internazionali, sia dal mondo accademico ed imprenditoriale, che si sono confrontati su argomenti riguardanti alla tematica generale del forum.

L'Ordine degli Ingegneri della Provincia di Roma è stato presente a questo importante evento con la partecipazione di

più colleghi che ringraziamo vivamente per il contributo espresso e per l'entusiasmo che sempre manifestano nello svolgimento della nostra professione.

Dott. Ing. Carla Cappiello

In questo numero speciale dedicato al World Engineering Forum pubblichiamo i contributi dei seguenti colleghi

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Ing. F. Garzia
Ing. G. Nicolai
Ing. A. Praitano
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CONTENUTI

THE INTERNET OF EVERYTHING SYSTEM FOR THE PAPAL BASILICA AND SACRED CONVENT OF SAINT FRANCIS IN ASSISI, ITALY

a cura di **M. GAMBETTI[1, 2], F. GARZIA[1, 2, 3, 4, 5], V. BAIOCCHI[6], F. J. VARGAS BONILLA[7], F. BORGHINI[3], D. CIARLARIELLO[1], S. CHAKAVEH[8], D. COSTANTINO[9], A. CULLA[3], R. CUSANI[3], M. A. FERRER[10], S. FUSETTI[1], J. KODL[11], S. LIVATINO[12], M. LOMBARDI[3], S. MARSELLA[13], V. SMEJKAL[11], S. RAMALINGAM[12], M. RAMASAMY[14], S. SACERDOTI[1], A. SDRINGOLA[1], D. THIRUPATI[15], M. F. ZANUY[16], Z. PENG[17]**

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The purpose of this work is to illustrate the methodology and show the results obtained from the study and the design of the Internet of Everything system for the Papal Basilica and Sacred Convent of Saint Francis in Assisi, Italy, considering all the sub-projects that have already started and the new sub-projects that are going to start.

Introduction

The Papal Basilica and the Sacred Convent of St. Francis in Assisi, Italy, together represent a unique and specific cultural heritage site where the mortal remains of St. Francis have been housed since 1230 AD (Fig. 1). Millions of pilgrims and visitors from all over the world visit this site each year. In 2000 AD, together with other Franciscan sites in the surrounding area, it achieved UNESCO World Heritage status. Important international events, such as those related to world peace and dialogue between religions, are organized in this site and are often attended by thousands of people. The Papal Basilica, where unique frescos by Giotto and other famous painters are displayed, comprises three stratified structures:

- the tomb of St. Francis, located at the lower level;
- the lower Church, whose altar is just above the tomb of St. Francis; and
- the upper Church, located above the lower Church.

Inside the Sacred Convent there is a museum, a library and sufficient space for hosting spiritual and cultural activities. Unique and complex cultural heritage sites, such as this, require a significant effort to ensure visitor security and safety. Along with such needs are cultural heritage preservation and protection as well as accessibility for visitors, with particular reference to visitors with disabilities, and for personnel normally present for site management, including the Friar's community.

From this point of view, it is necessary to consider other important aspects such as energy management, maintenance management and a plenty of other aspects that must be managed in an efficient way, using possibly a proper integrated technological system.

These aims can be achieved using integrated systems [1 - 5] and innovative technologies, such as Internet of Everything (IoE) which is capable of connecting people, things (mobile terminals, smart sensors, devices, actuators; wearable devices; etc.), data/information / knowledge and particular processes [6 - 10]. The IoE system must also provide all the actual and future IoE services planned and implement and support an integrated multidisciplinary model for security and safety management (IMMSSM) [11, 12] for this specific site.

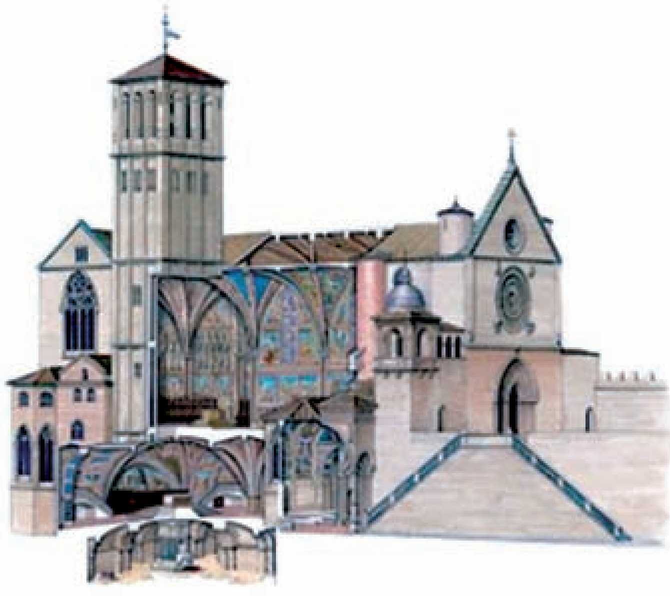
The purpose of this work is to illustrate the methodology and show the results obtained from the study and the design of the Internet of Everything system for the Papal Basilica and Sacred Convent of Saint Francis in Assisi, Italy, considering all the sub-projects that have already started and the new sub-projects that are going to start.

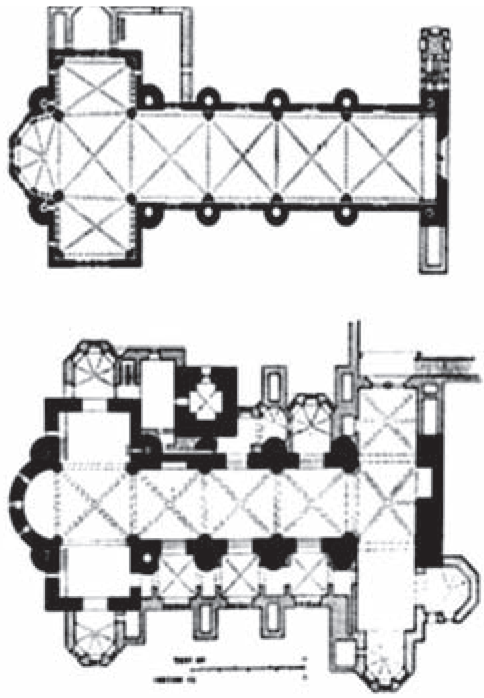
An Integrated Technological Framework for IoE Services and IMMSSM

The proposed IoE system is designed to support an integrated multidisciplinary model for security and safety management (IMMSSM) [11, 12] for the considered context as shown in Fig.2a. In addition, it needs to be flexible to incorporate advanced IoE services and make provisions for the inclusion of future IoE services.

> **Risks mitigation can be performed using fundamental operative factors**

Figure 1: Papal Basilica and Sacred Convent of Saint Francis in Assisi.





The IMMSSM is based on the following points: risk analysis, impact analysis, risks mitigation and residual risks management [13, 14]. Risks mitigation can be performed using fundamental operative factors or tools (OTs) which are represented by: countermeasures (physical/logical technology, and physical/logical barriers) and Security/Safety policies and procedures, considering also human factor and psychological aspects [15, 16]. Residual risk management can be done using fundamental tools, aided by OTs, which are represented by: emergency management, service and business continuity, disaster recovery [17].

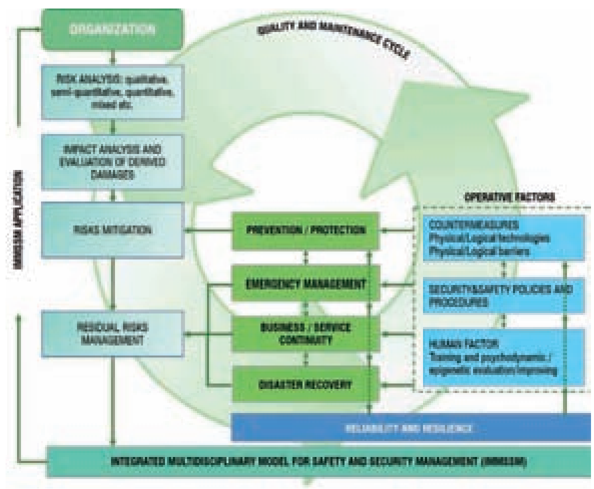
The IMMSSM can be implemented and supported using a proper Integrated Technological System Framework based on IoE (IoE-ITSF) which allows the full functionalities of the IMMSSM with high flexibility and modularity. In this way, it is possible to translate any eventual modification of the IMMSSM into a fast and low-cost modification of the ITSF at any time, ensuring always the best performances of IMMSSM and the possibility of providing the planned IoE services. The goal of the ITSF is to ensure: the maximum level of security and safety of people and of tangible and intangible assets, the maximum integration of all the IoE objects to produce high intrinsic-value solutions characterized by an optimal cost/benefit ratio, the maximum simplicity of utilization, using local and remote automation systems, the maximum level of reliability, resilience and flexibility, the maximum level of modularity and expandability, including IoE services. The general scheme of the proposed ITSF is shown in Fig.2b.

The system is characterized by a high modularity that allows for the addition at any time of any device, element, system etc. that needs to be integrated in the IoE system. Since the ITSF is designed to be a general system usable by most of organizations that can also plan for the presence of external visitor's presence. For security reasons, the networks used to perform supervision, control and security/safety services, internal personnel services and visitor's services are properly separated by physical and logical points of view. The system is characterized by a high modularity which allows for the addition at any time of any device, element, system etc. that needs to be integrated in the IoE system. Since the ITSF is designed to be a general system usable by most of organizations that can also plan for the presence of external visitor's presence, for security reason the networks used to perform supervision, control and security services, internal personnel services and visitor's services are properly separated by physical and logical points of view.

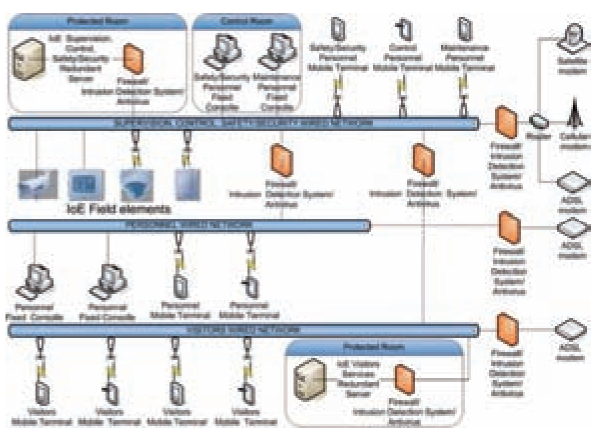
The different wired networks serve the different access points that ensure Wi-Fi services to securi-

Figure 2: (a) Scheme for IMMSSM (b) IoE based Integrated Technological System Framework (IoE-ITSF) enabling current and future technologies.

(a) IMMSSM



(b) IoE-ITFS



ty/safety and control personnel, internal personnel, including the Community of Friars, and visitors, increasing the security level of the communication and the protection of the system against cyber-attacks [15]. The system can communicate with all the "IoE objects", signalling any dangerous or critical situation to the operators (security / safety personnel, maintenance personnel, Police, Fire Brigades, Civil Protection, Medical etc.), in real time, using any kind of communication medium [15].

A proper privacy-compliant app, designed for the site, can be installed directly by security/safety personnel, internal personnel, including the Community of Friars, and visitors on their mobile terminals directly when they arrive in the site or in advance. This app allows access to all services planned for the user profile (general and augmented reality information, security & safety information, positioning services useful for emergency management, VoIP services for ordinary, security & safety and emergency communications with the related personnel, etc.) and allows the system to consider the mobile terminals as 'IoE objects' to reach the specific desired goals of the considered organization. Thanks to the app, it is possible to position people using both GPS system of mobile terminals and the Wi-Fi positioning capability of the system (that works correctly even in underground environments where the GPS signal is shielded or weak). This way, it is possible to manage an eventual emergency, communicating directly with people, if necessary, using the text and VoIP functionalities of the app. The ITSF is endowed with all the countermeasures necessary to prevent cyber-attacks, using firewall / intrusion detection system / anti-virus devices properly installed plus other prevention/protection countermeasures.

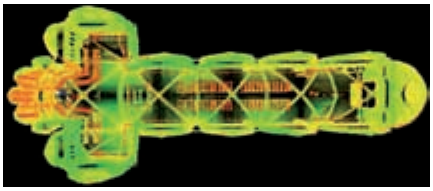
Design and Development of IMMSSM and IoE- ITSF System and Initial Results

The methodology adopted consists of several activities carried out both sequentially and in parallel, as a function of the available resources, always considering the final goal. Thus, a set of preliminary and fundamental series of multi-disciplinary activities formulated as subsystems of the IoE system are considered. These include:

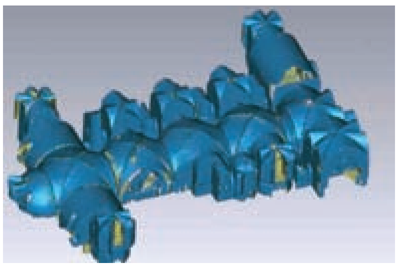
1) Laser scanning to acquire useful 3D information regarding the site [18, 19];
2) Building Information Modelling (BIM) to have a powerful and flexible informative tool for site management [19 - 21];
3) New communication network that represents the backbone of the IoE system [22];
4) Risk analysis and assessment, emergency management, disaster recovery, service continuity [13 – 15, 17];
5) Human Factor study and analysis to keep into consideration the psychological aspects regarding all the IoE services provided both to visitors and for personnel normally present for site management, including the Friar's community, to improve the quality and the efficiency of the IoE services themselves and of the ordinary signalling inside the site. These activities imply also the use of suitable tool for social opinion mining using social network [16];
6) Experimental microclimate monitoring system of the Papal Basilica [23];
7) New and suitable IoT/IoE services for the considered site, including Augmented Reality (AR) and Virtual Reality (VR) aimed at improving the visiting experience of the visitors [6, 24, 25];
8) Biometric solutions for the considered site, with particular care to privacy aspects [26 – 30];
9) Fluid dynamic analysis of the interior of the site to improve the quality of air with regards to people wellness and pictures preservation plus further activities related to the energy management / optimization / preservation and renewable energy [31 - 35];
10) Cybersecurity aspects of the IoE system. [15];
11) Big Data, security analytics for Big Data infrastructure, machine learning techniques for the site [36 - 38].

With this multi-disciplinary work, an international group started working remotely, first of all with a laser scanning activity of the Papal Basilica and of the Tomb (Fig .3). This is aimed at obtaining a 3D model of it [18- 19] that is going to be translated into a Building Information Modelling (BIM) and to use a powerful tool for all the necessary activities, including safety and security management [20]. This activity is fundamental

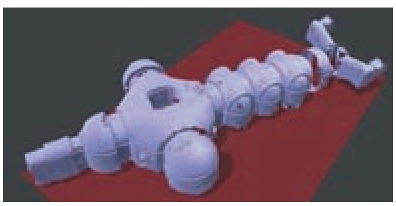
Fig. 3: Laser scanning results.



Point cloud of Upper Basilica



Meshing of lower Basilica

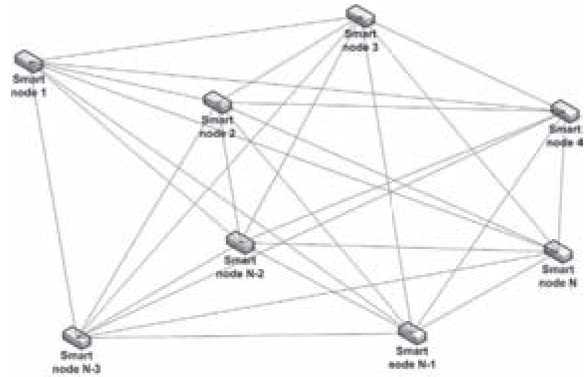


Representation of the Tomb using an open source environmen

due to the presence of strong architectural restrictions, which requires to take particular care in the installation of wires and devices [21, 39].

At the same time all the preliminary activities necessary to set up the IMMSSM [11 - 17] have started, included the other activities necessary to study and design the Site Management System (SMS), for the specific site, based on IoE (SMS-IoE), including the communication network that is essential to guarantee that all the information needed for the planned IoE services could be carried with the required level of security, safety, reliability and resilience granting the required confidentiality, availability and integrity [15, 22]. An apt Genetic Algorithm (GA) based technique has been studied and tested to design the connections between the different IoE Field Elements and the different smart nodes that comprise the network (Fig. 4) to ensure a reduction of final costs

Fig. 4: Architecture of the IoE system backbone network.



and an elevated level of reliability and resilience of the system itself, keeping, into consideration, the typical artifacts and restrictions of unique and peculiar cultural heritage sites such as the considered one [22].

In parallel, a study and analysis regarding human factor was made and is on-going. This takes into consideration the psychological aspects of the ordinary signalling and all the IoE services provided both to visitors and for personnel normally present for site management, including the Friar's community. This improves the quality and the efficiency of the IoE services themselves and of those inside the site. These activities require the use of suitable tools for opinion mining of social networks to receive feedback from visitors on perceived safety/security versus real safety/security [16].

Another activity in parallel relates to an experimental microclimate monitoring system (MMS) of the Papal Basilica, based on suitable microclimate monitoring modules (MCMM), has been studied and realized [23] and its architecture is shown in figure 5. The MMS is aimed at controlling the microclimate conditions to avoid reaching critical conditions that could activate damaging processes of the unique frescos of the Basilica. This system is able not only to monitor in real time the microclimate but also to forecast the future microclimate as a function of the actual situation, thanks to a proper designed artificial neural network (ANN) so that it can send this information to the SMS-IoE that is going to be realized and which

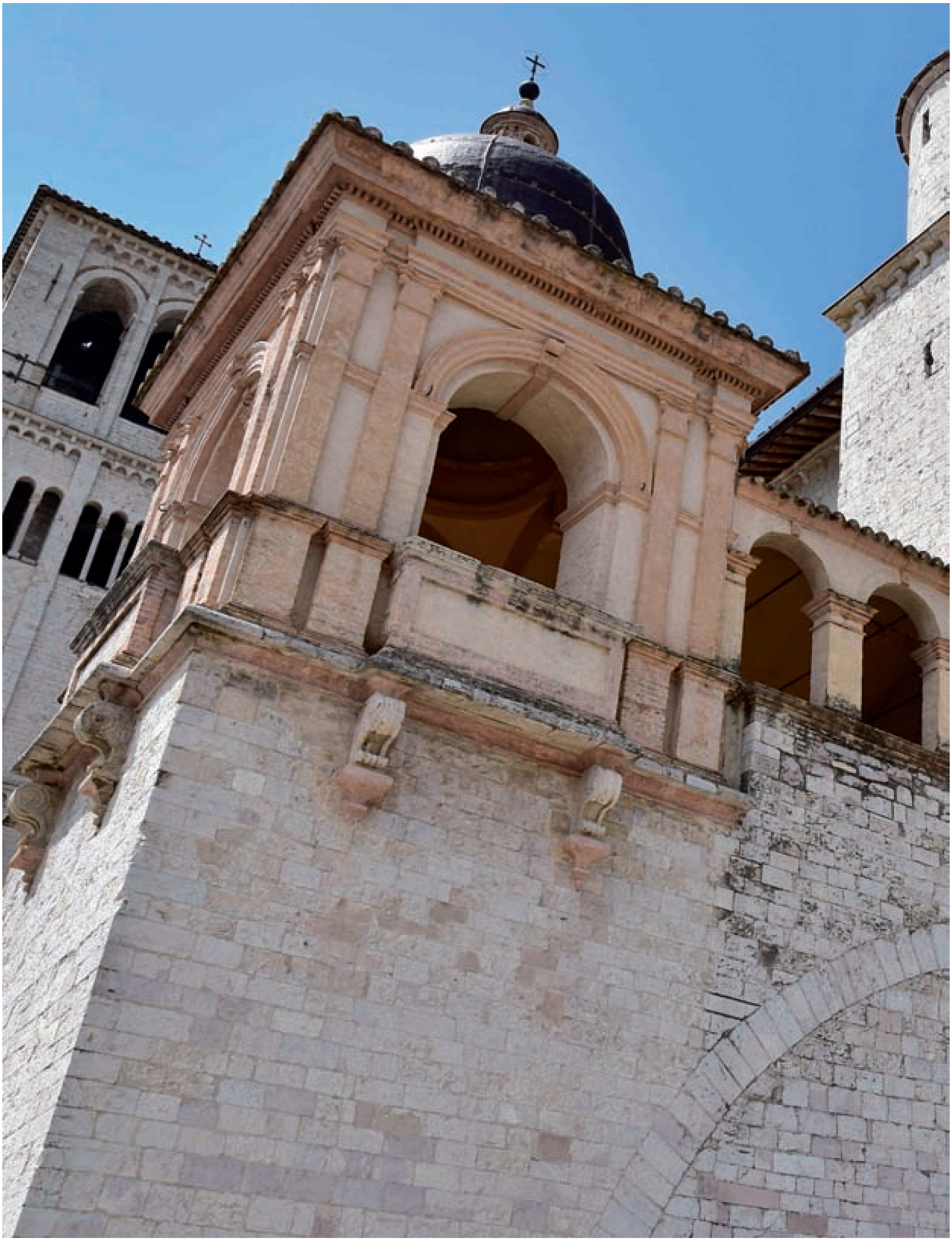
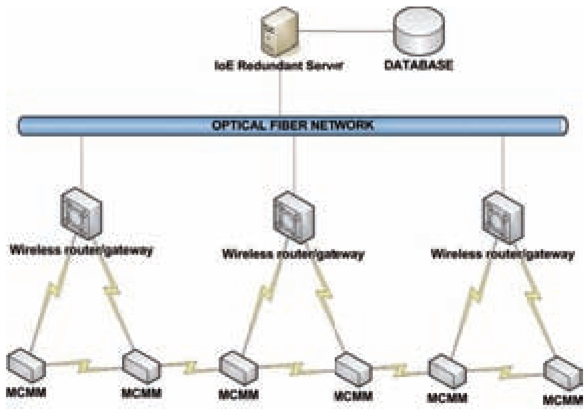


Fig. 5: Architecture of the microclimate monitoring system.



can activate all the necessary countermeasures such as reduce the number of visitors, activate proper cooling/fanning systems etc.

