TeMA

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Urban sprawl processes characterize the landscape of the areas surrounding cities. These landscapes show different features according to the geographical area that cities belong to, though some common factors can be identified: land consumption, indifference to the peculiarities of the context, homogeneity of activities and building typologies, mobility needs exasperatedly delegated to private cars.

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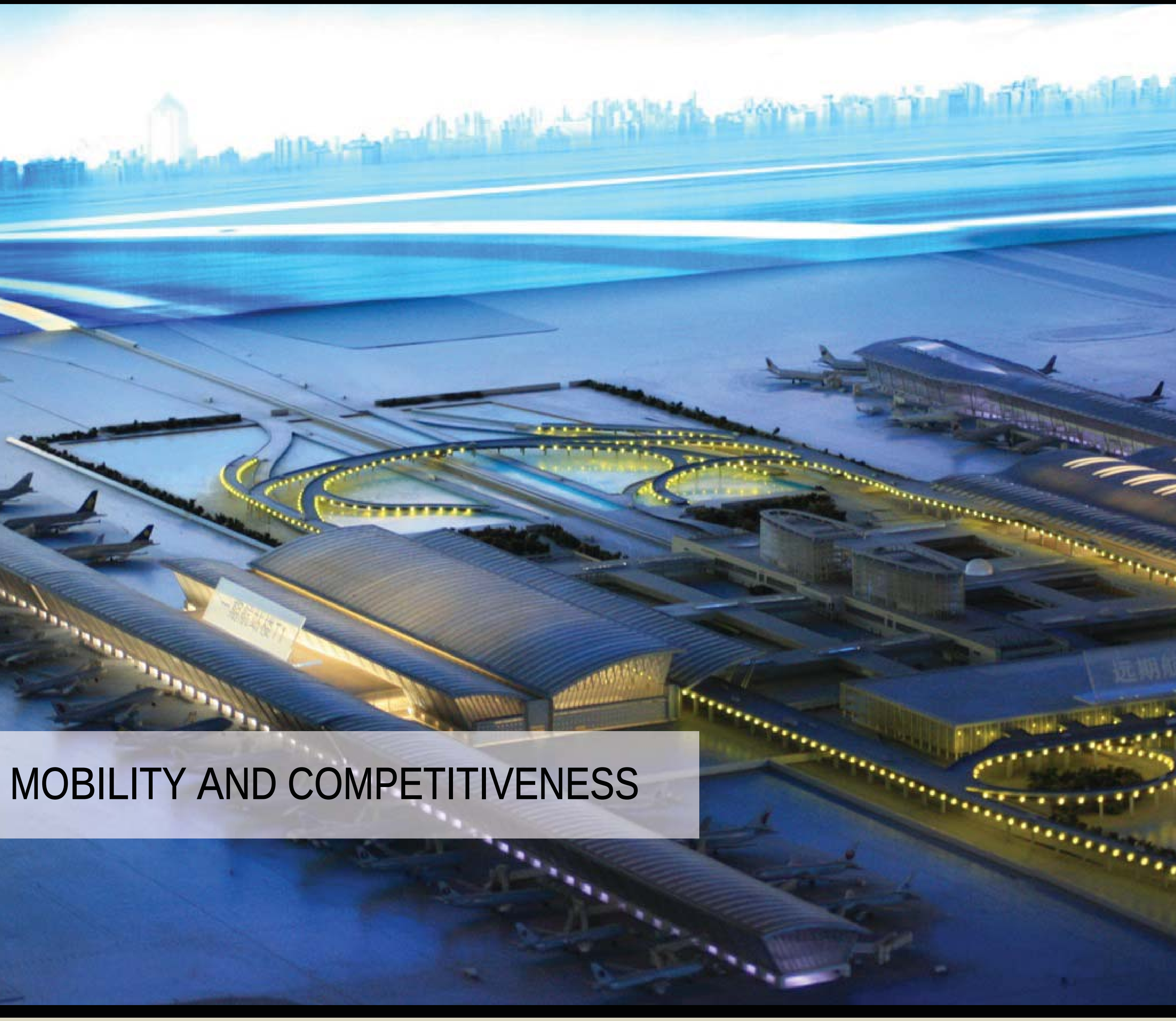

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HOW TO IMPROVE URBAN RESILIENCE?

INSIGHTS INTO THE ROLE OF CRITICAL INFRASTRUCTURES DISASTER MITIGATION STRATEGIES

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ABSTRACT

Critical infrastructures (CI) systems provide essential services “for the maintenance of critical societal functions, including the supply chain, health, safety, security and economic or social well-being of the people” (European Commission, 2008). These systems are exposed to a great number of hazards and threats, which may result in severe consequences for the population, the socio-economic system, and the environment. The issue is particularly relevant at urban level, where the disruption of one CI system can propagate to the other systems and paralyze the entire area. It is therefore necessary, not only to protect CIs through Critical Infrastructure Protection (CIP) strategies, but also to enhance the resilience of these areas. This article aims thus at providing some insights related to the evolution of the critical infrastructures disaster mitigation strategies from the sole protection towards resilience: what kind of strategies based on resilience can be developed to address CIs disruption at local or regional level? To what extent do these strategies contribute to increase the resilience level of the entire urban or metropolitan area?

