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Advanced Traffic Management Systems supporting resilient smart cities

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Extended Abstract

According to The Guardian, Resilience reflects a city's ability to persevere in the face of emergency, to continue its core mission despite daunting challenges (like managing disaster risk or climate change) while providing the same level of all typologies of services to its citizens. Urban Transportation Systems (UTS) provide essential support to every socio-economic activity in a city, while being themselves one of the most important economic sectors and, in the specific case of resilience management, UTS represent the paths that convey people, goods and information, while at the same being the paths through which risks are propagated. Therefore, regarding the case of Urban Transport Systems (UTS), operations have developed a prominent safety and business critical nature, in view of which current practices have shown evidence of important limitations in terms of resilience management highlighting the need of a technological upgrade for traffic management.

The present work addresses the topic of resilience management in UTS, and aims to qualify and quantify how advanced Traffic Management Systems contribute to build resilient smart cities.

According to resilience engineering perspective, the resilience represents the capability of a system of handling variability, through a continuous adaption to its operational environment.

However, resilience quantification and measurement for complex-socio technical systems as the UTS, is a challenge. In fact, resilience cannot be measured by means of verifications such as the adherence to standards and rules. A measure of resilience must be in direct relation with how a system performs, and how capable it is in monitoring and controlling performance throughout a given period. In this sense, some works in the literature consider that only the potential for resilience can be measured and not resilience itself. Only the processes the system develops towards resilience can be assessed in time. If a system experiences failure, it can still exhibit resilience in the form of survival and recovery from that failure. Conversely, if a system experiences success, it does not mean it will keep on doing so. This is why it is considered that a “constant sense of unease" is necessary for a system to maintain resilience, as this prevents complacency. Resilience parameters or inferable criteria must be able to capture a great diversity of system features and provide ample descriptions for resilience characteristics based on recognizable system aspects of system performance.

The article adopts a framework based on a Functional Resonance Analysis Method (FRAM) - driven approach in order to assess resilience of UTS, as a complex-socio-technical system. The FRAM model and its formalization have been proposed and used to model UTS complexity, having the scope to identify the system functions and their interdependencies with a particular focus on those that have a relation and impact on people and communities. A numerical analysis based on the definition of a hierarchical structure of composite indicators quantifying how advanced TMS enhance the 4 UTS resilience capabilities: Anticipate, Respond, Monitor and Learn, has been performed. In particular, it has been quantified how the introduction of advanced TMS technologies in UTS increase the dumping capacity of the system against internal unwanted/ unexpected performance variability.

The assessment object of this paper, supported by the work performed in the EC-funded project RESOLUTE, is the UTS of the city of Florence.

Capital city of the Tuscany, Florence is the most populous city in the region. It was declared an UNESCO World Heritage Site in 1982 due to its artistic heritage, being noted for its history, culture, Renaissance art and architecture and monument. So Florence is invested by broad touristic flow, with. 1645 km of roads ensure daily the mobility within its metropolitan area. Among the criticalities of the Florence UTS, performed risk maps show that over the 70% of the city transport infrastructures (streets and tram) are at hydro-geological risks with a range from “extreme” (level 4) to medium (level 2). Moreover, the city experiences a heavy touristic pressure, with more than 12,000,000 visitors every year and a business related logistics based on just-in time supply schemes that heavily affect mobility performances.

In this context, the Florence Mobility Supervisor, acting as a system for centralized control of the metropolitan road network that integrates 14 heterogeneous systems such as UTC, VMS, LTZ, Parking, etc represents the desirable technological upgrade able to enhance UTS resilience. In fact, the system computes the current road network status and, providing the evolution over one hour horizon, suggests solutions to reduce system variability, as bottlenecks and inconveniences. Moreover, within RESOLUTE, the Florence Mobility Supervisor has been integrated with a Strategy Management tool that enables the co-operative operations control by means of automatic scenario identification and relative response implementation (traffic control strategies) supporting both daily-life and emergency situations.

A scenario from those explored in RESOLUTE, the water bomb/flash flooding offered the opportunity to compare and quantify the variability of FRAM functions devoted to managing mobility aspects in UTS, considers two different contexts: where advanced TMS are deployed and where they are not (standard situation). The obtained result shows that a technological upgrade for mobility - related functions towards advanced Traffic Management Systems would have a significant impact on the system resilience as a whole.

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