Further work is devoted to new and suitable IoT/IoE services for the considered site, including Augmented Reality (AR) and Virtual Reality (VR) aimed at improving the visiting experience of the visitors [6, 24 - 25]; biometric solutions for the considered site, with particular care to the privacy aspects [26 - 30]; fluid dynamic analysis of the interior of the site to improve the quality of air with regards to people wellness and pictures preservation plus further activities related to the energy management/optimization/preservation and renewable energy [31 - 35]; cybersecurity aspects of the IoE system [15]; Big Data, security analytics for Big Data infrastructure, machine learning techniques for the site [36 - 38] etc., with the aims of reaching, step by step and with the contribute of all the people and subjects that are working on it, the desired goals.

Conclusions

In this work the methodology and the results obtained from the study and the design of the Internet of Everything system for the Papal Basilica and Sacred Convent of Saint Francis in Assisi, Italy, have been illustrated considering all the sub-projects that have already started and the new sub-projects that are going to start.
The whole SMS-IoE represents and always-going-on- project and it is opened to future solutions and contribution by anybody, with the aim of improving constantly the goals of it.

References

[1] Garzia, F., Sammarco, E., Cusani, R., "The integrated security system of the Vatican City State", International Journal of Safety & Security Engineering, 1(1), pp. 1-17, 2011.
[2] Contardi, G., Garzia, F., Cusani, R., "The integrated security system of the Senate of the Italian Republic", International Journal of Safety & Security Engineering, 1(3), pp. 219- 246, 2011.
[3] Garzia, F., Cusani, R., "The integrated safety / security / communication system of the Gran Sasso mountain in Italy", International Journal of Safety & Security Engineering, 2(1), pp. 13-39, 2012.
[4] Garzia, F., Cusani, R., "The safety / security / communication wireless LAN of the underground Gran Sasso mountain national laboratories of the Italian Institute of Nuclear Physics", International Journal of Safety & Security Engineering, 2(3), pp. 209-226, 2012.
[5] Garzia, F., Sammarco, E., Cusani, R., "Vehicle/people access control system for security management in ports", International Journal of Safety & Security Engineering, 2(4), pp. 351-367, 2012.
[6] Di Martino, B., Li, K. C., Yang, L., T., Esposito, A., "Internet of Everything: Algorithms, Methodologies, Technologies and Perspectives (Internet of Things)", Springer, 2017.
[7] Garzia, F., Papi, L.,"An Internet of Everything based integrated security system for smart archaeological areas", Proceedings of the Fifty Annual IEEE International Carnahan Conference on Security Technology, pp. 64-71, Orlando (USA), 2016.
[8] F. Garzia, L. Sant'Andrea, "The Internet of Everything based integrated security system of the World War I commemorative museum of Fogliano Redipuglia in Italy", Proceedings of the Fifty Annual IEEE International Carnahan Conference on Security Technology, pp.56-63, Orlando (USA), 2016.
[9] F. Garzia, "The Internet of Everything based integrated system for security / safety / general management / visitors' services for the Quintili's Villas area of the Ancient Appia way in Rome", Italy, presented at SAFE 2017 – International Conference on Safety & Security Engineering, Rome (Italy), 2017 and in print on WIT Transactions.
[10] Garzia, F., Lombardi, M., Ramalingam, S., "An integrated Internet of Everything – genetic algorithms controller– artificial neural networks based framework for security systems management and support", Proceedings of IEEE International Carnahan Conference on Security Technologies, Madrid (Spain), 2017.
[11] Garzia, F., "An Integrated Multidisciplinary Model for Security Management – Optimized Implementation Technique and Related Supporting Technological System Framework", Proceedings of the Fifty Annual IEEE International Carnahan Conference on Security Technology, pp. 107-114, Orlando (USA), 2016.
[12] Garzia, F., Lombardi, M., "Safety and security management through an integrated multidisciplinary model and related integrated technological framework", Proceedings of SAFE 2017 – International Conference on Safety & Security Engineering, Rome (Italy), 2017 and in print on WIT Transactions.
[13] Guarascio, M., Lombardi, M., Rossi, G., Sciarra, G., "Risk analysis and acceptability criteria", WIT Transactions on the Built Environment, 94, pp.131-138, 2007.
[14] Broder, J. F. & Tucker, E., "Risk Analysis and the Security Survey", Buttherwoth-Heinemann, New York, 2012.
[15] Garzia, F., "Handbook of Communications Security, WIT Press, (Southampton – UK, Boston USA), 2013.
[16] Borghini, F., Garzia, F., Borghini, A., Borghini, G., "The Psychology of Security, Emergency and Risk", (Southampton – UK, Boston USA), WIT Press, 2016.
[17] Marsella, S., Marzoli, M., "Smart cities and cultural heritage", Proceedings of the 2017 IEEE 14th International Conference on Networking, Sensing and Control (ICNSC), pp.281-286, Lamezia Terme (Italy) 2017.
[18] Garzia, F., Costantino, D., Baiocchi, V., "Security and safety management and role of laser scanning in unique and peculiar cultural heritage sites such as the Papal Basilica and the Sacred Convent of St. Francis in Assisi in Italy", International Journal of Heritage Architecture Vol. 2, No. 2, pp. 271-282, 2018.
[19] Angelini, M. G., Baiocchi, V., Costantino, D., Garzia, F., "Scan to BIM for 3D Reconstruction of the Papal Basilica of Saint Francis in Assisi in Italy", Proceedings of International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-5/W1, 2017 GEOMATICS & RESTORATION – Conservation

of Cultural Heritage in the Digital Era, pp.47-54, Florence (Italy), 2017.

[20] Garzia, F., Lombardi, M., "The role of BIM for Safety and Security management", Int. J. Sus. Dev. Plann., Vol. 13, No. 1, pp. 49-61, 2018.

[21] Haigh, C., O'Moore, C., Nash., F. J., I Swift Wolf, I, (Chakaveh, S. Supervisor), "Mobile BIM", Meng Thesis, June 2017, School of Electronics Engineering & Computing, University of Southampton, UK.

[22] Gambetti, M., Garzia, F., Vargas Bonilla, F. J., Ciarlariello, D., Ferrer, M. A., Fusetti, S., Lombardi, M., Ramalingam, S., Ramasamy, M., Sacerdoti, S., Sdringola, A., Thirupati, D., Faundez Zanuy, M., "The new communication network for an Internet of Everything based security / safety / general management / visitor's visitors' services for the Papal Basilica and Sacred Convent of Saint Francis in Assisi, Italy, Proceedings of IEEE International Carnahan Conference on Security Technologies, Madrid (Spain), 2017.

[23] Garzia, F., Culla, A., "The experimental microclimate monitoring system of the Papal Basilica of Saint Francis in Assisi, Italy", presented at SAFE 2017 – International Conference on Safety & Security Engineering, Rome (Italy), 2017 and in print on WIT Transactions.

[24] Livatino, S., "Main Approaches in Realistic Virtual View Synthesis". Compendium of Computer Vision (CVonline), Chpt.1(25). R.B. Fisher editor, Edinburgh (UK), 2003.

[25] Henriquez, P., Alonso, J. B., Ferrer, M. A., Travieso, C., M., "Review of automatic fault diagnosis systems using audio and vibration signals", IEEE Transactions on Systems, Man, and Cybernetics: Systems 44 (5), 642-652, 2014.

[26] Ramalingam, S., "Fuzzy interval-valued multi criteria based decision making for ranking features in multi-modal 3D face recognition", Fuzzy Sets and Systems, 2017.

[27] Faúndez-Zanuy, M., "Privacy issues on biometric systems", IEEE Aerospace and Electronic Systems Magazine, Vol. 20, 2, pp. 13-15, 2005.

[28] Faúndez-Zanuy, M., "Data fusion in biometrics" IEEE Aerospace and Electronic Systems Magazine, Vol. 20, 1, pp.34-38, 2005.

[29] Travieso, C. M., Alonso, J. B., Orozco-Arroyave, J. R., Vargas-Bonilla, F. J., Nöth, E., Ravelo-García, A. G., "Detection of different voice diseases based on the nonlinear characterization of speech signals", Journal Expert Systems with Applications: An International Journal archive, Vol. 82 Issue C, pp. 184-195, 2017.

[30] Smejkal, V., Kodl, J., "Development trends of electronic authentication", Proceedings of the IEEE International Carnahan Conference on Security Technology, pp. 1-6, Prague (Czech Republic), 2008.

[31] Wang, T., Zhang, Y., Peng, Z., "A review of researches on thermal exhaust heat recovery with Rankine cycle", Renewable and Sustainable Energy Reviews (SCI), Vol.15(1), pp. 2862-2871, 2011.

[32] Garzia, F., Veca, G. M., "Advanced Neural techniques for energy management", Proceedings of DUE - Domestic Use of Energy, pp.159-164, Cape Town (South Africa), 2002.

[33] Garzia, F., Veca, G. M., "Evolutionary computation and genetic algorithms for energy management and conservation", Proceedings of INTELEC 2002, pp. 386-393, Montreal (Canada), 2002

[34] Garzia, F., Veca, G. M., "Distributed genetic algorithms system for efficient use of electrical energy", Proceedinngs of EEDAL'03 International Conference on Energy Efficiency in Domestic Appliances and Lighting, Turin (Italy), 2003.

[35] Chaychian, S., Mistretta, E., Lee, M., Pissanidis, G., Ramalingam, S., Gan, H., Mallett, C., Wisely, D., "Embedded Trusted Monitoring and Management Modules for Smart Solar Panels", The World Congress on Sustainable Technologies (WCST-2017), University of Cambridge, 11-14 December 2017, accepted.

[36] Kleppmann, M., "Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems", O'Reilly Media (USA), 2017.

[37] Chio, C., Freeman, D., "Machine Learning and Security - Protecting Systems with Data and Algorithm", O'Reilly Media (USA), 2017.

[38] Soodamani, R., Liu, Z. Q., "GA-based learning for a model-based object recognition system", International Journal of Approximate Reasoning, Vol. 23, No. 2, pp. 85-109, 2000.

[39] Garzia, F., Cusani, R., "New technique for the optimization of security communication wired networks in historical buildings", Proceedings of IEEE International Carnahan Conference on Security Technologies, Medellin (Colombia), pp. 116-121, 2013.

NEW TECHNOLOGIES AND SERVICE PROSPECTS FOR THE SPACE

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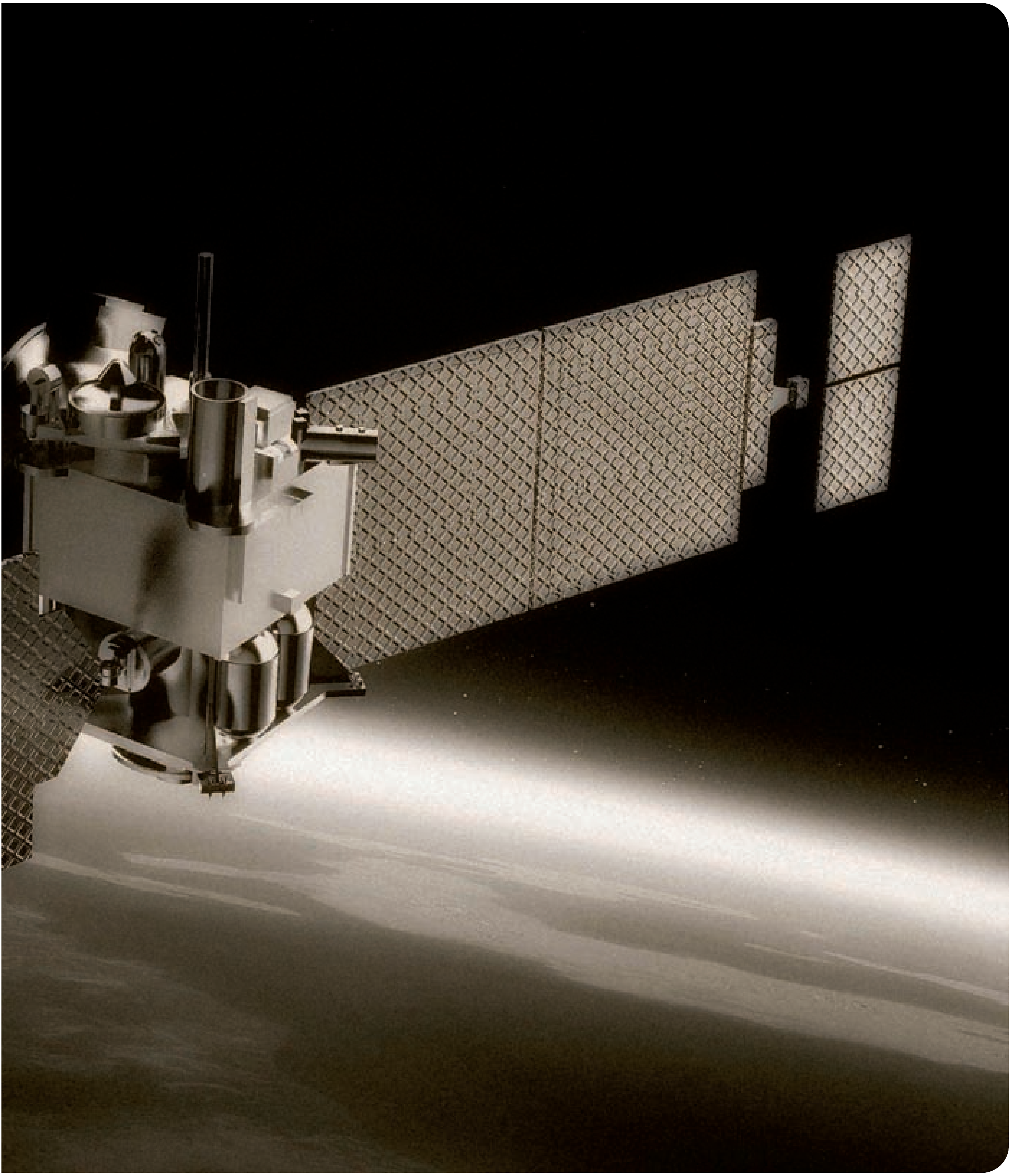

Introduction

Progress in technology has pushed the space community to focus on miniaturization of conventional satellites. Now the small satellite term does not just mean the educational satellite but extends to business for a large number of industries and large service companies. The miniaturization of satellites has opened new business opportunities for Telecommunications and Earth observation services.
Contrary to their size, the amount of data captured by these small satellites is large and growing. Existing data aggregation satellite systems (like Copernicus or GEOSS) will directly benefit from increased data from small satellite transmission capacity. This will have an impact on the amount of data available for some humankind safeguarding applications such as control of migratory flows of refugees and asylum seekers, control of natural disaster, control of agricultural resources and pollution.
The future of satellite services and applications will be measured by the ability to integrate different technologies, constellations and spatial segments (GEO, MEO, LEO) with the next generation 5G Mobile Terrestrial Network in order to reach the user directly.

Small Satellite

Small satellites are located on Low Earth Orbits (LEO) between 400 km and 800 km above the Earth's surface and have a visibility time from the receiving earth station in the order of 8 to 15 minutes. In this short period, all information gathered along a full orbit must be discharged to the receiving ground station. The characterization of these small satellites is shown in Figure 1.

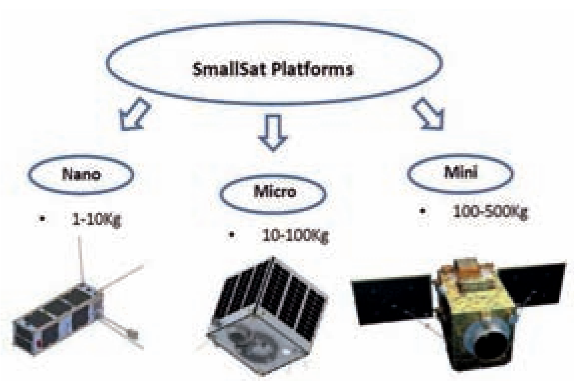

Figure 1: Small Satellite Characterization

Figure 2: Imagine acquired by Cubesat Doves

The most commonly used frequencies for data transmission from small satellite (nano, micro and mini) to ground facilities are the C (5-6 GHz) and X (7-8 GHz) frequency bands while the S (2 GHz) frequency band is normally used for telemetry and remote control.
Crucial applications for this kind of small satellites could be:

- Control of migratory flows of refugees and asylum seekers in the Mediterranean Sea;
- Control of Natural Disasters in Italy;
- Monitoring of Agricultural Resources and Pollution.

Bit Trasmission Rate and Technology

The maximum bit rate reached up to-date by these nano and micro-satellite missions is about 100 Mbps. So there is a great deal COTS (commercial off the shelf) technology to increase the transmission capacity of up to 500-1.000 Mbps on board these small satellites by:

- Standardization of Nano satellites;
- Frequency bands less crowded such as the Ka (26 GHz) band;
- Communication Technologies like Software Defined Radio (SDR);
- Photonic technologies for signal processing and optical signal transmission systems;
- High-definition sensors/cameras for data acquisition.

Another important aspect of this technological revolution is the integration of these small satellites and their constellations with the 5G terrestrial mobile network to provide services such as:

- Dissemination of Data to End Users;

- Realization of Integrated Services Centers with the 5G Network;
- Android Applications for Data Dissemination.