The first section focuses on the urban critical infrastructures systems as well as on the way their disruption can impact urban areas. The second section provides with some examples of key measures to operationalize resilience in the field of critical infrastructure disaster mitigation strategies. The last section highlights how the key measures developed to enhance the resilience against CI disruptions can benefit also to broader urban resilience.

KEYWORDS:
Critical infrastructures, metropolitan and urban areas, resilience, essential services

1 DEFINITIONS, BACKGROUND AND KEY ISSUES

Milan, Lombardy (Italy), 21st of December 2009: due to a heavy snowfall and to very low temperatures, major transportation and energy infrastructures of the urban area suffer disruptions (Figure 1), that will result in high socio-economic consequences. Cities are vulnerable to natural events and this vulnerability is aggravated by the impacts such events can have on so-called critical infrastructures. Critical infrastructure (CI) refers to "those assets or parts thereof, which are essential for the maintenance of critical societal functions, including the supply chain, health, safety, security and economic or social well-being of the people" (European Commission, 2008). The disruption or destruction of some of these infrastructures can be debilitating to the needs of society and individual citizens. The issue is particularly relevant at urban level, where the disruption of one critical infrastructure system can propagate to other systems and paralyze the entire area. An urban area is defined here as "a human settlement characterized by a significant infrastructure base – economically, politically and culturally – a high density of population" (Metropolis, 2011). Hence, the disruption of critical infrastructure systems in such areas can trigger catastrophic consequences. It is therefore necessary, not only to protect critical infrastructures through Critical Infrastructure Protection (CIP) strategies, but also to enhance their disaster resilience, i.e. "the capability to prevent or protect against significant multi-hazard threats and incidents, including terrorist attacks, and to expeditiously recover and reconstitute critical services with minimum damage to public safety and health, the economy, and national security" (TISP, 2006). Resilient critical infrastructures systems contribute to build resilient cities, which "create, enable, and sustain the services and institutions required for basic on-going survival [...]. They avoid relying on solutions that depend on anticipating specific hazards, and instead take a broader, integrated approach" (Metropolis, 2011).

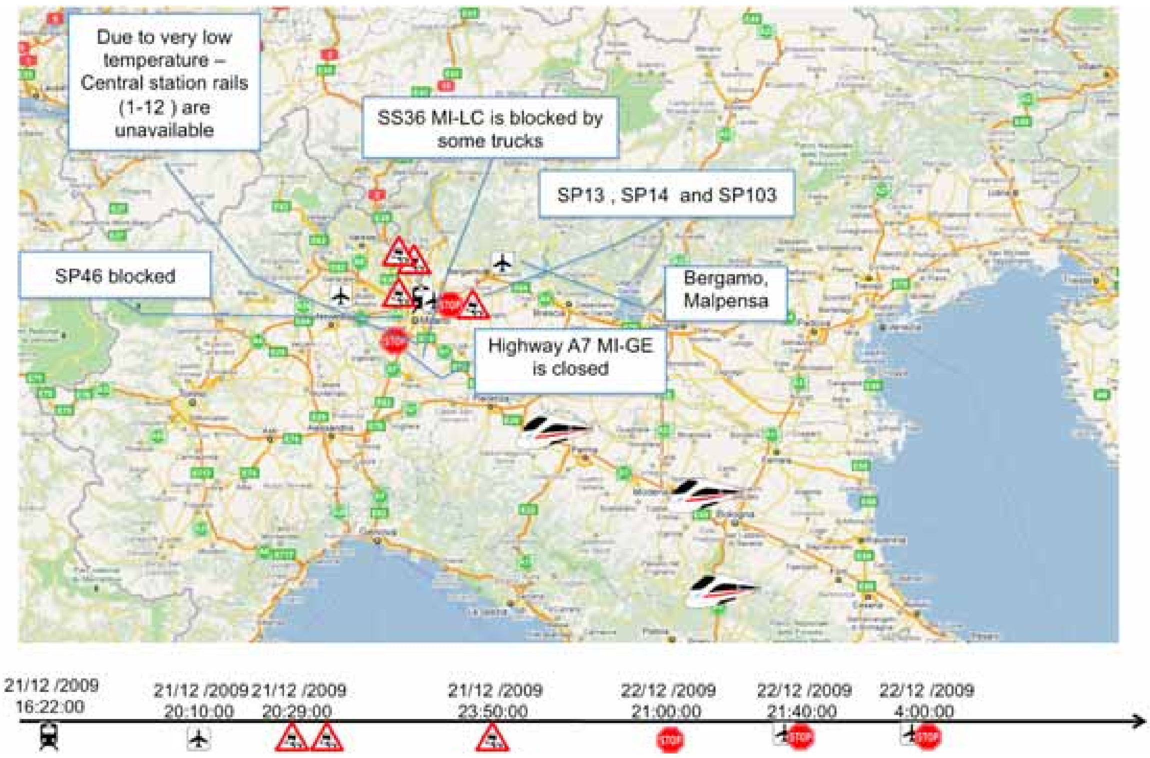

Fig. 1 Impacts on transportation systems of the severe snowfall in the Lombardy Region, 21st of December 2009