Standardization of Nano Satellites

Just like smartphones, satellites are becoming smaller and better. The Nano satellites today can do almost anything that a conventional satellite does, and even at a fraction of the convention satellite cost. And though no one contests that small satellites can not replace larger conventional satellites because of the pixel high resolution that the latter offer, both governmental and start-up organizations are trying to get a piece of the small cake. Only in 2016 about 300 satellites were launched, weighing between 1 and 50 kg.
The realization and success of commercial-based satellites is the first indication of the need for a change of technology. Various private initiatives in the United States, aimed at dramatically either reducing the cost of satellites launches and lowering their lifecycle costs, have led to the standardization of CubeSat satellites falling within the Nano Satellite typology.

The Nano Satellites were born as a tool of great utility in advanced didactic projects in the space sector but, thanks to the continued miniaturization of electronic components, they soon began to have similar capabilities to those of the larger satellites and attracted the attention of others aerospace world players for Earth Communication and Observation applications.
The short time period, from the design to the implementation of a micro satellite, allows to use

Figure 3: Cubesat Standard

Figure 4: Cubesat Mission

components and payloads at the state-of-the-art. In addition, standardization in the Cubesat class has produced two great advantages: firstly, the existence of a large community of operators working on the same platform and addressing similar problems by providing solutions that are widely shared over the Web. A second advantage is that standardization has produced automatisms in the integration into the launchers. There are several launchers (Vega, PSLV, Dniepr) that accept cubesat even a few months before the launch if they are released by the standard system (the PPOD). Contraindications are mainly related to the electrical powers that can be made available *(small satellites = little surface for solar panels)*.

New Service Prospects for the future

What is required for future satellite technology is therefore:

- Greater integration with land systems, adopting compatible standards allowing cheaper equipment and flexible bidding by operators;
- System Efficiency Increase, in order to reduce the cost per bits with limited power satellites adopting advanced technologies like DVB-S2X and SDR;
- On-board processing, more flexible and with a large number of interconnect bundles;
- Scalable satellite systems smaller and more powerful in order to avoid high costs.

Such satellites can be interconnected in orbit via inter satellite links (ISL), as well as they grow in number and flexible reconfiguration demand is required.

Smallsat Application Areas

Small Satellites in Low Earth Orbit (LEO) are often deployed in a constellation because the coverage area of a single satellite is relatively small. To maintain a continuous coverage of a particular area of the globe, several satellites are needed in low earth orbit.

Broadband applications benefit from short latency, so the LEO satellites have the significant advantage of having latency times of about 1-4ms compared to the theoretical 125ms of a geostationary satellite.
Therefore the main application areas for the smallsat constellations are related to:

- *Security* - The new geopolitical scenarios are pushing for growing security demand, both for civilian and military reasons. Particular emphasis should be placed on the management of migratory flows and their territorial distribution, both in terms of economic and cultural sustainability;
- *Search And Rescue (SAR) operations* - The term SAR refers to a set of rescue operations conducted by trained personnel in conjunction with the use of specific naval, aerial or land-based facilities for the safeguarding of human life;
- *Environment and Territory* - Climate changes and previous environmental stress, also deter-

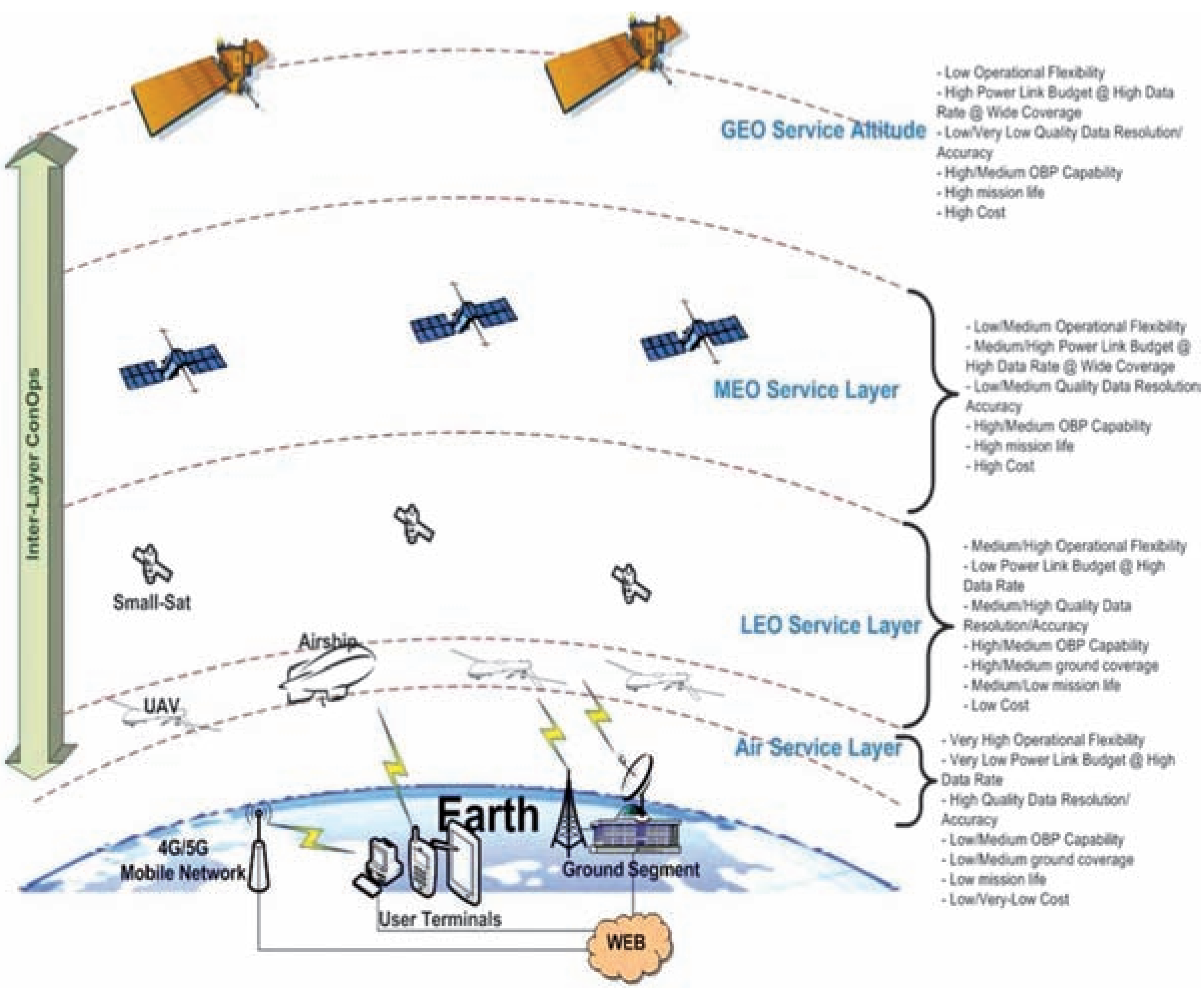

Figure 5: Future Scenarios for Satellite Services

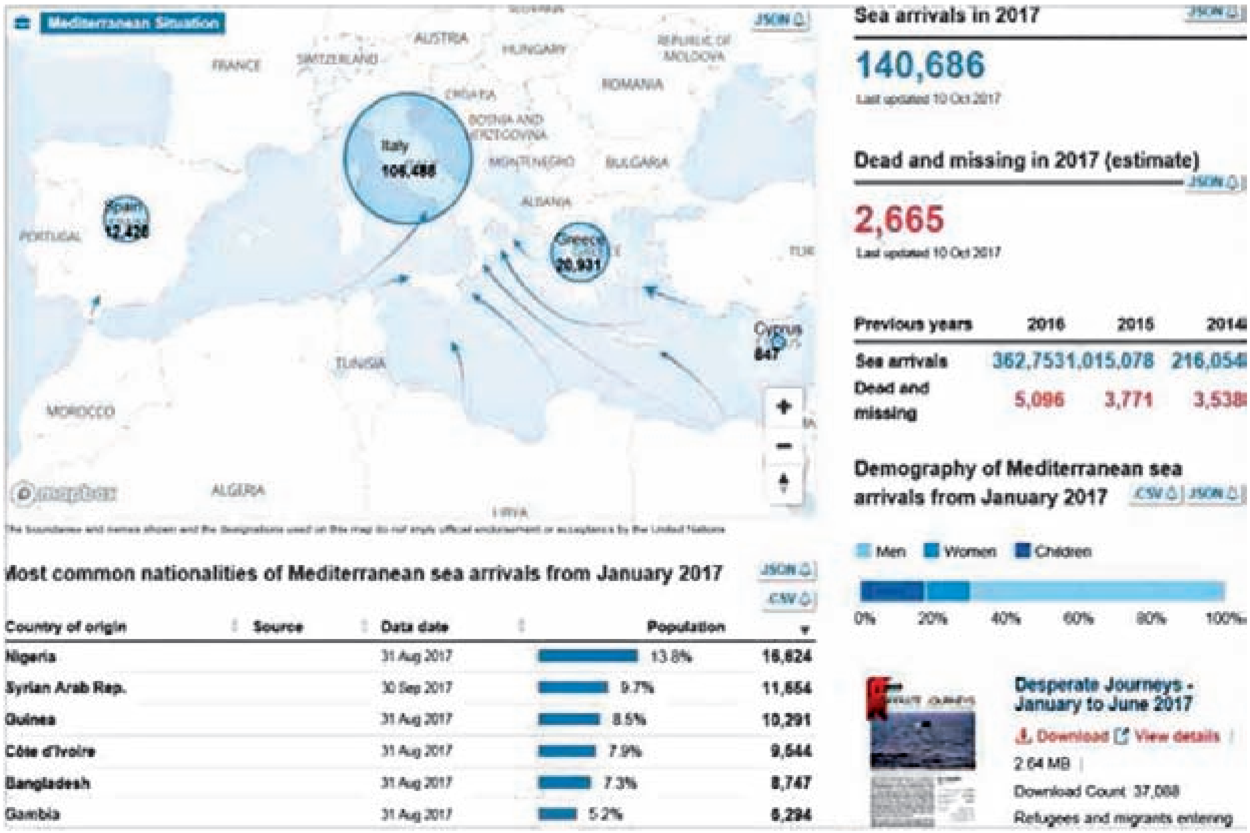

Figure 6: Dashboard with daily tracking (slide of October 10, 2017)

mined by human action, require increased attention both in monitoring and emergency management and after natural disasters.

Control of Migratory Flows via Smallsat Mission

In recent years, one of the major social problems is the illegal immigration of refugees. This 'Exodus' does not concern individual states, but it involves the entire European Community at different levels:

- Humanitarian
- Safety

How to minimize or prevent a migratory stream now out of control? Is it possible to use smallsat platforms to support existing resources? That is possible with smallsat mission having as a scenario of observation a portion of the Mediterranean Sea, with its sensitive areas, as a starting point for migratory flows. Area considered: square of about 500 km per side

An example of a satellite mission consists of a constellation of 8 cubesat 6U that make Earth Observation with optical sensors on a helium-synchronous orbit 650-750 km away from the earth.

- Optimal orbit and Smallsat number
- No. of satellites: 8
- Inclination: 35 °
- Estimated time of observation of square area for orbit: 2.5 min
- The maximum time between one observation and another (GAP): 100 min
- Operating Life: about 2 years

> **Is it possible to use smallsat platforms to support existing resources?**

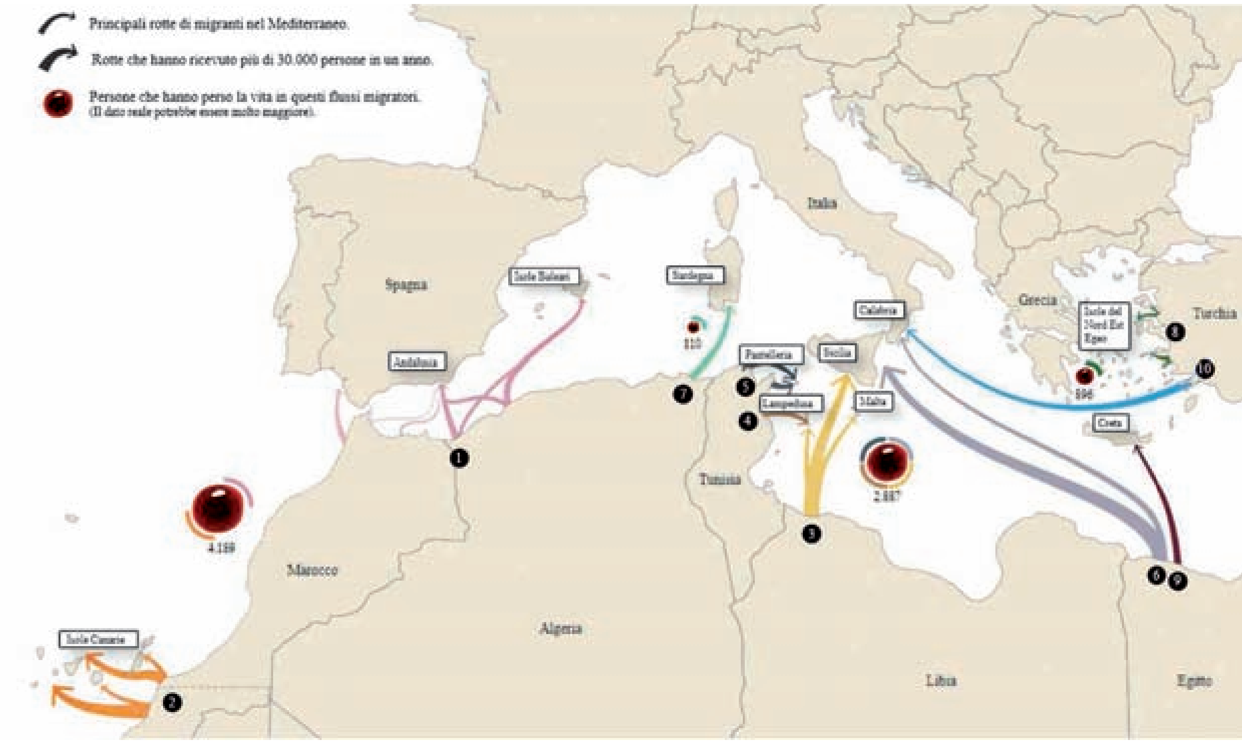

Figure 7: Scenario of the migratory flow in the Mediterranean Sea

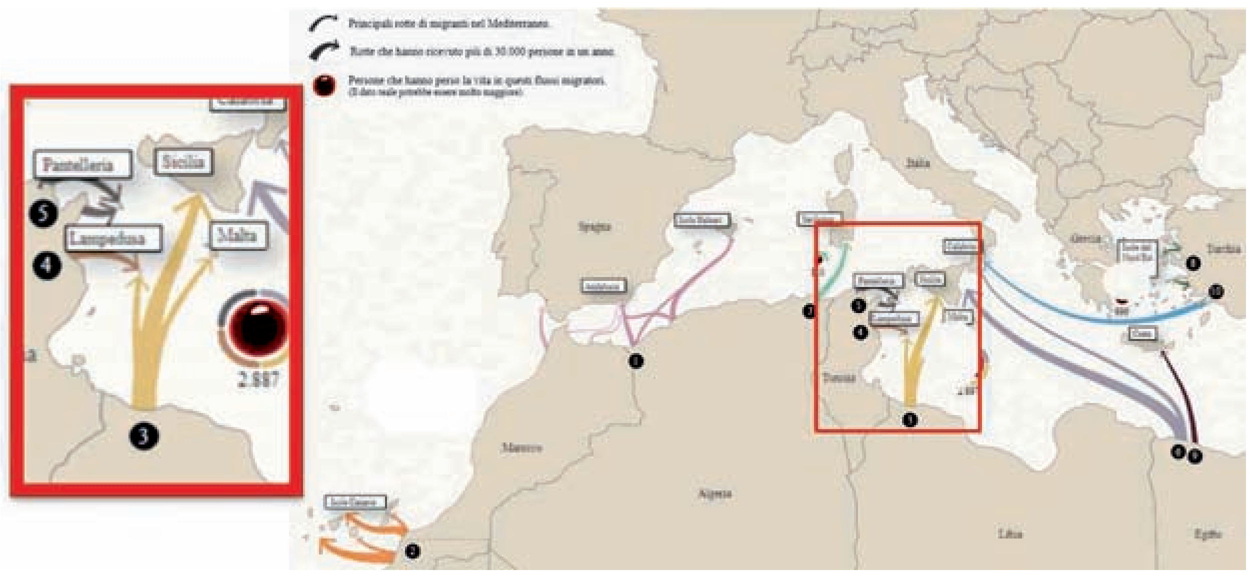

Figure 8: Example of Satellite Mission in the Mediterranean Sea

Ka Band Utilization and SDR Technology Developments

Regarding the use of new COTS technologies applicable to Small Sat particularly for Earth Observation (EO) applications, the advanced developments in the following fields are reported:

- Ka band at 26 GHz provides bandwidth 4 times greater than X bandwidth. The final report of the 2016-11-18_LEO26SG Expert Group says: "The 26 GHz frequency is a viable option for ground-based communications from low orbital space vehicles (LEOs). Mission planners may neglect the frequency of 26 GHz because of their insecurity, perceived risks, or the ease of implementation of a mission using a standard approach. Not considering the use of the 26 GHz band, however, missions may miss the opportunities offered by higher frequencies. " The generic functions of a 26 GHz communication system are shown in the block diagram below extracted from the final report 2016-11-18_LEO26SG.

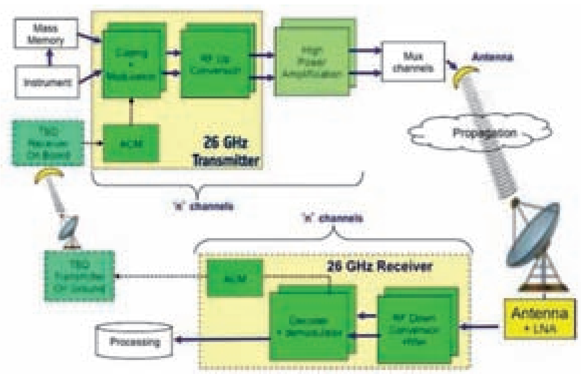

Figure 9: LEO Communication System at 26 GHz extracted from the final report 2016-11-18_LEO26SG

- On ESA programs compact Ka antennas (20x20 mm size patch antennas) and low cost RF (LNA and SSPA) devices are under development in order to be installed on SmallSat satellites to illuminate the Earth Receiver with sufficient beam widths during the passage in sight on the LEO orbit (8-15 minutes); moreover, the next GaN (Gallium Nitride) SSPAs will soon become a much more attractive solution since their efficiency and output power (approximately 10 W) will generally double the performance of the existing SSPAs already existing in GaAs (Gallium Arsenide);

Development of Modem based on SDR Communication Technologies utilizing programmable FPGA (Field Programmable Gate Array) signal processor, which provides a communication system capable of adapting to changing weather conditions with variable modulations from 8PSK up to 64 APSK, using Adaptive Codes and Modulations (ACM and VCM).

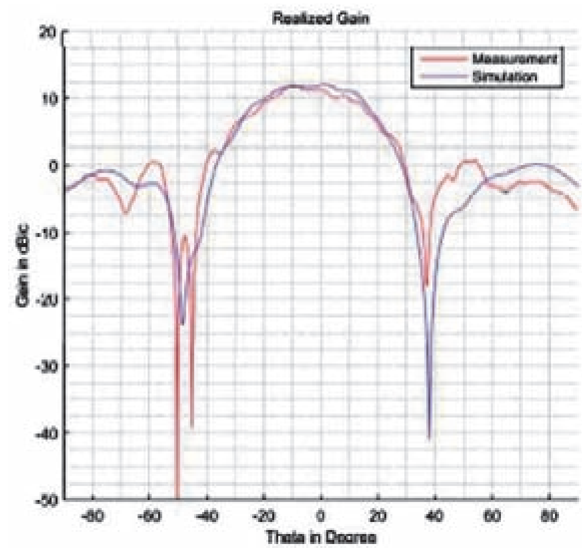

Figure 10: Patch Antenna at 26 GHz - Radiation Diagram

Figure 11: FPGA Board

Integration with the Terrestrial Network 5G and Service Development

The Integration of the Satellite Network with the 5G Terrestrial Mobile Network can create a variety of Service and Application Opportunities for

mobile users. The architectural scheme of this network is shown in the figure below.
With this architecture and with Reliable Terrestrial Smart Gateways as an interface for 5G Mobile Terrestrial Network, several Services and Applications could be created, such as:

- Processing of Received Data from Smallsat;
- Dissemination of Received Data to End Users;
- Realization of Integrated Services Centers with the 5G Network;
- Data dissemination applications.

The development of new technologies in the terrestrial segment (such as low-cost and low-power satellite equipment, electronically controllable dynamic beam, phased-array satellite systems) will make the use of satellite interesting for the IoT. The future of satellite services and applications will be measured by the ability to integrate different technologies, constellations and spatial segments (GEO, MEO, LEO) with the next generation Terrestrial Network in order to reach the user directly.

Some examples of the Satellite integration in the 5G Network are shown in the following figures.

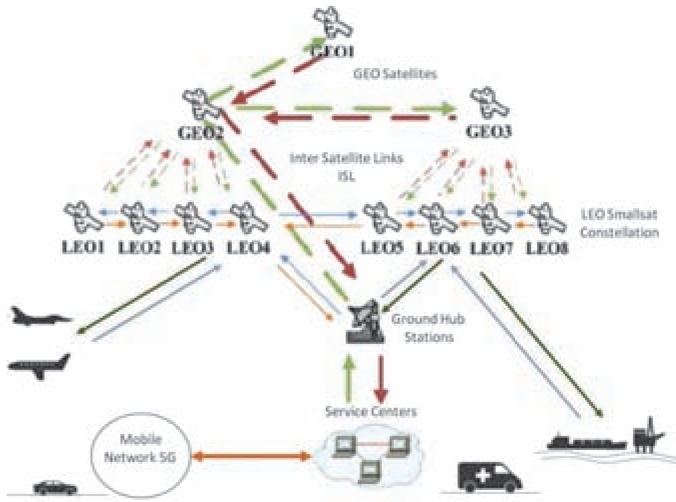

Figure 12: Architecture Space-Terrestrial Network

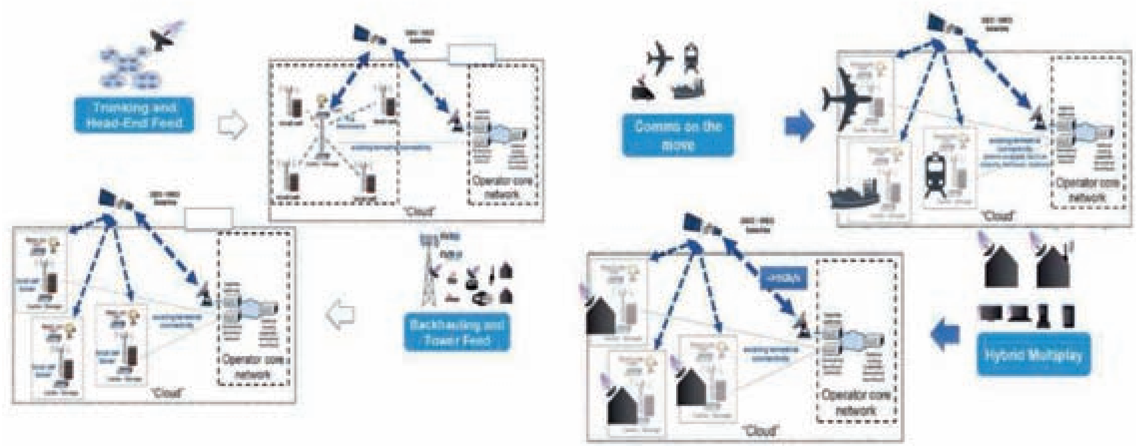

Figure 13: Examples1 of Integration 5G-Satellite

References

1. Low-Earth Orbit (LEO) 26 GHz K-band Study Group - Final Report November 2016
2. Geospatial World – Report April 2016
3. Nanosatellite Market: Industrial applications should witness fastest growth up to 2022" (Market Study Report – Luglio 2017)
4. Seminario internazionalizzazione e Aerospazio Dicembre 2016- Ordine Ingegneri Provincia di Roma
5. Lightweight and Cost Efficient Spaceborn Ka Patch Antenna 2016 IEEE
6. Cubesat Industry Days 2017 – June 2017
7. Seminario Lo Spazio in Rete 13 Ottobre 2017- Ordine Ingegneri Provincia di Roma
8. Articolo «Migranti, anche i satelliti nello spazio sorveglieranno le coste» pubblicato 01/07/2015 su adnkronos (website)

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INGEGNERIA NATURALISTICA IN AMBIENTE MEDITERRANEO

UN APPROCCIO ECOLOGICO

Le tecniche di Ingegneria Naturalistica sono state importanti nelle antiche civiltà rurali mediterranee: le piante hanno protetto il suolo con efficacia e i materiali necessari (piante, legname e pietrame) hanno abbondato nel paesaggio agricolo, spesso in associazione con i terrazzamenti.

Recentemente questa disciplina si è diffusa in diverse aree del bacino del Mediterraneo. Diversi metodi e specie vegetali sono stati sperimentati in territori con clima e vegetazione diversi da quello originario alpino.

Le tecniche di Ingegneria Naturalistica sono state applicate frequentemente in Italia, in particolare nel Vesuvio, nell'Appennino Laziale, Abruzzese e Marchigiano, in Sicilia e in diverse Aree Costiere e Marine Protette, anche mediante sperimentazioni, azioni didattiche e volontaristiche.

Questi sistemi hanno dimostrato che, nei progetti di Ingegneria Naturalistica nel bacino del Mediterraneo, l'uso di piante e di talee di specie xerofile è affidabile per ambienti siccitosi, desertificati e percorsi da incendi boschivi.

L'Ingegneria Naturalistica raggiunge così, sempre più diffusamente in ambito Mediterraneo, gli obiettivi di:

- proteggere contro i rischi naturali;
- ripristinare gli habitat;
- definire le specie ottimali per la loro architettura radicale;
- condividere e diffondere gli interventi.

Introduzione

Il Bacino del Mediterraneo è il terzo *hot spot* di diversità vegetale più importante in tutto il mondo, con più di 25.000 specie di piante, di cui oltre la metà endemiche e solo una piccola parte esotiche, in seguito divenute naturalizzate.

La tutela della biodiversità attraverso la conservazione delle risorse genetiche non è solo riservata alle amministrazioni pubbliche, ai ricercatori e agli universitari. Arrestare la perdita di biodiversità vegetale nel Mediterraneo può essere possibile anche grazie al contributo di diversi settori professionali. L'uso di specie vegetali autoctone di origine locale nel ripristino di *habitat* e nella progettazione del paesaggio e dei giardini, grazie alle tecniche e ai professionisti di Ingegneria Naturalistica capaci di applicarle, non solo può contribuire a fermare il degrado del territorio, ma può anche favorire lo sviluppo di un modello economico sostenibile.

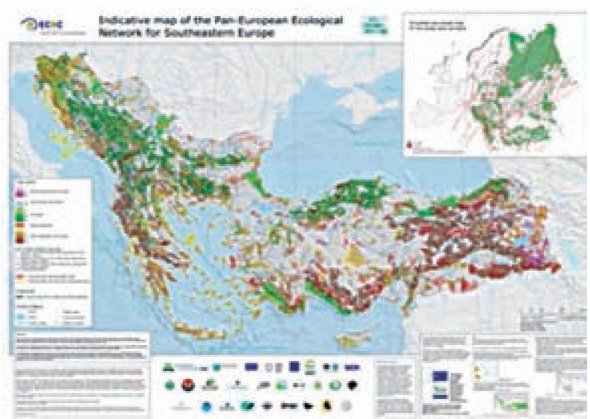

Figura 1: Mappa della Rete Ecologica Pan-Europea per la regione del sudest (da ECNC, 2006).

Figura 2: Ambiente dunale integro protetto alla foce del Coghinas (da F. Boccalaro, 2005)

Ingegneria Naturalistica

L'Ingegneria Naturalistica è una disciplina tecnica che utilizza le piante vive negli interventi antierosivi e di consolidamento, in genere in abbinamento con altri materiali (paglia, legno, pietrame, reti metalliche, biostuoie, geotessuti, etc.).

I campi di applicazione sono vari e spaziano dai problemi classici di erosione dei versanti, delle frane, delle sistemazioni idrauliche in zona montana, a quelli del reinserimento ambientale delle infrastrutture lineari (scarpate stradali e ferroviarie, condotte interrate, canali), a quelli delle cave e discariche, delle sponde dei corsi d'acqua planiziali, degli insediamenti industriali e altre infrastrutture puntuali, dei consolidamenti costieri, a quelli dei semplici interventi di rinaturalizzazione e ricostruzione di elementi delle reti ecologiche.

Gli interventi di I.N. si differenziano da quelli di tipo tradizionale principalmente attraverso le analisi stazionali delle condizioni delle singole superfici di intervento con riferimento ad alcuni parametri fondamentali vegetazionali, la cui conoscenza è condizione prima del successo dell'intervento legato, come si è detto, alla crescita delle piante.

L'uso delle piante locali garantisce l'idoneità generale alle condizioni geo-pedologiche e fitoclimatiche del luogo, fermi restando i problemi legati al periodo stagionale ed alle condizioni microambientali di messa a dimora.

Si tratta chiaramente di una disciplina "trasversale" che fa capo a vari settori tecnico-scientifici di cui si utilizzano, a fini applicativi, dati sintetici di analisi e di calcolo.

A livello mondiale vi è ormai un grosso fermento di acquisizione di strumenti tecnici e normativi nei settori della rinaturalizzazione e dell'ingegneria naturalistica, sia da parte dei professionisti che dei funzionari pubblici e delle imprese. Gli interventi di ingegneria naturalistica infatti rientrano nel filone degli interventi di mitigazione che fanno ormai parte integrante delle progettazioni infrastrutturali e del territorio.

Questa attività è per buona parte legata alla progettazione degli interventi di "ricucitura" del territorio attraversato, in particolare nei settori infrastrutturali e produttivi (strade, ferrovie, cave, discariche, etc.) per i quali i metodi dell'Ingegneria Naturalistica forniscono nuove soluzioni e notevoli possibilità di abbinamento della funzione tecnica (consolidamento di scarpate) con quella naturalistica di ricostruzione del verde. Si parla di verde, ma in realtà è più esatto parlare (come già detto sopra) di ricostruzione di ecosistemi paranaturali riferiti agli stadi delle serie dinamiche naturali (potenziali) della vegetazione delle aree di intervento. In ciò l'Ingegneria Naturalistica si differenzia dalle normali pratiche di rinverdimento ornamentale o architettonico legate in genere alle zone urbanizzate.

Tabella : Caratteristiche dei tre livelli tecnici delle reti ecologiche, degli interventi di miglioramento ambientale, delle tecniche di ingegneria naturalistica

	Reti ecologiche	*Interventi di miglioramento ambientale*	*Tecniche di ingegneria naturalistica*
Finalità primaria	Ricostruire un ecomosaico funzionale su uno scenario di medio periodo	Realizzare neo-ecosistemi in grado di incrementare la qualità ecologica sul territorio	Utilizzare fin dove possibile elementi naturali nelle opere di nuova realizzazione
Livello preferenziale di azione tecnica	Pianificazione	Programmazione Progettazione preliminare	Progettazione definitiva-esecutiva
Scala di riferimento	Area vasta	Ecomosaico locale	Sedime delle opere di progetto
Esempi tipologici	Sistema di habitat interconnessi Sistema di linee di fruizione qualificata del paesaggio Rete ecologica polivalente etc.	Sistemazioni di versante con tecniche di IN Recuperi di cave Ecosistemi filtro Rinaturazione di corsi d'acqua etc.	Palificata viva Viminata viva Fitodepurazione con *Lemna* Scala Denil per il passaggio dei pesci Sovrappasso faunistico etc.

Tabella 1: Caratteristiche dei tre livelli tecnici delle reti ecologiche, degli interventi di miglioramento ambientale, delle tecniche di Ingegneria Naturalistica (da Linee Guida PROGECO, 2017).

Figura 3: Briglia di fune per tronchi flottanti e sistemazione spondale su fiume Rienza in Val Pusteria (da F. Boccalaro, 2013).

Esperienza dell'I.N. nel Mediterraneo

Negli ultimi anni questa disciplina ha visto l'ampliamento della sua area di applicazione, arrivando a comprendere diverse aree nel bacino del Mediterraneo. L'ampliamento a territori climaticamente e vegetazionalmente diversi dall'originale campo di applicazione ha portato alla sperimentazione di diverse tecniche ed essenze vegetali.

Le tecniche oggi impiegate nell'ingegneria naturalistica erano conosciute già nell'antichità nel bacino del Mediterraneo. Gli antichi romani possedevano conoscenze approfondite in questo campo, come testimoniato da diversi scritti di Catone, Virgilio e Columella. Nei testi si trovano riferimenti sia alla parte viva che alla parte strutturale delle opere; ciò mette in luce come i principi di base per la realizzazione di queste opere fossero già note ai latini.

Queste tecniche hanno svolto un ruolo importante nelle antiche civiltà rurali, grazie all'efficacia empiricamente dimostrata dalle piante nel soddisfacimento di problemi da dissesti su versante e su corsi d'acqua (vedi anche i terrazzamenti) e all'abbondanza dei materiali necessari (piante, legname e pietrame) nell'ambiente rurale. Ciò dimostra come l'applicazione dell'IN costituisca spesso una riscoperta ed una reinterpretazione in chiave moderna di metodi tradizionali.

Negli ultimi anni c'è stato un interesse crescente verso questa disciplina, testimoniato dalla presenza di diverse esperienze e pubblicazioni in zone non alpine.

Variegata e ricca appare anche l'esperienza di Spagna e Portogallo. Grande attenzione è rivolta soprattutto alla gestione dei bacini idrografici, ma anche alla protezione dei suoli e alla prevenzione del dissesto dei versanti e delle coste.

Per ciò che riguarda le applicazioni di Ingegneria Naturalistica in Francia, diverse sono invece le applicazioni a protezione degli *habitat* naturali, specialmente fluviali, dove prevalgono interventi di ripristino ecologico-ambientale e limitatamente di Ingegneria Naturalistica. Si citano a titolo di esempio la salvaguardia degli stagni litorali del Languedoc-Roussillon, delle valli alluvionali del nord ed est della Francia ed in generale delle torbiere, e di tratti costieri.

Figura 4: Rigenerazione dune a Cala Mesquida (da F. Boccalaro, 2010).

Figura 5: Valorizzazione dell'alveo e delle sponde della Brenne a Vénarey-les-Laumes (da Biotec, 2002).

Ancora in gran parte da esplorare appare invece l'esperienza dell'I .N. nell'area ellenica e nei paesi in via di sviluppo, con alcuni casi studio per la Grecia e la Tunisia.

Esperienza Italiana

Rilevante in Italia è il patrimonio dell'esperienza diretta sviluppata sul territorio con applicazioni locali da parte delle Comunità Montane e da parte dei Consorzi di Bonifica. Applicazioni che hanno riguardato il riordino e la sistemazione o la manutenzione dei corsi d'acqua e nell'ambito dei rimboschimenti nei bacini montani.

In Umbria, come in altre regioni italiane, le Comunità Montane, fin dai primi anni '90 hanno applicato alcune tecniche di I.N.. In particolar modo si sottolineano gli interventi di riqualificazione idraulica e vegetazionale del fiume Nera con la messa in opera di piccole scogliere di pietrame rinverdite con talee vive.

Molte Regioni ormai hanno cercato di inserire tali tecniche a diversi gradi di pianificazione ed intervento cercando nel contempo di normare tali aspetti. In particolare esemplare è stata l'attività della Regione Lazio, con una ricca casistica di interventi in ambito montano, fluviale, costiero anche in aree protette.

Un caso a parte, per la vastità, qualità e innovazione degli interventi di Ingegneria Naturalistica realizzati su un territorio tipicamente mediterraneo è quello del Parco Nazionale del Vesuvio.

Figura 6: Vivaio forestale del PNR dei Monti Aurunci (da F. Boccalaro, 2006).

Figura 7: Sistemazioni dunale al PR di San Rossore (da F. Boccalaro, 2008).

Esperienze nel Parco del Vesuvio

L'esperienza effettuata nel Parco Nazionale del Vesuvio ha offerto la possibilità di effettuare un grosso passo in avanti nella definizione e nelle specifiche funzionali e tecniche delle opere di Ingegneria Naturalistica in ambito Mediterraneo.

Nel corso dei progetti di manutenzione e restauro delle rete sentieristica del complesso craterico "Somma Vesuvio", divenuto Parco Nazionale il 5 giugno 1995 con la legge istitutiva 394, si sono specializzate le tecniche di Ingegneria Naturalistica e si è rivalutata la storia delle sistemazioni idraulico-forestali perpetuate nel secolo precedente per la gestione delle emergenze vulcaniche, con le eruzioni del 1800 sotto il Regno di Napoli, ad opera di tecnici illuminati. Un esempio è stato la gestione del territorio conseguente alle eruzioni del 1800 (in soli 100 anni il Vesuvio ha manifestato la sua attività vulcanica negli anni dal 1804 al 1806, 1810, 1812, 1817, 1822, 1834, 1839, 1850, 1855, 1858, 1861, 1868, 1872, 1891, 1894).

Le eruzioni nello specifico sono di solito precedute, nei mesi ed anni precedenti, da un'intensa attività effusiva ed esplosiva: il Cono appare così segnato da molte colate. Poco dopo si sviluppa, nelle aree prossime al cratere principale, un'elevata colonna eruttiva che provoca una forte ricaduta di ceneri vulcaniche. Queste ceneri depositandosi al suolo coprono ogni cosa e interrompono il normale funzionamento di qualsivoglia attività. Le piogge seguenti provocano il dilavamento delle superfici, già al limite di equilibrio, e numerose colate di fango.

Le opere di sistemazione diffusa montana e le relative attività di manutenzione, nel corso del tempo, oltre a riattivare la normale vita comune e la riappropriazione dei terreni per la loro gestione, hanno generato una notevole produzione legislativa che riportiamo, evidenziando i riferimenti ed i collegamenti alle opere di Ingegneria Naturalistica.

- Legge 19.07.1906 n. 390 (eruzione dell'aprile 1906).
- Legge 30.05.1909 n. 407 (manutenzione opere).
- Legge 13.04.1911 n. 311 (riparazione dai danni da alluvione a ottobre 1910).
- R. Decreto 21.12.1911 n. 1471 (opere di bonifica e sistemazione).

Fino al più recente D.M. 20 agosto 1912, "*Norme per la preparazione dei progetti dei lavori di sistemazione idraulico-forestale nei bacini montani*", che impone l'uso di materiali vivi e morti oggi ascrivibili all'Ingegneria Naturalistica.