In the literature and in practice, critical infrastructures disaster mitigation strategies are mostly addressed by approaches related to the risk and emergency management. The focus is most often laid on the immediate coping capacities to respond to a crisis due to critical infrastructure disruption, while the factors related to the broader resilience of societies to stand and face these events are often underestimated (Petrenj et al., 2011). The resilience literature is characterised by numerous fields of applications, e.g. in ecology (Holling, 1973), in psychology (Richardson, 2002) or in climate change research (Pandolfi, 2003). Because of this fragmented vision, the way critical infrastructure disaster mitigation strategies contribute to urban resilience, as well as the importance of addressing critical infrastructure disruptions on the basis of the resilience principles is too seldom analysed. There is still a lack in understanding how both concepts interact: what kind of strategies based on resilience can be developed to address critical infrastructure disruption at local or regional level? To what extent do these strategies contribute to increase the resilience level of the entire urban or metropolitan area?

This article aims therefore at addressing this conceptual gap, proposing some insights on how local or regional critical infrastructure disaster mitigation strategies can participate to building broader urban resilience. Our reflection is based on the experience of the authors in supporting different Authorities to develop and implement policies focusing on Critical Infrastructures (e.g. Regione Lombardia, 2012), as well as on the results of two international Workshops reviewing the main on-going experiences related to regional and local critical infrastructure protection and resilience strategies[1].

The first section demonstrates to which extent critical infrastructure disruptions make urban areas more vulnerable and how the strategies adopted need to shift from the sole protection policies towards approaches based on resilience. The second section aims at understanding the most relevant characteristics of the emergent critical infrastructure disaster mitigation strategies based on some resilience principles at local level. The last section highlights the main links between critical infrastructure disaster mitigation strategies and urban resilience with the view to propose some preliminary recommendations to the decision-makers involved in enhancing the capacities of our society to face major disruptive events.

2 CRITICAL INFRASTRUCTURES DISRUPTIONS INCREASE URBAN VULNERABILITIES

This section focuses on the urban critical infrastructures systems as well as on the way their disruption can impact urban and metropolitan areas. Addressing the issue of critical infrastructure disruption can thus be seen as a key to read urban vulnerabilities. As a consequence, we argue that critical infrastructure disaster mitigation strategies are not only a matter of risk and emergency management, but are also strongly related to the question of resilience.

2.1 CRITICAL INFRASTRUCTURES DISRUPTION AS A KEY TO READ URBAN VULNERABILITIES

Some infrastructures systems, as means towards ensuring the delivery of goods and service, play a critical role in metropolitan and urban areas because they provide an essential foundation for social and economic interactions. In particular, critical infrastructures contribute to:

- Delivering the vital services to the high densities of population concentrated in urban areas, e.g. water, energy for domestic use, health and emergency services, etc.;

[1] 1st International workshop on Regional Critical Infrastructure Protection organised by Risk Governance Solutions S.r.l. for the Lombardy Region in Milan, 16-17-nov 2011 and the 2nd International Workshop on Regional Critical Infrastructure Resilience organised by Risk Governance Solutions S.r.l. and the Scottish Government in Edinburgh, 15-16th november 2012. For more information, see www.recipre.org

- Supporting and developing the economic system, through telecommunication, energy supply, financial, banking and insurance services, transportation, etc.;
- Supporting the socio-political functions, as for instance administrative, governmental services;
- Connecting the urban area with the rest of their region, country or other countries, thanks to transportation systems and telecommunications.

Within a urban area, critical infrastructures do not exist in isolation of one another and are increasingly interdependent: airports and railways depend on electricity and communications, the power grid depends on communication among power plants and distribution nodes, telecommunications networks depend on power supply for the transmission links and the exchange nodes, etc. (Gheorghe, Schlaepfer, 2004).

These interdependent systems of critical infrastructures are exposed to external sources of hazards and threats (e.g. floods, storms, landslides, seism, etc.) or to internal events like technological failures of the system components or assets (Table 1).

TRIGGERING EVENTS	CATEGORY	INTERNAL	EXTERNAL
Natural	Non-intentional		E.g. Floods, earthquake, landslides, etc.
Technological	Non-intentional	E.g. Technical failure	E.g. Industrial explosion, failure of other CI systems
Human	Non-intentional	E.g. Human error	E.g. Human error
	Intentional	E.g. Sabotage	E.g. Terrorist attack

Tab. 1 types of triggering events causing Critical Infrastructures disruption

These hazards and threats can trigger three levels of impacts:

- 1. The direct impact refers to the technical vulnerability of the infrastructure and is located where the triggering event happens, e.g. a technical failure within a power production plant.
- 2. The indirect impacts are due to the cascading or domino effects. The initial failure can propagate inside the infrastructure system or from one system to another (e.g. because of the blackout, trains have to stop). Table 2 shows the cascading effects of a power disruption on other urban critical systems.
- 3. The final consequences at urban or metropolitan level are the result of the service disruption. They refer to the vulnerability of an area against essential services disruption. They affect the population (e.g. people who could not heat and cook in Bulgaria because of the Ukraine-Russia crisis during winter 2006 and 2009 (BBC News, 2009), the economic life, (e.g. the interruption of the US economic activities after the World Trade Center attacks amounted at 517 billions Euros (Bouchon et al., 2008), the public confidence (e.g. the decrease of confidence in the authorities and in the food production industry after the mad cow disease in UK (Cleeland, 2009), or the environment.