L'esperienza del Parco Nazionale del Vesuvio, a sua volta, ha diffuso l'uso di tali tecniche a basso impatto ambientale, incoraggiando la legislazione fino alla pubblicazione del D.P.G.R. n. 574 del 22 Luglio 2002, "*Emanazione del Regolamento per l'attuazione degli interventi di Ingegneria Naturalistica nel Territorio della Regione Campania*", presentato nel Bollettino Ufficiale della Regione Campania del 19 Agosto 2002. Una delle innovazioni di questa norma è l'art. 3 "*Relazione sulla*

Figura 8: Sentiero attrezzato in quota e muretto a secco (da G. Menegazzi, 2001)

Figura 9: Palificata e palizzata vive in legname e pietrame (da G. Menegazzi, 2001)

Figura 10: Sistemazioni di versante e idraulica tra antichi ruderi a Monte Somma (da G. Menegazzi, 2002

applicabilità dell'ingegneria Naturalistica", che ha lo scopo di formulare un giudizio tecnico di massima applicabilità dell'I.N.. Tale relazione deve essere redatta a cura di un tecnico il cui *curriculum* dimostri una comprovata esperienza nel campo dell'Ingegneria Naturalistica. Le relazioni dovranno prevedere, oltre le finalità progettuali, la definizione dei limiti di applicabilità delle tecniche, la individuazione delle stesse, il giudizio tecnico e il *curriculum* professionale dell'estensore.

Conclusioni

In sintesi è necessario, per una buona gestione del territorio, disporre di un sistema integrato di risposte operative che combini le tecniche puntuali di Ingegneria Naturalistica (elementi dei singoli progetti definitivi ed esecutivi) con interventi locali di miglioramento ambientale (definiti da programmi di azione, da studi di fattibilità e progetti preliminari, nonché da progetti integrati di interesse locale), con gli scenari più complessivi a livello di area vasta (utilizzabili come riferimento per la pianificazione).

Per conseguire l'obiettivo di un impiego corretto e diffuso il più possibile dell'Ingegneria Naturalistica è quindi necessario:

- redigere normative tecniche sia regionali (completamento) che nazionali (difesa del suolo, ecc.) oltre che un atto di coordinamento ed omogeneizzazione delle normative al riguardo;
- normare la possibilità di reperimento delle materie prime vegetali (prelievo dal selvatico delle talee di salice e di alt re piante) con procedura semplificata;
- favorire la creazione di una banca dati sulla consistenza delle formazioni arboree ed arbustive impiegabili per il reperimento del materiale vegetale dal selvatico;

- favorire la creazione di vivai specializzati nella produzione di materiale per l'Ingegneria Naturalistica;
- programmare corsi di aggiornamento e di formazione per personale degli enti territoriali, dei comuni, delle comunità montane, dei consorzi di bonifica, ecc. sia a livello di progettisti, sia a livello di capi-cantiere e di operai;
- favorire la formazione e specializzazione di progettisti (ingegneri, architetti, agronomi, forestali, geologici, biologi, naturalisti, ecc.);
- riesaminare i tariffari professionali per adeguarli alle prestazioni richieste;
- garantire attraverso controlli la specializzazione e qualificazione di ditte esecutrici di opere di IN anche a livello di categorie riportate nell'albo nazionale costruttori;
- censire e monitore le opere di Ingegneria Naturalistica già realizzate;
- sviluppare settori di ricerca e sperimentazione per questa disciplina;
- normare il collaudo di tali opere, separato dal collaudo delle opere tradizionali in "grigio" (in materiali artificiali, senza impiego della componente vegetale).

È verso questa direzione che si muove anche la Commissione Ingegneria Naturalistica dell'Ordine degli Ingegneri della Provincia di Roma.

Bibliografia

AA.VV. – PROGECO: Linee Guida di Ingegneria Naturalistica, Progetto MEDOCC, 2006.
AA.VV. – PODIS: Manuale di Ingegneria Naturalistica, MinAmbiente, 2005.
BIFULCO C., MENEGAZZI G., CORNELINI P. - Interventi di Ingegneria Naturalistica nel Parco Nazionale del Vesuvio, 2001.
BOCCALARO F., Difesa delle Coste e Ingegneria Naturalistica, Dario Flaccovio, Palermo, 2012.
FLORINETH F. – Piante al posto del cemento, Il Verde Editoriale, Milano, 2007.
MENEGAZZI G., PALMERI F. - Il dimensionamento delle opere di Ingegneria Naturalistica, Regione Lazio, 2013.
SAULI G., CORNELINI P., PRETI F. - Manuale di Ingegneria Naturalistica applicata alle sistemazioni di versante, Regione Lazio, 2006.
SCHIECHTL H. M. - Bioingegneria Forestale e Biotecnica Naturalistica, Edizioni Castaldi, Feltre (BL), 1991.

LOW-COST SENSING PLATFORM FOR AIR QUALITY MONITORING

Air pollution is a long-standing problem for public administrators and a constant concern for citizens. It is often considered as an emergency situation, but the issue of air pollution is structural and as such should be addressed. The common approach for monitoring air pollution is by means of monitoring fixed stations, which are expensive, complex and provide low spatial resolution data, since are low density deployed. These stations satisfy legislative requirements but do not provide data about local gradients of pollutant concentrations that can be important for health protection. Furthermore, in smaller towns or in developing regions, air pollution stations may not exist. A possible solution to increment spatial resolution data is by means of lower-cost platforms that provide data in near real time. This is a current trend worldwide and has the potential to integrate regulatory air pollution monitoring stations, and also promoting community engagement. In this work a prototype of a low-cost air quality platform is presented. It allows measuring several metoclimatic parameters and fundamental air quality pollutants (NO2, O3, PM2.5/10). Furthermore, it can be continuously connected to a smartphone allowing geolocalization and providing the user about pollutant levels. It has been compared with reference stations and has been tested in the city of Rome so as to obtain spot data and distributed information on the territory allowing the realization of concentration maps.

a cura di: **ING. L. SHINDLER**
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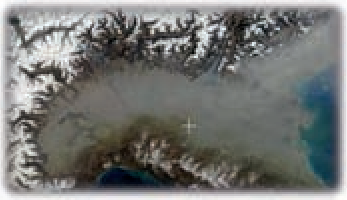
Introduction



Ambient air pollution is a long-standing environmental problem and is a significant health hazard worldwide.

"Globally, 3.7 million deaths were attributable to ambient air pollution (AAP) in 2012. About 88% of these deaths occur in low - and middle –income (LMI) countries, which represent 82% of the world population. " (*WHO, 2014*).

In many urban areas ambient air pollution is the greatest environmental issue threatening human health.

Air quality monitoring

Air quality monitoring is fundamental for:

- understand health effects;
- environmental assessments;
- transportation planning;
- air pollution mitigation strategies;
- provide air quality data to the general public;
- provide data for air quality modelling.

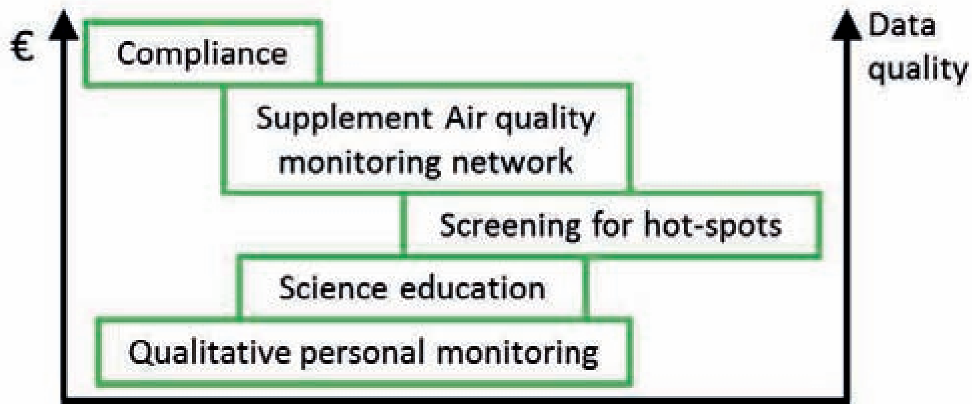
The common approach for air pollution monitoring is by means of fixed stations, which are complex and provide low spatial resolution data, as they are low density deployed.

"Current sophisticated, expensive ambient air pollution monitoring technology is not economically sustainable as the sole approach […]." *US-EPA New Generation Air Monitoring Roadmap 2013*

papers

A possible solution to increase spatial resolution data is by means of mobile or multiple low-cost platforms. This can be conducted with monitors that are becoming smaller in size thanks to technological advances.

This is a current trend worldwide and has the potential to supplement regulatory air pollution monitoring networks (*Snyder et al., 2013, C. Borrego et al., 2016, Velasco et al., 2016, Castell et al., 2017*).



LILI-1: Low-cost air quality platform

Compact, light weight air quality station, which can be easily moved and installed in different places.

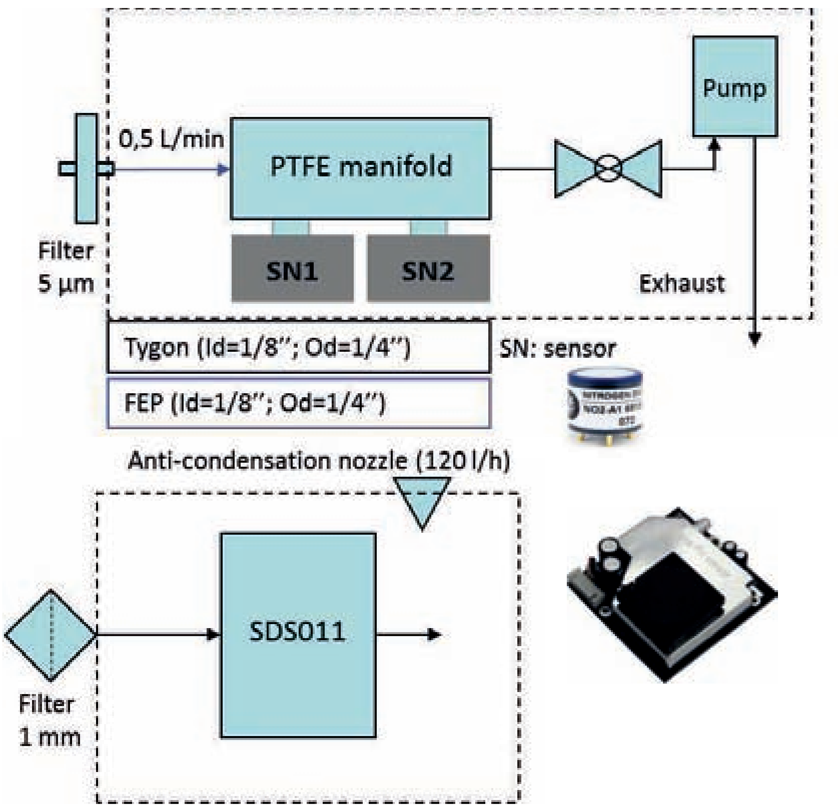
It can also be installed, for example, on a bicycle and georeferencing acquired data

Characteristics

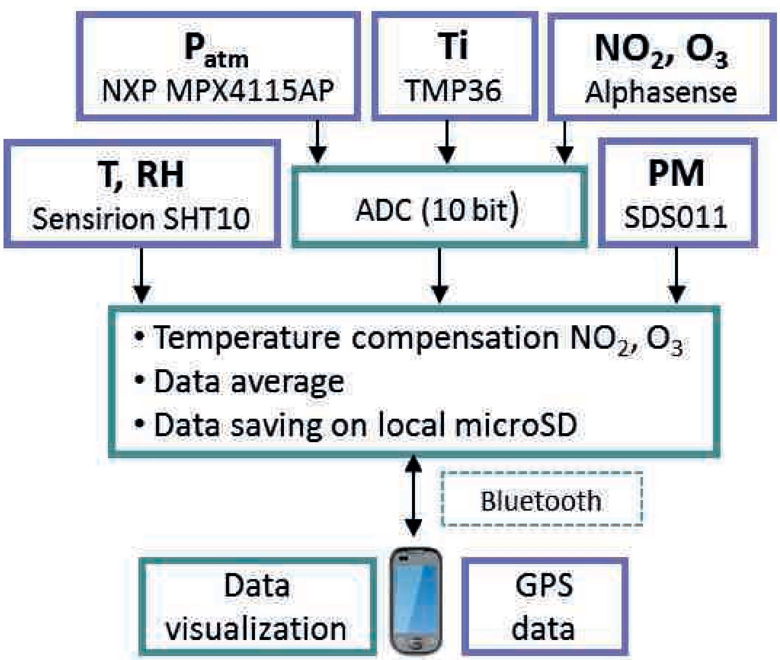
- Max dimensions: 170x270x210 mm
- Weight: 1.5 kg
- Parameters: NO_2, O_3, PM10, PM2.5, temperature, relative humidity, pressure;
- Power: < 2A@5V

Low-cost sensing platform for air quality monitoring

Pneumatic system



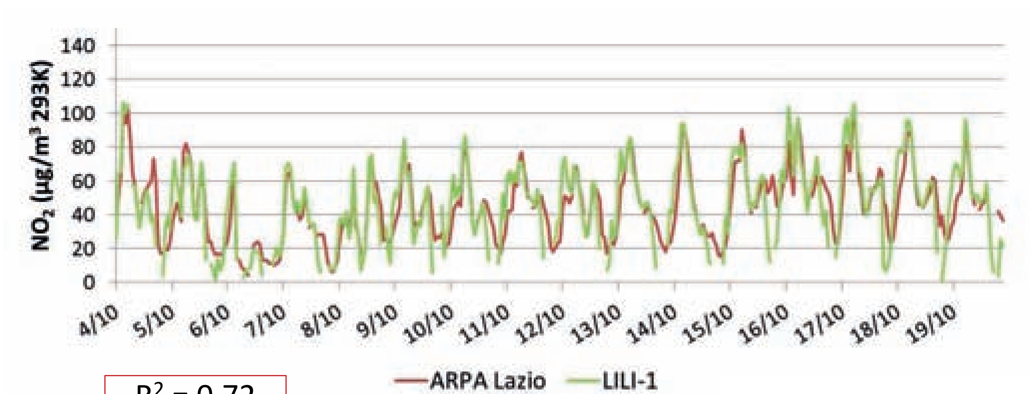
Data transmission



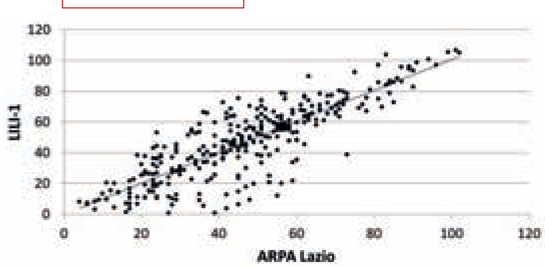
Validation test

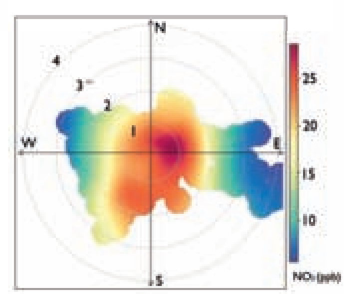
LILI-1 located on the roof of ARPA Lazio building in the center of Rome for 16 days, comparing it with certified NO_x (*Teledyne-API 200E*) , O_3 (*Teledyne-API 400E*), PM10 (*ENVIRONMENT MP101M*) and PM2.5 (*SWAM5a FAI*) analyzers.

Validation test: NO_2

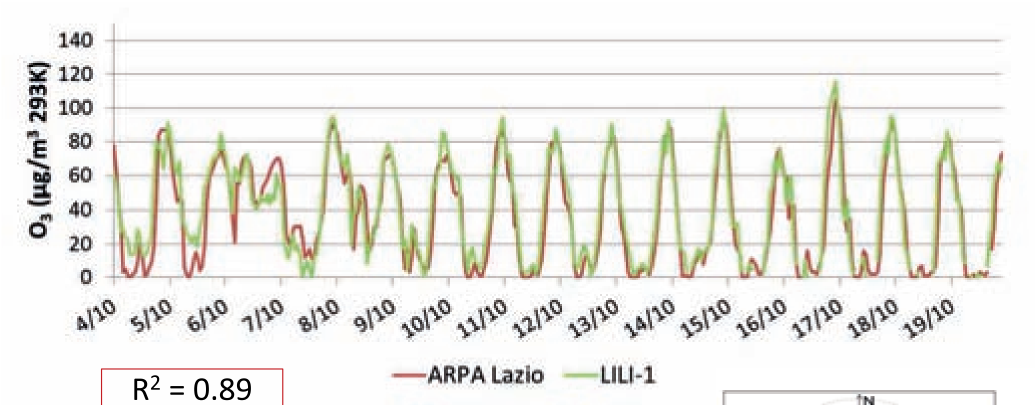


$R^2 = 0.72$

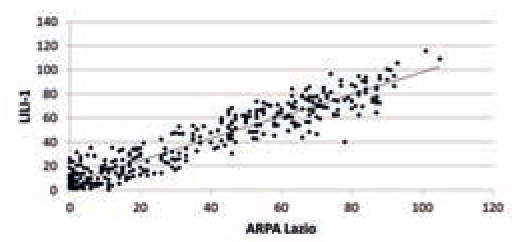


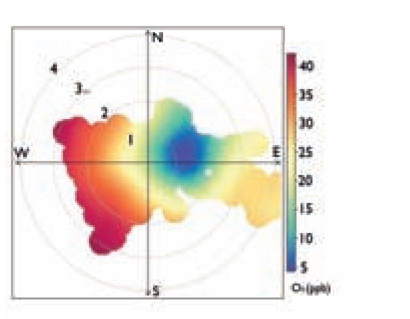


Validation test: O_3

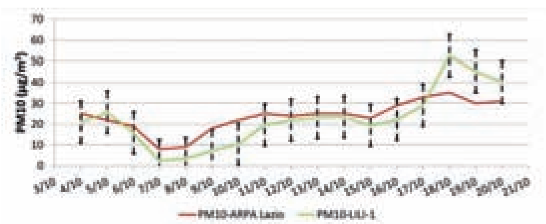


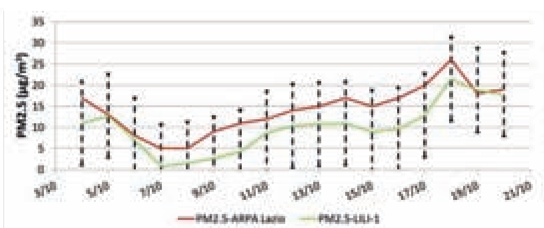
$R^2 = 0.89$



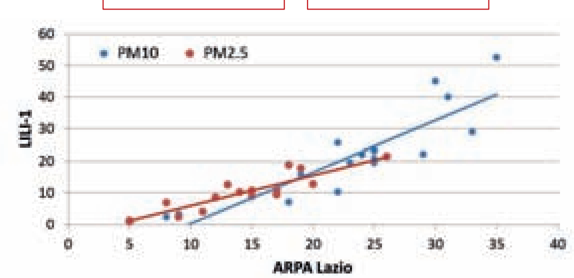


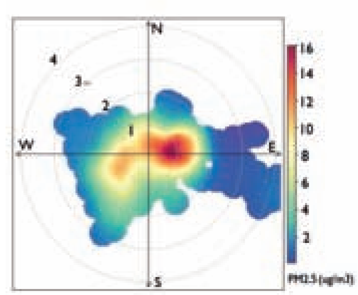
Validation test: PM





$R^2 = 0.75$ (PM10) $R^2 = 0.81$ (PM2.5)