Infrastructure	0-2 hours	2-8 hours	8-24 hours	24 hours >>
Transport	Depends on characteristics of area and nature of train-system. Electricity dependent: no traffic, non- dependent on electricity: traffic with delays. Urban systems stop, road traffic in chaos	Delays increase and ripple through to un-affected parts of the system. No traffic at all on affected parts	No traffic at all, fuel supply problems	No public transport
Communication	Difficult to supply information, outages of transmission poles	Information back set, more personnel needed		Availability of personnel decreases
Waste disposal	Difficult due to traffic congestions, delay in disposal of waste		Collection is difficult, possible un-hygienic circumstances	
Electricity			Difficult to keep communication up	Possible problems with fuel supply for generators
Drink water	Production: control of remote stations Distribution: local pressure drops on stations without generators, in case of loss of pressure devices: nor water on higher floors			Water is guaranteed
Sewage management	Low lying areas, with rainfall: flooding of sewer water after 2 hours	Flooding in higher areas as well	Also flooding in case of no rain	Flooding
Gas	Generally no problems, receivers will endure problems in energy dependent systems; climate control, watersupply.			In case of pressure loss: temperature drops
Telecommunication	Telephone is assured, possible problems with GSM systems, internal operators outage. No fax, congestion in telephon network			Telephone system assured. Possible problems with generators due to fuel supply problems

Tab. 2 cascading effects in time after electric power supply failure

Because of the potential severity of their consequences, critical infrastructures disruptions are a key to read the vulnerability of urban societies that strongly rely on essential services. The example of the damages encountered by the Taiheiyo Belt of Japan during the tsunami and the earthquake in March 2011 is quite representative: major critical means of transportation of the country are concentrated in this highly industrialized and populated region. During the earthquake and the tsunami, these infrastructures were severely impacted: five stations of the Shinkansen system were destroyed, the railway network suffered damages in 1,100 locations, and 347 km out of 675 km of the Tohoku Expressway needed rebuilding works. The widespread blackout caused by the earthquake caused loss of traffic control, shutdown of elevators, loss of access to media, disruption to mobile phones, etc. The sole damages to infrastructures amount to 3, 5 trillion yen (Kitamura, 2011). In order to mitigate the potential damages due to critical infrastructure disruptions and to reduce these vulnerabilities, the first Critical Infrastructure Protection (CIP) policies appeared in the mid 1990's in the USA and around 2000 in Europe (Ritter et al., 2004). Though the focus laid on protective strategies is now questioned (Kroger, 2008).

2.2. FROM PROTECTION TO RESILIENCE STRATEGIES TO ADDRESS CI DISRUPTIONS

On the basis of the first results reached by the first Critical Infrastructure Protection policies, we argue that critical infrastructure disaster mitigation strategies are not only a matter of risk and emergency management, but are also strongly related to the question of resilience of local or regional territories. The objective of protection is to make the infrastructure invulnerable to any kind of disruption or attack. This can be achieved through protection measures aiming at enhancing the robustness of the infrastructure. Though these measures have a high cost, often supported by the critical infrastructure operators directly and their efficiency is not proved yet: it appears very difficult to make an infrastructure system reliable at 100%. This is the reason why resilience strategies can be seen as complementary to protection measures. Resilience is the “system’s ability to rebound, return, or recover its original state” (Holling 1973) or the capacity of a system “to utilize or even benefit from perturbations and changes that attain it, and so to persist without a qualitative change in the system’s structure” (Van der Leeuw et al., 2001). The resilience can be the resilience of the infrastructure system (e.g. through redundancy, backups, geographical isolation) or the resilience of the society depending on the services provided by the infrastructure system (e.g. through a better preparation of the authorities, of the population and of the economic world (e.g. business continuity, etc.). The resilience approach takes then more sense when applied at local or regional level, because this is where the direct and indirect impacts of critical infrastructure disruptions are felt in a first place. Critical Infrastructure Protection strategies have traditionally been driven from a National Security and Counter Terrorism perspective. Though, these strategies have shown some limits (Scalingi, 2011). Regional and local policies are based on the assumption that critical infrastructure systems, which mostly operate at local or regional levels need to be analysed in their context, i.e. in the territory where they are embedded.