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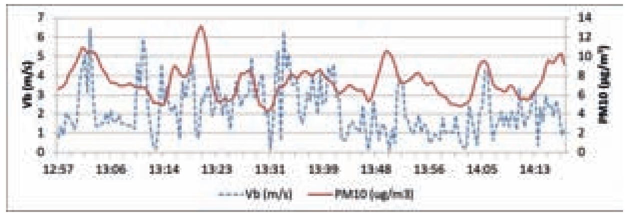
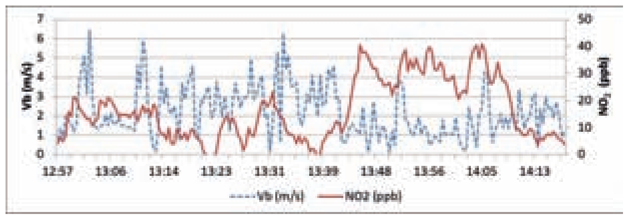
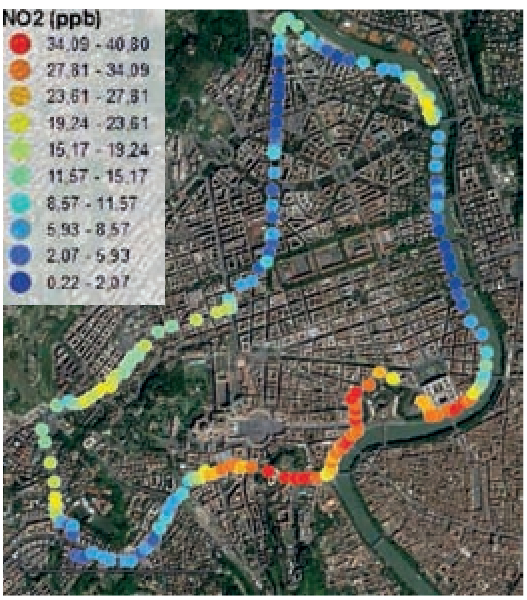
Field test

The Air quality sensing device was transported by bicycle in the center of Rome by alternating static and moving periods in order to verify if movement affects precision

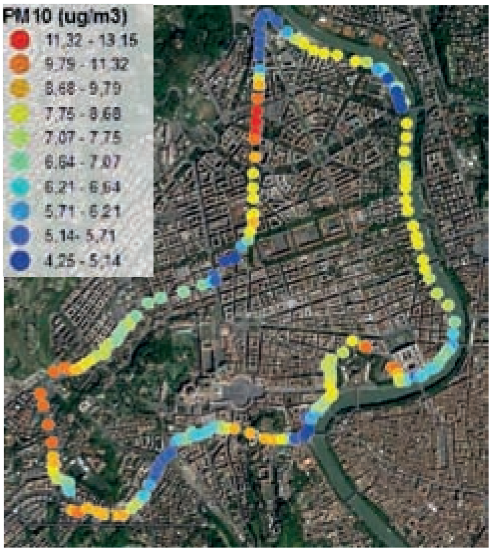




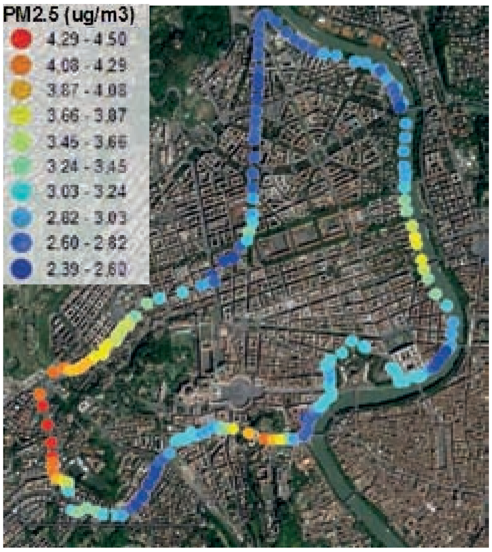


NO_2

O_3



PM10



PM2.5

Conclusion

- A mobile and low-cost system to monitor air quality is proposed to complement the existing compliance one in urban areas.
- The proposed system is capable of increase spatial resolution down to street level.
- The measurements although less accurate, have demonstrated a strong correlation with compliance analysers.
- Monitoring can be conducted in multiple locations and using a geolocalization system.
- Future works will include further validation and field measurements, and testing other case design.

The future of Air Quality monitoring could be a combination of high cost compliance monitoring stations and a high number of low-cost monitoring platforms.

THE CYBER SECURITY FRAMEWORK FOR HUMANKIND'S HERITAGE

Humankind's heritage preservation today is crucial since criminal damage and natural threats have increased the likelihood of occurrence and their reach
Global heritage sites monitoring, to be effective, must take place in real time and must be based on geomatic 3D models that allow the gathering of information from the site to identify and mitigate man-made and natural threats.
Security is not only the physical protection related to video surveillance systems, but an advanced model of correlation of measures on the territory, monitoring and operational management based on the risk indicators built.
The model of monitoring proposed, uses optical sensors, laser, thermal, multispectral, photogrammetry by UAV for the modelling of sites to be protected, physical security tools (TVCC, barriers) for the protection, information security methodologies for the classification of the heritage to be protected and key risk indicators (e.g. destruction, unauthorized access) that will then be valued by the various measures collected in the field.
The approach is to use a risk management methods and tools needed in order to have a better handle of vulnerabilities The framework include best practices defining what to protect, how to protect it, and how to monitor deployed controlsand to assess each risk.

a cura di

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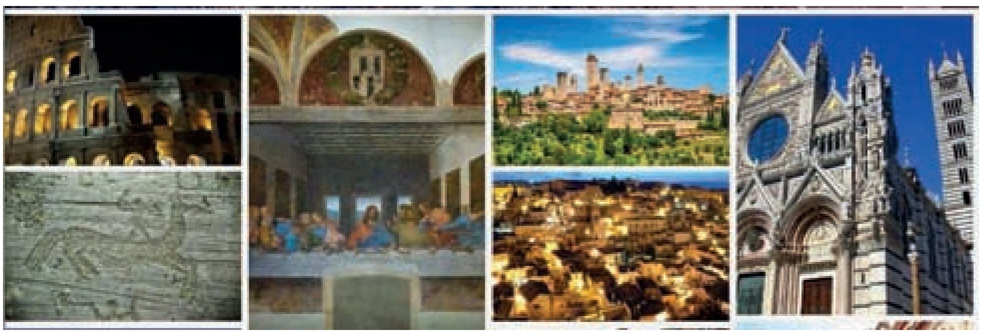
Definitions of the cultural and the natural heritage

The following shall be considered as `cultural heritage':

- **Monument**
- **Groups of buildings**, special value from the point of view of history, art or science;
- **Sites** : topographical areas, are of special value by reason of their beauty or their interest from the archaeological, historical, ethnological or anthropological points of view.



Natural heritage refers to the sum total of the elements of biodiversity, including flora and fauna , ecosystems and geological structures:

- **natural features** consisting of physical and biological formations or groups of such formations, which are of special value from the aesthetic or scientific point of view;
- **geological and physiographical formations, special** value from the point of view of science or conservation;
- **natural sites** or precisely delineated natural areas of special value-from the point of view of science, conservation or natural beauty, or in their relation to the combined works of man and of nature.

RISK MANAGEMENT

R=Risk
P= Hazard (Probability of occurence)
V= Vulnerability
E= Exposure

Risk is one of the most important parameters to be evaluated in order to prevent extensive damages and loss of lives.

Risk management is everything we do to understand and deal with possible negative impacts on our objectives.

It includes the:

- **identification**
- **analysis**
- **prioritization** (we call it evaluation) of risks.

Then we take action to '**treat**' risks, i.e. to *avoid, eliminate or reduce the risks* that we consider unacceptable. We can also transfer those risks to others.

The RISK IS UNDER CONTROL?

Geomatics Science

What does it mean geomatics?

Geomatics is:

the discipline that deals with the acquisition, processing, interpretation, dissemination of geographic data.

Geomatics as discipline for the knowledge and SMART management of the territory…

Geomatics provides the best way to give an efficient response by combining many techniques which are able to observe and measure environment, infrastructures and structures.

All the geomatic techniques may be integrated one with each other. This allows to represent the investigated area «from a lower to an higher» scale .

Geomatics applications from small up to very large scale.

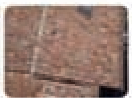
Geomatics

environmental monitoring and management

from small up to medium scale applications (Remote Sensing, GNSS and SAR monitoring of landslide)

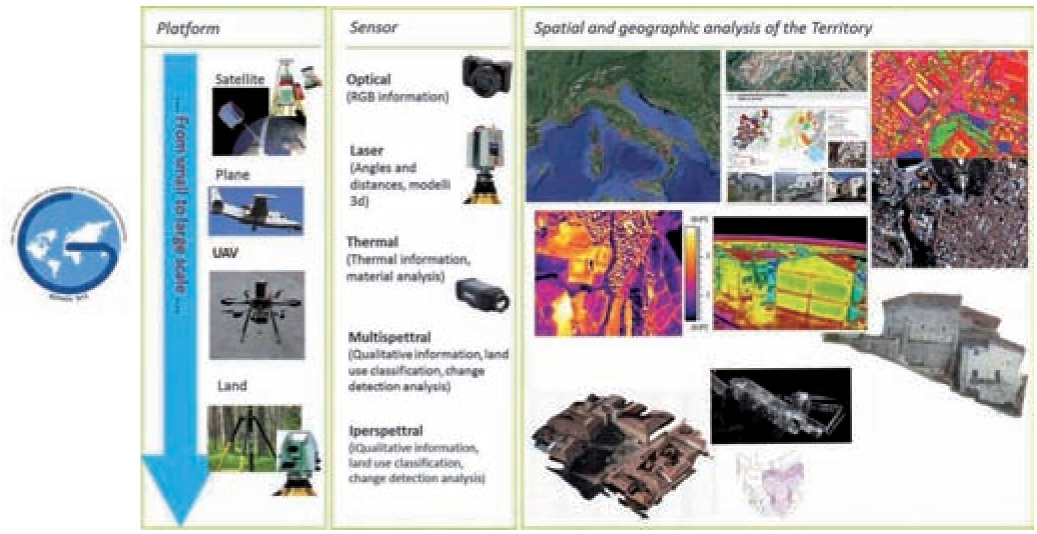
cultural heritage monitoring and civil applications

from very large up to large applications (3D modelling using UAV photogrammetry and laser scanner techniques, displacement monitoring)



Knowledge Phase – 3d Geo-Spatial modeling

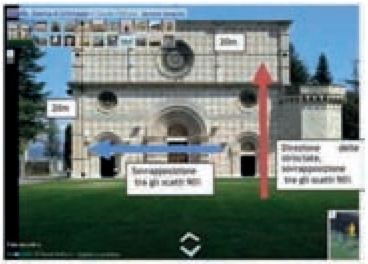
The idea is to develop an OPERATIONAL and COMPLETE METHODOLOGY capable to lead the entire process of the sustainable recovery of the historical centers through the 3 important phases of KNOWLODGE, MULTILAYER ANALYSIS AND DESIGN of the best solution defining a systematic process that can be replicable in any historical centers context.



Gitais Model

Case study: ‘Collemaggio’ Basilica

- Flight planning

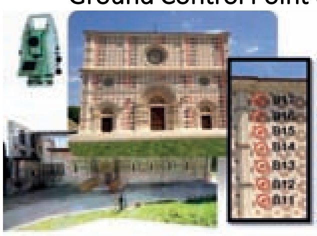


The flight planning was generated at the distance of 30 m on the facade.
The overlapping of the photogrammetry was equal to 90%.

- UAV Equipment

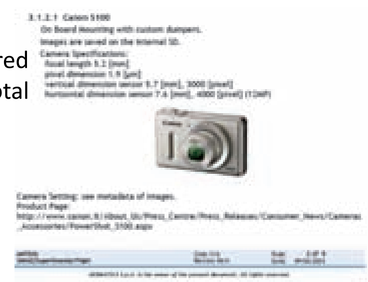
UAV

- Ground Control Point (Total Station)



Network of Ground Control Point (GCP)

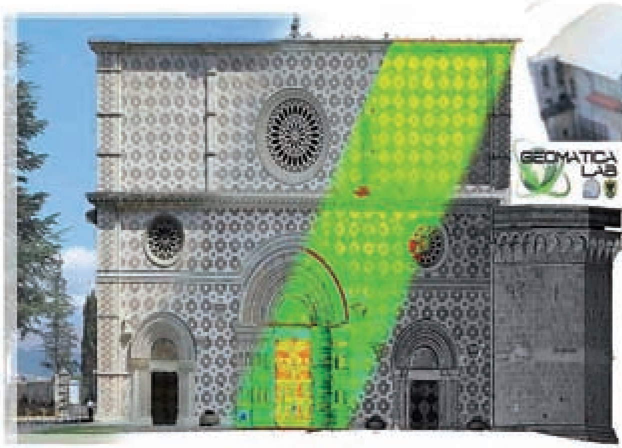
A network of GCP was measured on the facade using the Total Station TS30.



Camera specifications

Basilica Santa Maria Di Collemaggio, L’Aquila

Acquisition mode/image number	*UAV*	*291*
	Terrestre	*0*
GSD (Ground Resolution distance)		
Geometry acquisition		*Oblique*
Flight height/distance		*30 -15 m*
Photograms overlap		*90%*
		90%



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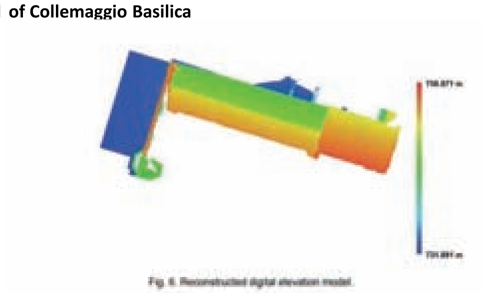
- Results

Results of Bundle Adjustment

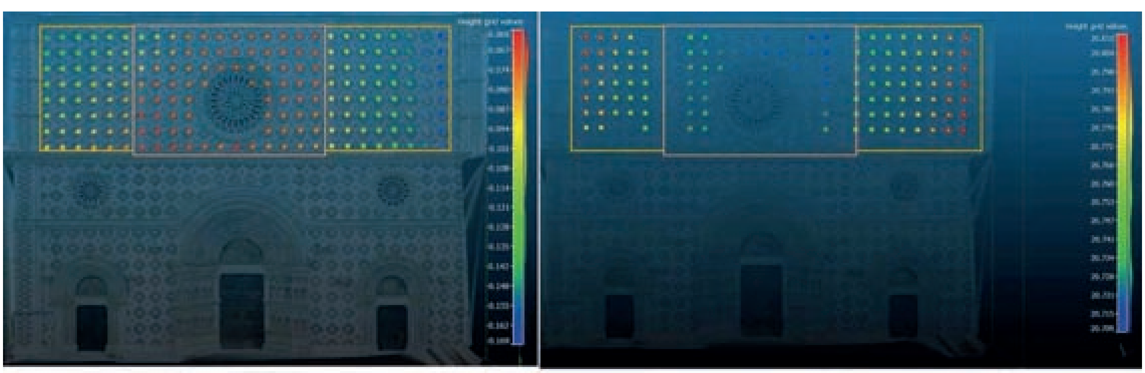
Case 1	Number	Error (m)	Error (pix)
GCP	7	0.035584	1.364605
Check point	45	0.061569	1.397261
Case 2	**Number**	**Error (m)**	**Error (pix)**
GCP	11	0.031943	1.322391
Check point	41	0.038778	1.409865
Case 3	Number	Error (m)	Error (pix)
GCP	20	0.027105	1.364835
Check point	32	0.046871	1.408498

3D Model of Collemaggio Basilica



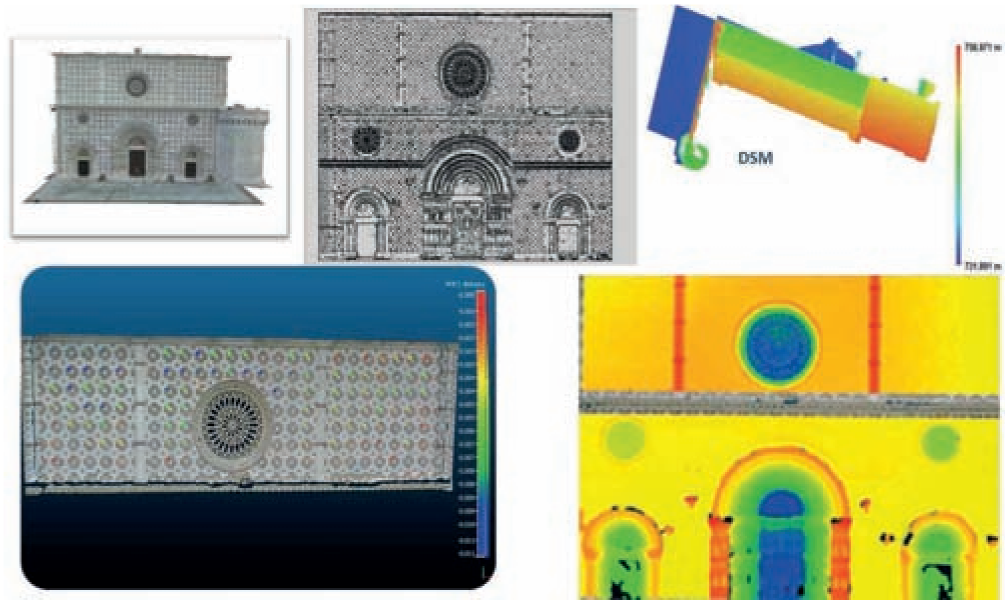
- Results

VERTICAL ANALYSIS ON THE FACADE



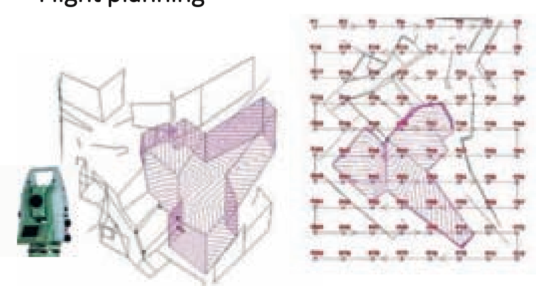
Photogrammetric point cloud → **Good agreement** ← **Total Station point cloud (σ = 2-3 mm)**

- Results



Case study: 'Fontecchio' build-up area

- Flight planning



For the flight planning has been used the volume of the build-up area previously measured with a total station.
The waypoint computation was performed considering an overlapping value of about 80% between the various photograms.
The obtained flight altitude was equal to 30 m.

UAV

GoPro hero3+

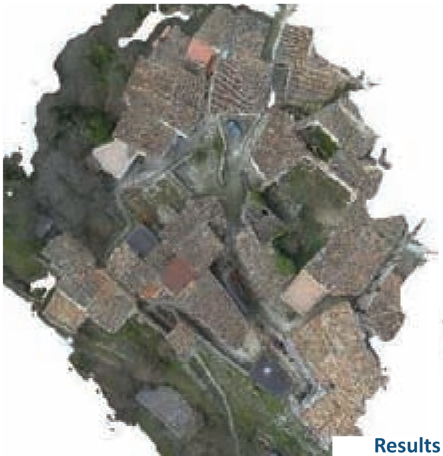
Weight: 74g
Resolution: 12 MP (4000x3000)
Wide field of view
Focal lenght: 3mm

- Ground Control Point (NRTK)

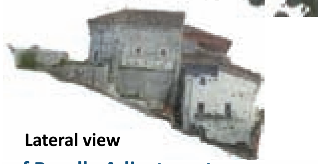
Only 4 GCPs were measured due to the low satellite visibility .