An approach based on resilience allows therefore shifting from a focus set on the infrastructure as technical system to capture the complexity of the critical infrastructures as socio-technical systems. This evolution is close to the emergence and development of the urban resilience, which has become much stronger in urban growth management, not only as a buffer against natural disasters, conflicts and involuntary migration, but as “means of enabling economic development and civil society to adapt in circumstances too complex to be incorporated into urban services and infrastructure plans” (Metropolis, 2011).

One of the main results of the 2nd International Workshop on Regional Critical Infrastructures Resilience (Edinburgh, 2012) is to have acknowledged the importance of shifting from protection issues towards resilience issues. Though one of the main challenges is to understand how to operationalize resilience so that it does not stay as a concept but is translated into concrete measures. In the following section, some key measures of CI disaster mitigation strategies at local level are given to illustrate the implementation of resilience principles.

3 KEY MEASURES TO OPERATIONALIZE RESILIENCE IN THE FIELD OF CRITICAL INFRASTRUCTURE DISASTER MITIGATION STRATEGIES

Based on the results of the two workshops organized in Milan (2011) and Edinburgh (2012), it is possible to highlight some key measures that allow operationalizing the concept of resilience in the field of disaster mitigation strategies. These key measures are described and illustrated with relevant examples, but the limits of difficulties for their implementation are also emphasized.

3.1. EXPANDING THE KNOWLEDGE ON INTERDEPENDENT CRITICAL INFRASTRUCTURE SYSTEMS

In a first place, a resilient approach to critical infrastructure disaster mitigation should build on a good understanding of how the critical infrastructure systems are organized and of the kind of failures they could suffer. The main assumption is here that building resilience is a matter of knowing better the potential scenarios that could trigger disastrous consequences for the local communities. This is quite a challenge with respect to critical infrastructures systems which complexity is very difficult to model (Cagno et al., 2011). In particular the focus on the interdependencies and on the identification of all the potential cascading effects is challenging. This why the research projects or strategies aiming at expanding the available knowledge on local or regional systems can be seen as a key measure to operationalize resilience.

Examples of this are given for instance by the research carried out by the Ecole Polytechnique de Montréal on modelling the interdependencies and domino effects for critical infrastructure systems in Quebec City, Canada (Cloutier, 2011; Robert et al., 2010). The research was developed to support the development of the Quebec governmental policy for the resiliency of its critical systems, in collaboration with 15 government departments and other critical infrastructure operators and industrial partners. Based on the resources exchanged by these operators, the model allows the visualization and the anticipation of domino effects in time and space, enabling the operators to set up convenient mitigation measures to avoid their propagation. Results are gathered into a GIS system to analyse domino effects and their propagation in time, based on the geographical information collected among operators and organizations. This tool allows critical infrastructure operators and public safety managers to visualize interdependencies and potential cascading effects and implement mitigation measures. In Italy, the University Polytechnics of Milan has developed for the metropolitan area of Milan (Lombardy Region) a functional model of vulnerability and interoperability, based on a Service Oriented Architecture (SOA). Threats, vulnerable nodes of interdependent infrastructures are modeled, which makes it possible to assess the propagation of inoperability and demand variations throughout the nodes of the same critical infrastructure and between inter-dependent systems (Trucco et al., 2011).

The added value of this type of research works for resilience is that they provide results that are directly useful for the various stakeholders involved in critical infrastructure disaster mitigation activities. In particular, mapping technologies are essential to gain and maintain the stakeholders' interest, as dynamic maps of potential domino effects constitute a concrete, visible output of a scientific research project made operational. Although the importance of the research activities aiming at characterising, understanding, and modelling urban or metropolitan interdependent critical infrastructures systems is acknowledged, they are still limited by difficulties due to the collection and update of relevant data and information, as well as by the necessity to benchmark different modelling strategies and formalisms. Main challenges are still about creating a trustable and secure environment to exchange data and other information among different operators, modelling the complexity of such systems and about providing valid results that meet the needs of both the operators and policy-makers.

3.2. IMPLEMENTING PUBLIC-PRIVATE PARTNERSHIP BETWEEN AUTHORITIES AND CRITICAL INFRASTRUCTURE OPERATORS

Another key measure to implement resilience in the field of critical infrastructure disaster mitigation strategy is related to the development of collaboration schemes between public and private stakeholders. Resilience is a matter of the whole community and not only of the Public Authorities. This why main governance models are seen as a fundamental pillar to enhance resilience (Provan et al., 2008). The development of critical infrastructure disaster mitigation policies at local or regional level can be seen as a field of application of the concept of network governance (Sutter, 2011). The core argument of this approach is that complex problems can no longer be resolved by traditional, centralized and hierarchical forms of governance, but need to be addressed by decentralized and highly specialized networks of actors with specific skills and resources. In the field of critical infrastructures disruptions, there is a need for collaboration because of the systems' interdependencies and the complexity of the risks that individual organizations cannot address on their own. Information is therefore the critical resource (on threats, risks, countermeasures, goals and means of attackers, interdependencies) as well as the related networks of information sharing. Access to this kind of information is though a major difficulty because it is confidential and operators are not willing to share it. For any organization, protecting its critical information is primarily a question of security since disclosing confidential information can make this system extremely vulnerable. Cross sector and public/private information sharing requires the creation of an environment of trust where stakeholders feel safe to share their concerns and vulnerabilities.