- Results

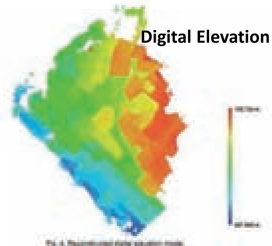
3D Model



Ortophoto



Lateral view



Digital Elevation Model

Results of Bundle Adjustment

Label	X error (m)	Y error (m)	Z error (m)	Error (m)	Projections	Er
gps1	-0.023200	-0.002612	-0.013203	0.026821	16	[illegible]
gps5	0.016597	0.053314	-0.014569	0.057707	36	[illegible]
gps6	-0.032304	0.042269	0.053469	0.075426	33	1.651860
gps2	0.038617	-0.093032	-0.025533	0.103914	38	2.480539
Total	**0.028933**	**0.057643**	**0.031215**	**0.071653**	**123**	**1.995353**

Table. 2. Control points.

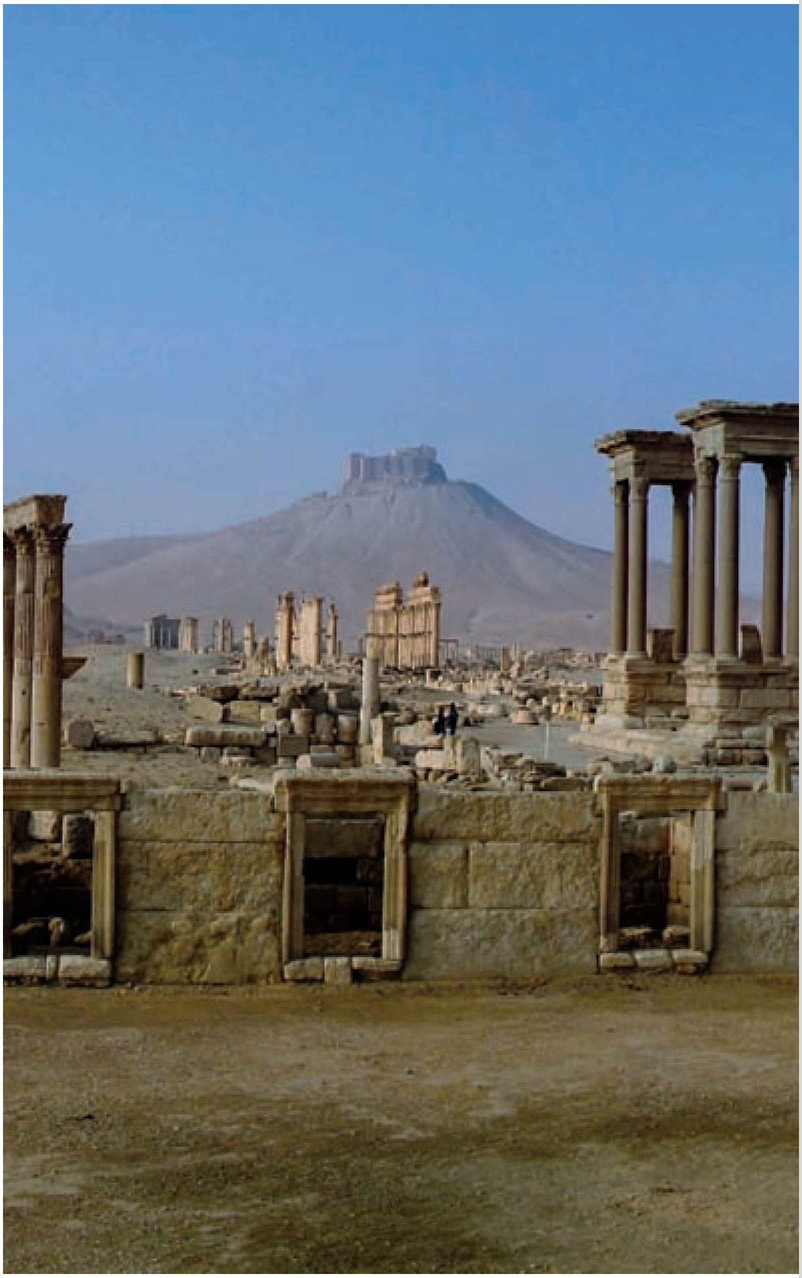
Conclusions

Security is not only the physical protection related to video surveillance systems, but an advanced **model of correlation of measures** on the territory, monitoring and operational management based on the risk indicators built.

The model of monitoring proposed, uses optical sensors, laser, thermal, multispectral, photogrammetry by UAV for the modelling of sites to be protected, physical security tools (TVCC, barriers) for the protection, information security methodologies for the classification of the heritage to be protected and key risk indicators (e.g. destruction, unauthorized access) that will then be valued by the various measures collected in the field.

The approach is to use a risk management methods and tools needed in order to have a better handle of vulnerabilities. The framework include best practices defining what to protect, how to protect it, and how to monitor deployed controlsand to assess each risk.

The safeguard of the human's heritage is not just the defense of cultural properties and works of art and thought.
Technological development and empowering role of IT has enabled the creation of information and images silos, such as copies of originals, to guarantee the memory and the accessibility of the assets over time and place. In some cases, the digital copy is the only copy that survived to the destruction of the original one.
Humanity's cultural heritage is under attack for economic interests or new iconoclastic phenomena. It is not to be undervalued the risk that the attacks to the integrity and availability should extend to digitals' copies, to completely alienate the memory of the target cultural heritage.
You notice how increasingly concrete the dual use of cyber attacks is. Methods already practiced to public entities can effectively be used towards warehouses or silos of cultural information. These attacks are increasingly executed with hybrid techniques whose response passes through preparation, identification, mitigation, technical and perhaps political answers.
Regard computerized cultural heritage increasingly as a critical resource, like critical infrastructures, to be protected from targeted threats aimed to alteration or radical alienation. Engineers' skills and defense's techniques play a key role in the organizational and technical response to these threats.
The goal is Right-To-Be-Remembered (RTBR) instead of Right-To-Be-Forgotten (RTBF) as from GDPR.



a cura di **ING. G. G. ZORZINO**[1], **ING. A. PRAITANO**[1], **ING. M. PIRRÒ**[2]

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HYBRID CYBER THREATS TO HUMANITY'S CULTURAL HERITAGE: RISKS AND OPPORTUNITIES

My desktop background

Table of contents

HYBRID THREATS

Hybrid is the new "buzzword" in the military field

Exploitation of vulnerabilities on the target, using conventional and unconventional methods, to generate ambiguity to hinder decision-making processes

- ✓ generate surprise;
- ✓ seize the initiative;
- ✓ generate deception and ambiguity;
- ✓ avoid attribution of action;
- ✓ maximize deniability of responsibility for aggressive actions.

The resulting mixture of Cyberspace with other enablers like Air and Space domains, the so-called "cyber dimension of Hybrid Warfare", could represent a risk to national interests, cultural too.

Dual perspectives for the use of cyberspace:

- *as an attack on warfare domain*
- *as an threat on assets, goods, economy, culture, infrastructure, human psychology, etc.*

How they work

"Multimodal, low intensity, kinetic and non-kinetic threats to international peace and security including cyber war, low intensity asymmetric conflict scenarios, global terrorism, piracy, transnational organised crime, demographic challenges, resources security, retrenchment from globalization and the proliferation of weapons of mass destruction were identified by NATO as so called hybrid threats"[1]

There is a variety of hybrid cyber threats:

- cyber espionage by State actors for economic and intelligence objectives;
- cyber hacking through individual and organized actors, organized crime (involved in narcotics, arms, human, illicit trafficking in antiquities or works of art, and other threats);
- attacks on Integrity, and Availability domains of security (C.I.A.);
- …

[1] "BI-SC Input to a New NATO Capstone Concept for the Military Contribution to Countering Hybrid Threats." 2010. http://www.act.nato.int/images/stories/events/2010/20100826_bi-sc_cht.pdf

papers

ICONOCLASTIC ATTACKS

Iconoclastic attacks to cultural heritage sites are:

- on the historical or archaeological heritage of a nation,
- often originated by a true or supposed iconoclastic justification,
- motivated by religious or politically non-conforming prescriptions.

The last most sensational cases of targeted destruction of cultural goods have taken place in Syria, some of which are also World Heritage Site (UNESCO heritage).

Previously, it had happened in recent time with:

- the library heritage of Timbuctu in Mali for the sake of the Mahdi,
- the Taliban's Bamiyan Buddhas,
- …

Remember the Latin phrase "*damnatio memoriae*".

INFORMATION SILOS OF CULTURAL HERITAGES

Some cultural sites in "List of World Heritage in Danger[1]" have been completely documented (satellites photos, laser scanner 3D detection, images, history, etc.).

Other endangered sites, at the border or near to instability areas around the world, need to be fully documented.

All this info must to be maintained into information silos of cultural patrimony to preserve the cultural heritage and forward it to future generation.

This IT sites or IT silos need:

- to be protected (IT secured)
- to be promoted to UNESCO Cultural Heritage Sites like the artifacts they document because they are "the last repositories of cultural identities of a population"

[1] http://whc.unesco.org/en/158/

WHAT RISKS AND OPPORTUNITIES

Risks:

- Attacks on IT silos aim to destroy every kind of existing memory for a discussed artifact
- Remote attacks or delegated exploitation of vulnerabilities to cancel or alter the memory
- Complete loss of cultural identities of a population

Opportunities:

- Enrich the resilience (yet defined from UNESCO) not only from natural or human induced physical hazards
- Improve IT security applying IT security standards (ISO27001, NIST Framework, ISO31000)
- Document in-depth and comprehensively collect all the information available
- Reproduce, substitute the artifacts in danger, and recover it in safe place
- Give the wide availability of the artifacts based on the popular sharing technologies

RTBR INSTEAD OF RTBF

RTBF as Right To Be Forgotten – Google Spain – EUCJ 2014

Our target is

- maintain the memory and informations (culturals, technical, historicals, political, etc.)
- keep this memories up from every attacks
- preserve the memories, otherwise the heritage disappear

In few words → **RTBR** as Right To Be Remembered

WAY AHEAD

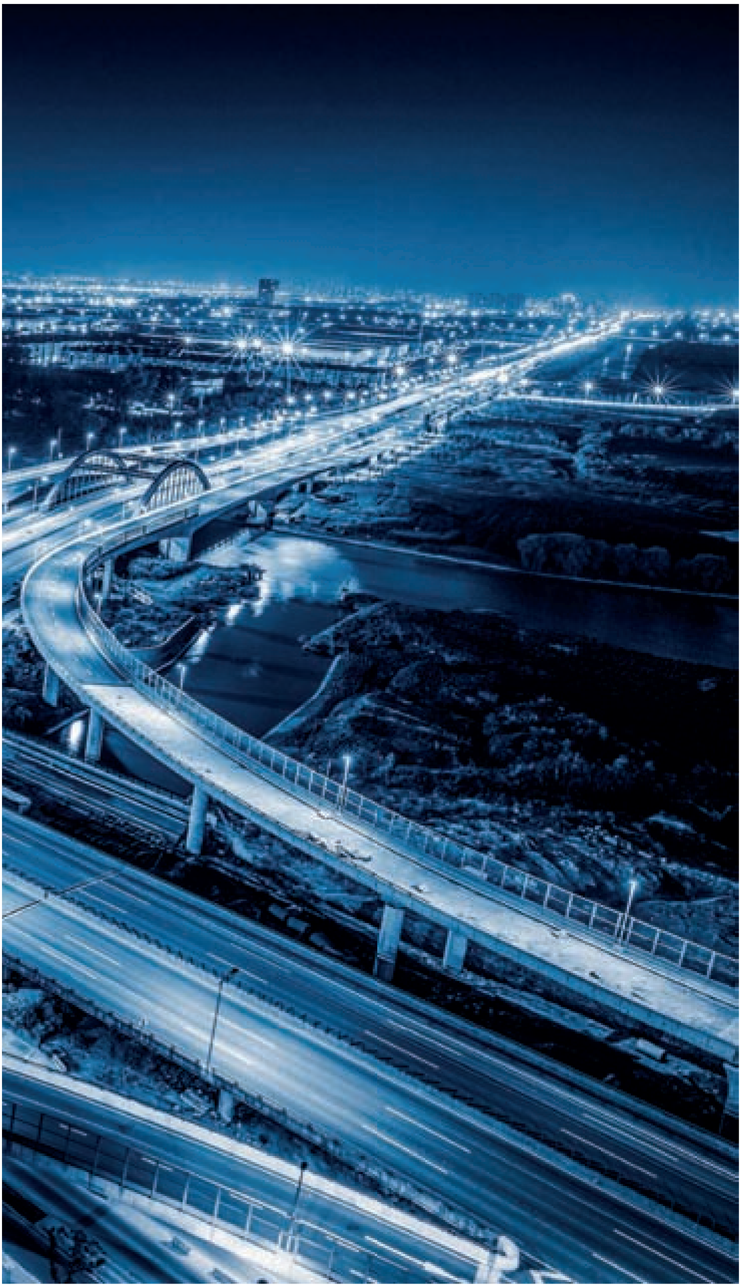
- Digital heritage transformation as a way to protect the "original" sites based on a digitalisation standard
- IT silos → gain the status of UNESCO sites of cultural heritage mainly for destroyed site(s) the digital version became the "primary" site
- Activate all IT strategies (security governance) to protect the integrity and availability of documentation data of UNESCO
- Aware the people to hinder the potential threats to alter the information describing the cultural assests
- A new way to make available the digitized cultural heritage of the artifacts

The target is

"Right To Be Remembered" or RTBR

A NEW ALGORITHM FOR THE CITY: THE USE OF TOPOLOGY AND TRANSPORT MODELING TO MAKE URBAN AREAS MORE EQUITABLE

The prevailing model of urban development is increasingly oriented to a territorial isotropy, despite the evidences of a considerable literature.



This is due to the lack of mathematical models able to translate this awareness into appropriate analytical and functional models.
Nowadays a city no longer exists as mere physical built place, but as a dematerialized "cloud" of flows: people, goods, information. The paper presents a methodology that allows us to use the modeling tools already in the planning and design phases to promote new mobility paradigms that reduce the displacement need and the soil consumption.
The concept of Set is the cornerstone of most of modern mathematical expositions. It is primitive and intuitive, because it is introduced as a generalization of the concept of a finite set, like a box containing homogeneous material objects. A domain is the closure of an open set, i.e. a closed set formed by the union between an open set and its border: a neighborhood unit is a domain.
The proposal is to use the topological theory to highlight the physiological processes of a city. Through the measurement of the mileage it is possible identify the effective improvements: a functional "mixité" of a neighborhood unit; a connection of two clusters to reduce the radial displacements; a more homogeneous distribution of facilities. Proceeding in a controllable and measurable way.
Final aim is to promote a greater local distribution of the flows that make the slow mobility functional and structural.

a cura di **ING. A. SPINOSA**

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Introduction

Although this is the information age, it does not mean that the displacements are decreasing. The cities are being renovated but the per capita movement of people and goods will increase by 30% at 2050 (The World Bank). This means that a proper planning of displacements will be essential for achieve the sustainability. The guiding principle is that a balanced city produces social - and environmental – well-being.

To make possible a restructuring of urban flows, it is necessary to rethink the relationship between mobility and the isotropic structure of the contemporary territory. In fact, whether the dispersion is considered as a deleterious phenomenon to be stopped, or it is accepted as a positive process of the current phase of capitalism, the spatial results of 40 years of dispersion process are almost irreversible.

It is necessary to design a mobility system that mitigates the inefficiencies and diseconomies of real estate industry, without denying the specific dilated conformation of the dispersion. An integrated system able to reorganize what exists but that is able to evolve over time. This requires reviewing the philosophy underlying the conceiving of transport networks, that is to rethink the relationship between the consolidated city and sprawl.

Today to a territorial isotropy that expands the city up to coalesce into a regional-scale urbanized continuum – corresponds an anachronistic logic that sees a centripetal transport planning from downtown to the suburbs. In this frame, the transport modelling is involved at the end of urban planning, when all decisions have been already made. This is because the mathematical modeling is perceived as a verification tool, at most as a tool useful to sizing the urban items.

The paper presents a methodology that allows us to use the modeling tools already in the planning and design phases to promote new mobility paradigms that reduce the displacements. The measurement unit is the mileage, i.e. the number of trips by the traveled distance. The urban body is discretized in homogeneous areas, the neighborhood units. More neighborhood units form urban clusters. In carrying out their daily activities, people will choose to move into or out of a cluster, depending on whether they can find what they need in the same cluster.

Territorial division should follow a careful reading of the territory: this means translating the physical elements in a mathematical language. Area, border, barrier: these are all concepts describable by the principles of the Analytical topology. The concept of Set is the cornerstone of most of modern mathematical expositions. It is a primitive element, because it is introduced as a concept not derivable from more basic concepts. It is intuitive, because it is introduced as a generalization of the concept of a finite set, like a box containing homogeneous material objects. A domain is the closure of an open set, i.e. a closed set formed by the union between an open set and its border: a neighborhood unit is a domain.

The topological model

The proposal is to use the topological theory to highlight the physiological processes of a city. Through the measurement of the mileage it is possible identify the needed improvements: a functional "mixité" of a neighborhood unit; a connection of two clusters to reduce the radial displacements; a more homogeneous distribution of new facilities.

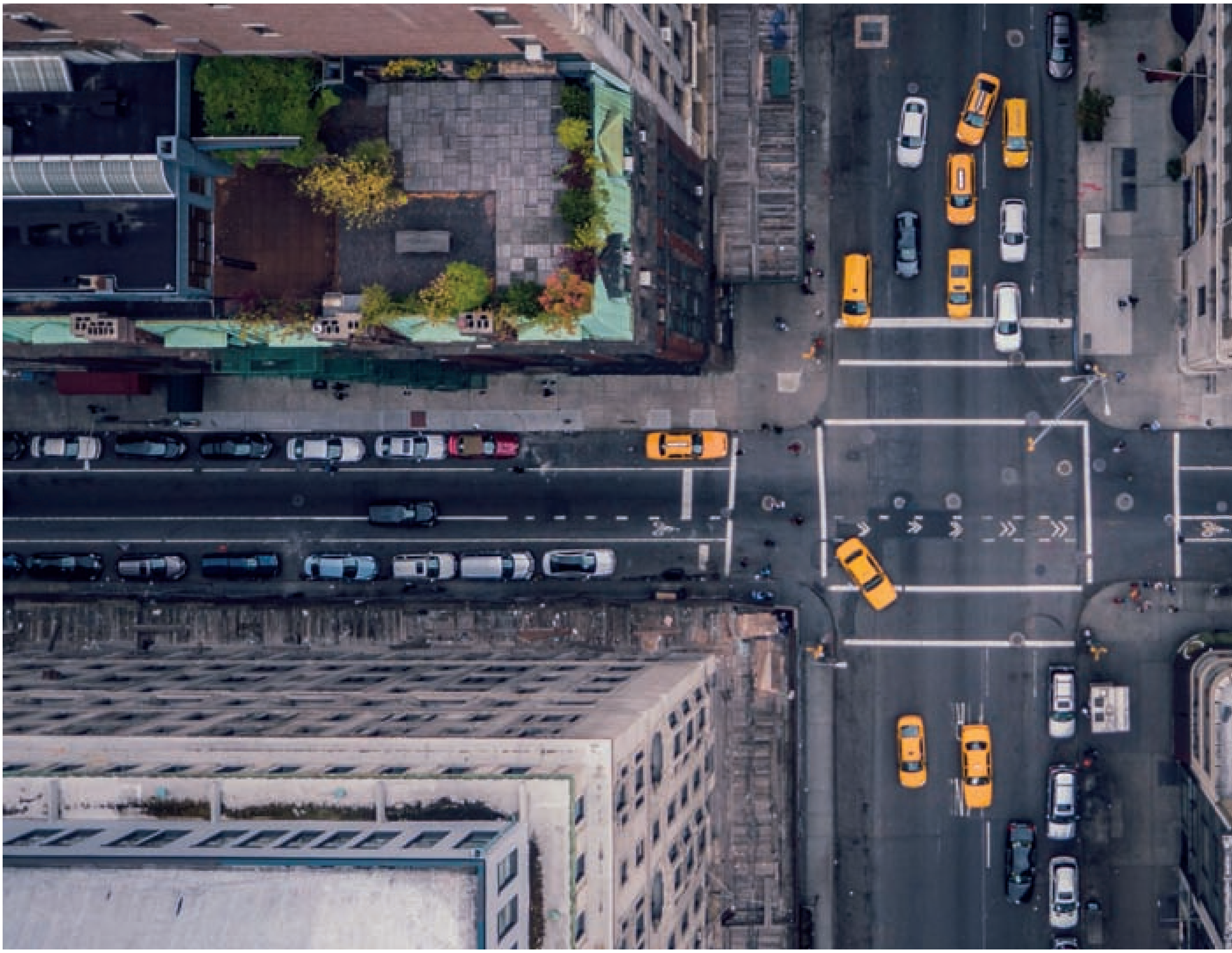
All to promote a greater local distribution of the flows that make the slow mobility functional and structural.