This is why Public-Private Partnerships (PPP) play an important role in building resilience to support shared critical infrastructure disaster mitigation strategies. Such PPP are already operational for instance in Scotland, where the regional Critical Infrastructure Strategy "Secure and Resilient" is based a Critical Infrastructure Partnership Framework between Government and those responsible for the critical assets, with the view "to minimise disruption to any part of that infrastructure or to any of our communities living and working across Scotland" (The Scottish Government, 2011). In the Lombardy Region, Italy, the Civil protection Authorities have developed a collaborative approach with the key regional energy and transport operators, in order to improve the existing emergency management practices (Regione Lombardia, 2012). Their work focused in particular on identifying the relevant flows of communication during a critical infrastructure disruption event (the scenarios focused on a severe snowfall event and a blackout) and on the development of a web-sharing platform for the communications. The operators could state the kind of information they needed (e.g. very precise meteorological predictions), the information they could provide (in particular if this information could have an impact for the other operators), the role they expected the regional crisis management center could play (e.g. to communicate with the public). A dedicated information and communication system was created and tested during an exercise (Figure 2).

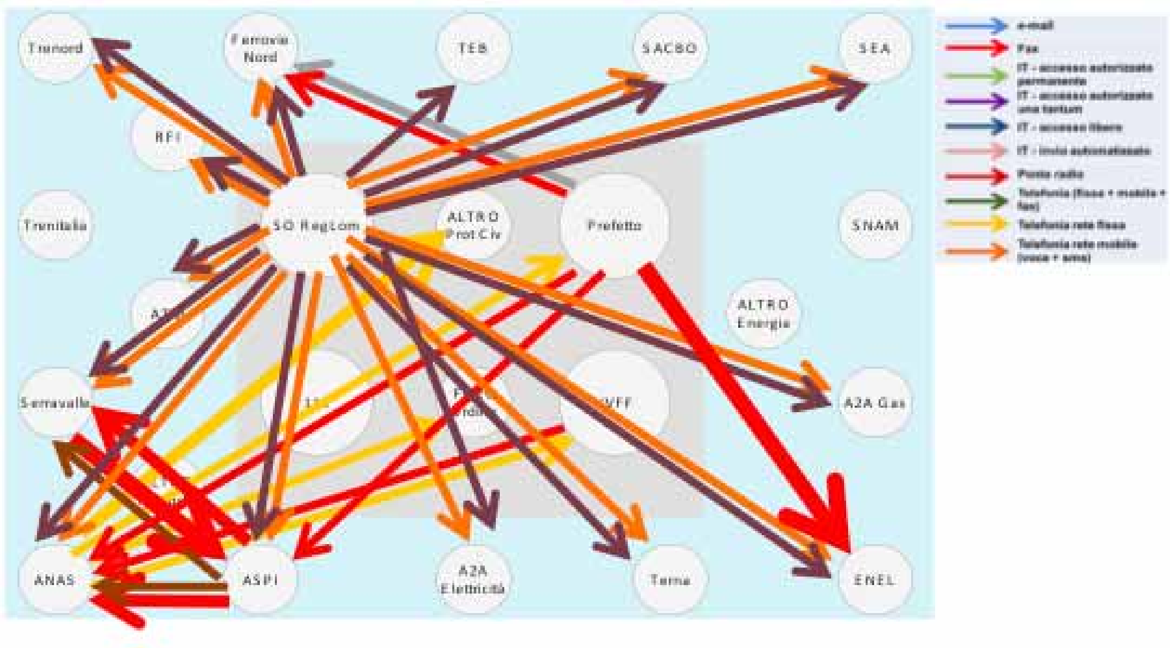

Fig. 2 Communications map among Lombardy Region Civil Protection authorities and CI operators during an emergency

Main challenges towards the development of sustainable governance scheme in the field of critical infrastructure strategies remain among others the identification of the stakeholders (not too few, not too many), the types of collaboration process to be developed (e.g. protocols, informal discussions, exercises, etc.). The long-term sustainability of these processes is also a key issue: it is fundamental to maintain the interest of involved stakeholders by looking and taking into account their needs and perspectives. The adoption and the development of adequate technologies and communication systems is also particularly relevant to support local/regional collaboration processes. Finally sustainability is also a matter of funding: if collaboration processes create lots of excitement at the beginning, funds are necessary to maintain them active in the long range. New forms of synergies and innovative co-financing strategies of PPP, involving the participation of both public and private actors need to be explored.

3.3. SETTING UP ACTION PLANS TO ADDRESS PREPAREDNESS AND SECURITY GAPS

Current emergency management practices are questioned by the possibility to face major critical infrastructure disruptions. Main issues are related to the need to address new types of scenarios emphasizing the complexity of the potential emergency situations, to the need to work directly with the operators, and to the necessity to develop efficient coordination strategies supported by adequate tools, such as GIS systems. Notwithstanding these difficulties, improving the emergency management capacities is a key element to increase the resilience level of a territory. This is even more relevant in the case of critical infrastructures, which constitute potential targets for terrorist attacks. Terrorist threats are difficult to predict and this is the reason why emergency management systems need to be designed to mitigate also unexpected events.

Key measures in that regard are related to the integration of “critical infrastructure interdependencies and cascading effects mitigation into planning and preparedness activities” (Peters, 2011). In practice, this means setting up efficient coordination schemes, defining in a coherent way the distribution of resources, responsibilities and roles, enhancing the capacity planning, supporting the use of digital maps for the strategic management level, to avoid fragmented views and to share relevant information. To operationalize resilience, it is also important to set up action plans to address preparedness and security gaps. In the United States, the FEMA has developed the “whole community” approach where regional, local, state and national government agencies, utilities and other essential service providers, businesses, non-profit organizations and social service groups, academia, faith-based and ethnic groups are mobilized (FEMA, 2011). This approach aims at bringing cross-sector and multi-jurisdiction representatives together with experts from diverse disciplines to examine vulnerabilities, consequences, and preparedness gaps for all-hazards incidents and disasters (Figure 3). This enables stakeholders to develop a baseline needs assessment to collectively determine areas of improvement and cost-effective solution options. The biggest benefit of this approach is to build trust among heterogeneous groups (multicultural, interdisciplinary, cross-sector, etc.), in order to operationalize resilience and to build a sustainable, on-going resilience process based on public-private collaboration. This process has been driven in the United States for the Pacific NorthWest Economic Region (PNWER)[2] and the Bay Area Regional Disaster Resilience Action Plan Initiative[3] (Scalingi, 2012).

[2] http://www.pnwer.org/
[3] http://quake.abag.ca.gov/resilience/

Fig. 3 The regional disaster resilience model

Critical infrastructure disaster mitigation strategies are only emerging and the examples given above do not cover all the possible ways to operationalize resilience. Though these key measures express the need to develop actions that are directed towards reducing the potential consequences of critical services interruption of supply, taking into account the fact that critical infrastructures are systems which require protection but that they are also embedded within territories which resilience need to be increased. Since critical infrastructures systems are embedded within the urban territories and support the urban activities and functions, it is possible to ask how critical infrastructures mitigation strategies can contribute to increase the resilience level, not only of the critical infrastructure systems but also of the urban territories.

4 FROM CRITICAL INFRASTRUCTURE RESILIENCE TO URBAN RESILIENCE: SOME PERSPECTIVES

This section aims at answering the following question: what can we learn from the experience developed in the field of critical infrastructure resilience, which would be also relevant to enhance urban resilience? To which extent the key measures taken to mitigate critical infrastructure disruptions consequences could contribute to increase the overall resilience of the communities? Keeping in mind that a resilient city is able "to withstand a variety of challenges if the following elements [redundancy, flexibility, capacity to learn, capacity to reorganise] are incorporated into urban systems and the ways in which people construct and maintain those systems" (Resilience Alliance, 2007), we propose here some insights provided in the form of recommendations addressed to local or regional decision-makers aiming at increasing their resilience level.

Develop the knowledge and increase the understanding of how our societies work: The activities related to increasing the knowledge and understanding of the interdependent critical infrastructures systems are of key importance to build resilience against critical infrastructure disruptions. We believe here that building a knowledge basis of the territory seen as a complex system where social, technical, natural, economic, and political aspects are interacting is extremely relevant to build urban resilience. For instance the information related to how interdependent critical infrastructures systems are organized are relevant for critical infrastructure disaster mitigation activities but also to understand where the bottlenecks of these systems are and which future modifications or extensions of these systems could be planned. Better analysis of the supply chain of essential services, as well as their visualization on a GIS tool provide a sound support to the decision-making process to address critical infrastructure disruptions but also to elaborate strategies for future infrastructures development, ensuring an equal accessibility of all inhabitants to the essential services, etc. It contributes then to the identification of the main challenges faced by some urban areas as well as it enables those challenges to be responded more directly and effectively.

Draw lessons learnt from the past events: Developing a sound knowledge basis also includes a good capacity to learn. Capacity to learn encompasses the "ability to internalise past experience, respond to them, and avoid repeating mistakes to ensure that future decisions are made with appropriate caution and forethought" (Metropolis, 2011). For instance, in Japan, the Tohoku northeast area of mainland Japan expected an earthquake of magnitude 7 or higher based on historical records; the japan railway company expected a possibility of derailment, so they had introduced an early earthquake warning system. The quake measurement equipment has been improved and increased and the time from early tremor detection to electric supply cut has been reduced from 3 to 2 seconds. In March 2011, all 27 trains stopped without derailment injuries or fatalities. Notwithstanding these measures, what was not well anticipated was the combination of hazards, in particular the magnitude of individual earthquakes and tsunami, nor evaluated their combined effects (Kitamura, 2012).