In mathematics, a topological space is the basic object of Topology. It is a very general concept of space, accompanied by a notion of "closeness" defined as weak as possible. Thus, many of the spaces commonly used in mathematics (such as Euclidean geometric space) are nothing more than topological spaces. What virtually characterizes a topological space is its form, and not the distance between its points. this is because the distance between two points X and Y cannot be defined as a general law using topology rules.

The topology is one of the most important branch-

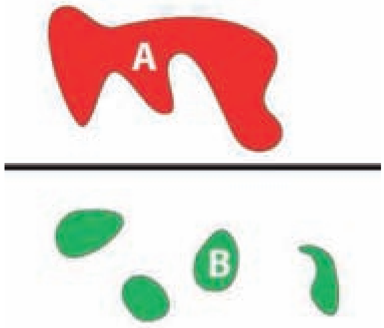
The proposal is to use the topological theory to highlight the physiological processes of a city.

es of modern mathematics: here fundamental concepts such as convergence, limits, continuity, connection or compactness found their best formalization.
The concept of closure is found in mathematics in many fields and with different degrees of generality. Intuitively, a set is close if it is possible to move enough in any direction from any point in the set without departing from the collection itself. Following the general definitions one can move beyond this intuitive idea. Through the definition of open set, it is possible to define terms like "near", "far", "attached", "separate". Non-intuitive definition of open sets corresponds to mathematical situations in which these concepts are used in a non-intuitive way. It is the case, for example, of non-Euclidean geometry.
A domain is connected if it is not divisible into in-



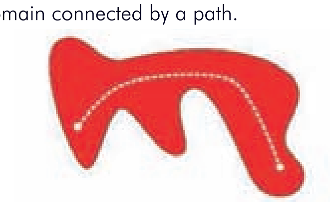
dependent portions. In mathematical terms is said that a nonempty topological space is called connected if the only pair of disjoint open subsets (separated) whose union is X are {Ø, X}. These are called banal subsets: the empty one and the X itself.
In simpler words - but quite intuitive - it can be said that the connection is the topological property of a set of being formed by a single "piece".
The limit connected subsets of a topological space X are the connected components of X. In other words, a subset of X is a connected component if it is connected and is not contained in any other subset connected. The connected components of X are disjoint and their union is X: they form a partition of X. In most problems it is sufficient to consider only connected space, because they are the "building blocks" in which are made all topological spaces.

Figure 1: "A" represent a connected domain while "B" not, it consists of 4 related - but disjointed – entities.



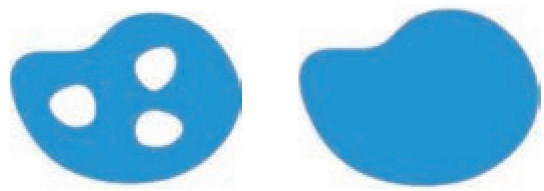
A topological space X is connected by arcs if for any two points x and y of the space there is a path that connects them. In other words, there is a continuous function f from the range [0, 1] in X so that f (0) = x and f (1) = y. A space connected by arcs is connected. The two notions do not coincide, because there are spaces connected but not connected by arcs.

Figure 2: Domain connected by a path.



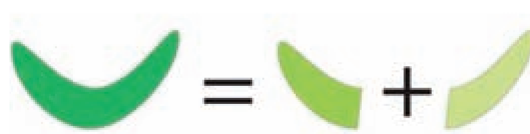
A domain is simply connected if it is made of one piece and has no holes. More precisely, a topological space is simply connected if is connected by arcs (one piece) and every closed curve can be deformed to be reduced to a single point (no holes). Is p a point of a domain X. A path starting from p is a continuous function f: [0, 1] → X such that f(0) = f(1) = p. The path is contractible if there exists a homology that transforms the path into the constant path g(t) = p for every t belonging to X. In other words, it is contractible if it can be "squeezed" continuously up to become arbitrarily small. The topological space X is simply connected if every path centered at p is contractible.

Figure 3: The domain on the left is not simply connected. It becomes connected by eliminating the holes (figure on the right).



In the Euclidean plane a Set is said convex if - for each pair of points (a, b) of the set - the segment ab that joins them is entirely contained in the set. Examples of convex sets are circles, spheres, cubes, planes, half planes, trapezoids. Not convex sets (called concave) are arcs of circles, torus or any collection containing holes or depressions. Generally, all the not connected sets are convex. Intuitively, a convex shape is a compact, while a concave figure is an arched shape.
The definition of concave set in not used in Set theory, but it is employed through the more complex notion of connected space.

Figure 4: Decomposition of a concave set in two convex subsets.



In the Euclidean space a convex set is simply connected. Vice versa a set concave can be divided into two or more convex subsets.

From the city to the archipelago of urban islands

The discretization of an urban area can be done in very different ways [1]. The proposed method involves the identification of homogeneous areas by territorial density. These elements are urban islands characterized by a degree of urbanistic homogeneity. Each island is a geographical space having the following characteristics:

- homogeneous urban structure, described by the homogeneity of territorial distribution;
- be topologically representable by a simply connected domain (that is a connected-for-density domain).

  Starting from a certain neighborhood – the pivot -, to delimitate the urban island it is possible to proceed in two ways:
- by aggregating neighboring entities to the pivot;
- by disaggregating administrative entities and then by aggregating to the pivot only the equipollent urban portions***.

Of course this is a simplified discourse. The density threshold value approximates a real situation that is much more complex. The urban structures are organized in parties related by multiple elements. The population density (conceived as an approximation of the contiguity of the built-up area) is just one of these elements. A city exists not as a fixed entity (built-up area) but as a cloud of high-density relational paths. People, goods and information move by following a complex logic but a robust literature [2] has shown that this complexity is related to residential density. A relationship that does not depend so much to the absolute value of the density, as far as the mutual differences between the various parts of the city.

Thanks to GIS tools [3], it is possible to automate the procedure described above by implementing the following algorithm:

1. acquire the administrative boundary of the municipality
2. acquire the territorial density values, at the most disaggregated value (e.g. urban districts or neighborhoods)
3. divide the municipal area according to an elemental grid of 250 meters' side
4. n = number of grid columns
5. m = number of grid rows
6. v = 1
7. w = 1
8. i = 1
9. for v = 1 to n repeat the following cycle:

Figure 5: A simplified urban area in which four distinct homogenous urban islands are discernible. The first, U1, is derived from the aggregation of three neighborhoods with different densities: the pivot area (dark colored) exceeds 3,000 people per km^2. The second urban area, U2, is formed by the incorporation of two neighborhoods for density and annexation of a third (with a density below the reference) by contiguity. U3 and U4 are mononuclear or banal.

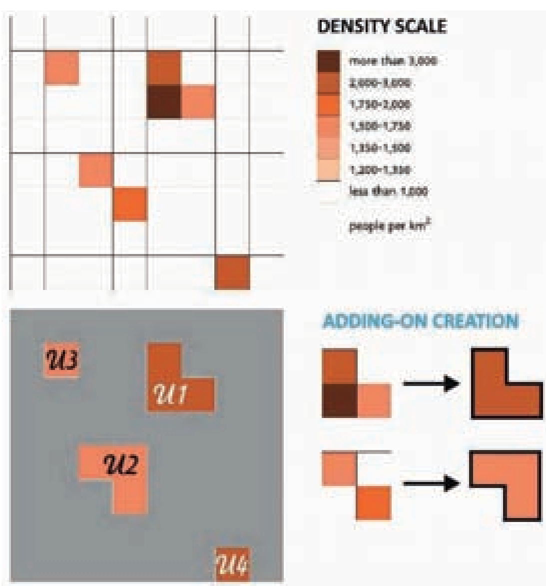
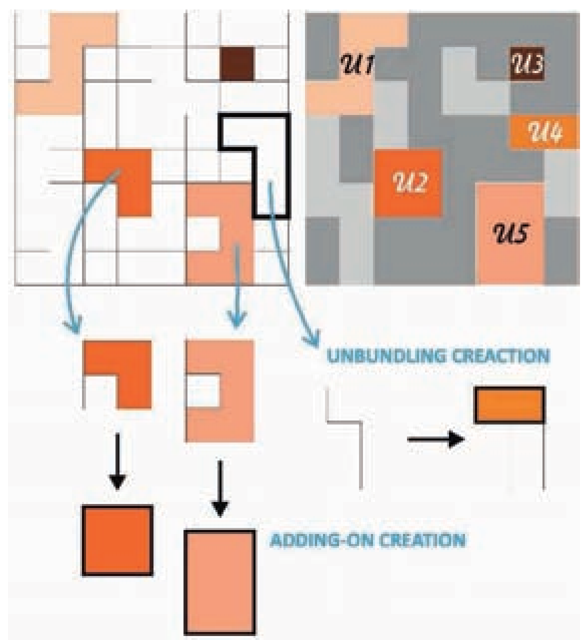


Figure 6: In the second example beside, it is shown the urbanism island be formed even for disaggregation of a demographically not homogeneous neighborhoods. Starting from a common non-simply connected domain, it is split into two sub-domains in which one hosts the main urban nucleus and the other the remaining land.



10. for $w = 1$ to m repeat the following cycle:
    11. domain assignment $U_i = c_{vw}$
    12. assign $s_i = 1$
    13. assign $h = n$
    14. assign $k = m$
    15. for $i=1$ to h repeat the following cycle:
        16. for $j=1$ to k repeat the following cycle:
            17. if $0{,}8 \cdot D_{hk} < D_{ij} < 1{,}2\ D_{hk}$
                then $U_i = U_i + c_{ij}$
                    and $j = j+1$
                    and $s_i = s_i + 1$
                else $j=k$
            18. If $s - i = 0$ then $i = i + 1$
                else $i = h$
    19. $w = w + 1$
20. $v = v + 1$
21. end

The elementary function D_{hk} returns the territorial density value in the cell c_{hk}. The working grid has 250 meters' side because the distance of 250 meters can be assumed to be acceptable distance for most the population to be walked on foot in their daily trips.
In this way, the municipality inscribed in the grid $m \cdot n$, is divided into i urban islands U_i formed by k rows and s_i contiguous columns.
The next step is to make the urban islands U_i a topologically connected domains. The routine to apply is described by the following algorithm:
1. domain assignment $D = U_i$
2. if D is connected (in a topological meaning)
then go to end
else
3. $D=D$ + internal holes
4. h = row (U_i)
5. k = column (U_i)
6. while D is not connected (in a topological meaning)
    7. if $k<m$-1 then $k=k+1$
       else $h=h+1$ and k = column (U_i)
    8. $D=D+U_i\ (h,k)$
9. end

This operation involves that the urban islands may be reduced by number since some of them might merge one each other to comply with the connection condition.
The discretization procedure in a set of urban islands topologically connected is applicable:
- to an administrative unit (municipality);
- to an urban area formed by multiple administrative units (larger urban zone or metropolitan area).

The trip generation model

For an urban transport line with N stations, the number of daily passengers [4] will be the result of two separate contributions:

Daily passenger = P_d = node effect+network effect

Denoting with S_i the i-th station or stop of the line:

$$P_d = \sum_{h=1}^{h=N} P_d(S_k) + \prod_{h=1}^{h=N} \prod_{k=1}^{k=N} P_d\,(S_h \leftrightarrow S_k)$$

The node effect is due to passengers generated or attracted by a specific single station, valued as if it were isolated and not inserted in the wide context.
The net effect is additional to the previous and results from the mutual synergies of the network: a passenger moves from A to C because he is interested to go to B.
In general, these modes of displacement are a function of the same elements in other words trip way = f (age class, average income, land services).
The model formulated on these rules, acts like a gravitational field [5]: each node exercises on a hypothetical user an action directly proportional to its population size and its equipment of services and inversely proportional to the distance that separates it from the own place of the user.
What was said above is also generalizable for private transport. In this case, the infrastructure on which passengers move is the urban road network. Stations and stops are the junctions and the car parks which are distributed along the road network.
In Italy (Istat), in an urban area it can be assumed that about 82% (it was 85% at the beginning of the 2000s) of the resident population make at least one trip every weekday. The number of trips made by people traveling in an urban area is 2.7.
For each urban island U_i of a city, with a population Πi, the number of daily generated trips T_i is

$$T_i = 0,85 \cdot \Pi_i \cdot 2.7$$

Currently urban planning requires to the transport modeling to improve the networks performance that is lower overall impedance. Road impedance from a node N_h to a node N_k is defined as

$$Z_{hk}^{R} = 1 + \alpha \cdot ln(\tau_{hk})$$

Where _(hk) is the travel time from h to k, and is an integer constant. τ_{hk} is a function of the average speed σ_{hk}

$$\sigma_{hk} = \sigma_{MAX} - \gamma_{hk}$$

γ_{hk} is the average congestion factor on the path hk. But also the following relationship is valid, where β is an integer constant

$$\gamma_{hk} = 1 + \beta \cdot ln(\Pi_i)$$

This means that road congestion is related to the population or that the reduction in traffic depends on the location of the attractors. Attractors which are the land services that to meet the needs of the population. Schools, hospitals, shops and shopping malls as well as jobs.

Of all daily trips T_i generated by an urban island U_i, a part I_i will remain within the perimeter of the island and another part O_i will go to the outside.

$$T_i = I_i + O_i = \iota \cdot T_i + o \cdot T_i$$
$$(1 - o) \cdot T_i + o \cdot T_i$$

In each case, the distances will be different so the impact on the city will be different. For the coefficient of the outside trips is $0<o<1$.

Containing the coefficient o means reducing the number of trips directed towards the outside of the urban island, i.e. reducing the overall mileage of daily urban trips. Reducing this ratio means balancing the mutual relations between the urban islands i.e. make each island U_i more attractive compared to the needs of its residents.

It is possible to set the following classes between the value of the coefficient and the character of an urban island

$0 \leq o < 15\%$	closed
$15 \leq o < 30\%$	moderately open
$30 \leq o < 45\%$	open
$o \geq 45\%$	very open

A closed urban island is very rich in land services, on the contrary an open island is very poor in land services, and it forces its residents to move out.

Taking into account the physiological synergies within the different parts of an urban area (center, suburbs, fashionable quarters), it would be appropriate that each urban islands is at least moderately open, i.e. the outside trip ratio is $15 \leq o < 30\%$.

Reprogramming the city

Discretizing a city - or an urban area - in a series of topologically connected element, allows to study more effectively the circadian physiology.

GIS tools allow to work on a large scale with a large amount of information. Big data allows a much more detailed reading of the flows than fieldwork's survey.

Floating car data (FCD), also known as floating cellular data, is a method to determine the traffic speed on the road network. It is based on the collection of localization data, speed, direction of travel and time information from mobile phones in vehicles that are being driven. Based on these data, traffic congestion can be identified, travel times can be calculated, and traffic reports can be rapidly generated. In contrast to traffic cameras, number plate recognition systems, and induction loops embedded in the roadway, no additional hardware on the road network is necessary.

For what concern public transport, the Automatic Vehicle Monitoring System (AVM) is GPS-based vehicle location information in real time, showing that information on a map. Further, it correlates vehicle information with customer-specific information and streamlines exchange of information between a dispatcher and vehicles.

FCD and AVM allows a real-time picture of urban flows, but also to weigh the effects of urban planning actions.

It is always more important not so much to reduce trips in their number as in their length. This means redesigning entire quarters, favoring slow-moving short-range mobility.

In this way the concept of urban island described above can become to plan environmental islands where the environment is conjugated also as the quality of social relationships.

Long distance trips, outside the urban islands, must be largely sustained by mass transport.

The assessment of a rapid transit line health ef-

fects must be related to local conditions of the project corridor. The evaluation [6] requires the following characteristic data:

- Average daily PM10 concentration (in g/m3)
- Traffic average PM10 emission rate (R)
- Daily road trip (RT)
- Daily road mileage (RM)
- Public transport rate
- Larger urban area resident population
- Population density (inh. /km2)

A rapid transit (RT) project corridor has a length (km) and a weekday average demand i.e. a weekday average mileage (trip km). The corridor subtracting a share of traffic by the road:

ΔRT = Road subtracted trip = RT demand · (1-Public transport rate)

On safe side:

ΔRM = Road subtracted mileage (trip km)
= Road subtracted trip · corridor length

Finally, [7], the average daily PM10 concentration reduction is:

$$\Delta PM10 = \varepsilon_R \cdot \frac{R_M}{\Delta R_M} \cdot \gamma$$

Then act on the distribution of trips, means acting on the circadian cycles of the city, improving global urban energy consumption efficiency and thus reducing pollutant emissions.

Conclusion

The prevailing model of development of urban areas is increasingly oriented to a territorial isotropy, notwithstanding the evidences of a considerable literature. This is due to the absence of mathematical models able to translate this awareness into appropriate financial models.

Nowadays a city no longer exists as mere physical built place, but as a dematerialized "cloud" of flows: people, goods, information. The vicious circle is all here: the car has allowed the urban sprawl; mass transit does not allow the widespread use of a city.

This is the time of urban sustainability. If each urban element (home-work-facilities) is framed dynamically within the daily circadian rhythm that connects them, it will be possible to develop a sustainable solution that is not partialized on a specific sector. A balanced city produces social wealth: that turns into a financial one because it can be measured.

References

[1] R. Moreno, E. Vayá, Técnicas econométricas para el tratamiento de datos espaciales: La econometría especial Edicions Universitat de Barcelona, Barcelona (2000)
[2] J.D. Ortuzar, L.G. Willumsen, Modelling transport, John Wiley & Sons, Chichester, United Kingdom (2001)
[3] L. Anselin, I. Syabri, Y. Kho, GeoDa: An introduction to spatial data analysis - Spatial analysis laboratory Department of Agricultural and Consumer Economics - University of Illinois, Urbana-Champaign, IL (2004)
[4] L. Yao, H. Guan, H. Yan, Trip Generation Model Based on Destination Attractiveness, Tsinghua Science and Technology, ISSN 1007-2014 10/25 pp- 632-635, Volume 13, Number 5 (2008)
[5] A.A. Amavi, J.P. Romero, A. Dominguez, L. Dell'Olio, A.Ibeas, Advanced Trip Generation/Attraction Models, Procedia - Social and Behavioral Sciences, Volume 160, Pages 430-439 (2014)
[6] L. Moccia, G. Laporte, Improved models for technology choice in a transit corridor with fixed demand, Transportation Research Part B: Methodological Volume 83, Pages 245–270 (2016)
[7] A. Spinosa, Enhanced financial analysis to evaluate mass transit proposals in terms of contribution on resilience increasing of urban systems, in Dell'Acqua G., Wegman F., Transport Infrastructure and Systems: Proceedings of the AIIT International Congress on Transport Infrastructure and Systems (Rome, Italy, 10-12 April 2017), CRC Press, Taylor & Francis Group (2017)

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