Be prepared to face disastrous situations: since not all disastrous situations can be anticipated, a factor of resilient societies is to be ready to face unexpected events. This includes measures such as improving the redundancy, the flexibility and the preparation of the communities. Redundancy is featured when several urban systems serve similar functions and provide substitutable services when another system is disrupted, such as using multiple energy sources with a variety of pathways distributing power to all parts of the city, or installing generators into hospitals and major health infrastructures. Redundancy has a cost but if planned in an efficient way, it can contribute to reduce a city's vulnerability. Flexibility is important for resilient cities to have the ability to absorb shocks and slow-onset challenges in ways that avoid catastrophic failure if thresholds are exceeded. In the field of critical infrastructure disruptions, flexibility is for instance the fact that energy suppliers have identified priority consumers and other customers that can switch to another source of energy in case of disruption. The preparation of the communities means that the territorial vulnerabilities against critical infrastructure disruption are questioned, which can also serve as a starting point to think and take actions to increase the resilience of the area against other events. This implies actions to create awareness within the population, the authorities and the other stakeholders about potential crisis situations.

Be prepared to recover from disastrous situations: The recovery phase after a crisis is of major importance to restore an equilibrium and go back to the normal conditions. Actions taken to mitigate the potential consequences of CI disruptions contribute to reduce the crisis phase: for the critical infrastructure operators the business continuity plans are essential to reduce the economic consequences of a disastrous events while for the civil protection authorities the political issues at stake during the recovery phase are related to helping the people to recover normal living conditions. The capacity to reorganise also covers the ability to change and evolve in response to changing conditions. This can include, for example, the existence of business continuity plans for the companies, not only to recover after an emergency but also to adapt their management to evolving conditions (e.g. higher fuel supply prices, increased traffic congestion, etc.).

Create trust among stakeholders: To build resilience, it is essential to provide for dialogue between stakeholders and help develop consensus-based solutions. The governance models applied in the field of critical infrastructure resilience can be used as models in the field of urban governance. Existing experiences of critical infrastructures collaboration schemes show that important factors are the voluntary dimension of the collaboration, the creation of win-win situations in which all stakeholders see an advantage in collaborating, the need to take time to build a real trust environment with the view to discuss and exchange sensitive information. The sharing of powers and responsibilities is also a key aspect of a sustainable governance model.

Optimize the distribution of resources: in a period of limited resources, in particular for governmental institutions, there is a need to reprioritize the agenda at different institutional levels, according to the expected effectiveness of possible actions, and reallocate funds and resources accordingly. As a matter of example, when the urban critical infrastructure strategy, based on a well established PPP, assures reduced inoperability and faster recovery process for an essential service - e.g. thanks to collaborative management in the urban transportation system - this means higher service level to citizens and lots of money saved both for public and private sectors. Such a societal and economic argument can turn into a political argument for policy-makers, in order to build on existing security and resilience capabilities.

5 CONCLUSIONS

With the view to investigate how strategies addressing critical infrastructure disruptions at local or regional level could participate to building broader urban resilience, some examples were developed to show that critical infrastructure disruption increase urban vulnerabilities and require therefore to be addressed not only from a security standpoint (i.e. protection measure) but also within a resilience approach. Developing strategies based on resilience to address critical infrastructure disruptions at local or regional level include increasing the knowledge on critical infrastructure systems and their disruption, working in straight collaboration with all stakeholders, in particular private operators of infrastructures and in setting up action plans not limited to critical infrastructure disruptions but considering the multiple aspects of local and regional resilience against all hazards. These strategies appear to be adequate also for urban and metropolitan areas since they are based on tailored approaches to be adapted to the different geographical contexts and the different types of stakeholders to be involved. While taking actions to enhance urban resilience, not limited to issues related to critical infrastructure disruption, appear to be a way to exploit limited resources dedicated to urban management and critical infrastructure resilience, there are still a great number of challenges to address, among others creating and raising awareness of urban and metropolitan authorities about the necessity to address critical infrastructure disruption at local level and, of the added value this can have for a better urban management, but also to show the benefits of urban/metropolitan critical infrastructure approaches to national authorities. Many practitioners and political leaders see the successful management of infrastructure and services – their planning, procurement and operation – as the heart of good urban management. Hence, it is necessary to link better the strategies developed in the field of critical infrastructure disaster mitigation strategies, and of emergency management with more comprehensive urban management strategies: this would allow finding synergies, mutualizing the efforts, cross-fertilizing and as a consequence, result in setting up a more coherent development and management strategies for cities and metropolitan areas.

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Pic. Pg. 1: Bouchon, 2012

Fig. 1: Dimauro, C. for the Regione Lombardia (2011) “PReSIC - Programma Regionale per la Collaborazione ed il Coordinamento nella Sicurezza delle Infrastrutture Critiche” http://www.protezionecivile.regione.lombardia.it/Regione Lombardia

Fig. 2: Trucco P., for the Regione Lombardia “PReSIC - Programma Regionale per la Collaborazione ed il Coordinamento nella Sicurezza delle Infrastrutture Critiche” http://www.protezionecivile.regione.lombardia.it/Regione Lombardia (2011)

Fig. 3: Scalingi, 2011

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