TEACHING MATERIAL GUIDANCE

1) Title of the material

Bellini, E.; Bellini, P.; Cenni, D.; Nesi, P.; Pantaleo, G.; Paoli, I.; Paolucci, M. An IoE and Big Multimedia Data Approach for Urban Transport System Resilience Management in Smart Cities. Sensors 2021, 21, 435. https://doi.org/10.3390/s21020435

https://www.mdpi.com/1424-8220/21/2/435

2) Which section of the SUMP it is relevant to?

This article aims at introducing a new conceptualization for resilience and presenting an innovative full-stack solution to exploit the Internet of Everything (IoE) and big multimedia data in smart cities to manage the resilience of urban transport systems (UTS), which is one of the most critical infrastructures of the city. Therefore, the article can be linked to the third, fourth and fifth sections of the SUMP circle related respectively to the determination of planning framework, analysis of the mobility situation (in particular the analysis of problems and opportunities for all modes of transport - **subsection 3.2**.), scenario building and joint evaluation (development of scenarios of possible futures - **subsection 4.1**.) and vision and strategy development (arguments for stakeholders – **subsection 5.1**).

3) Which Mobility Manager knowledge this material is the most relevant to?

It is related to Transport and mobility planning (section 1 of the Mobility Manager competencies) especially 1b (employment of ITS/ICT and smart measures) and Data analysis for mobility planning (section 5 of the Mobility Manager competencies) especially 5a (data collection and analysis) as well as Stakeholder involvement tools (section 7 of the Mobility Manager competencies).

4) Problem approached and content overview

Problem approach – general understanding of how to manage resilience of urban transport systems (UTS) in smart cities. A smart city must be prepared for both expected and unexpected situations, and the ability to mitigate the effects of uncertainty underlying the causes of disruption by analysing all possible data generated by the city opens up new possibilities for operationalising resilience. This paper aims to introduce a new conceptualisation of resilience and present an innovative full-stack solution using the Internet of Everything (IoE) and big data multimedia in smart cities to manage the resilience of urban transport systems (UTS), one of the city's most critical infrastructures. The approach is based on a novel data-driven resilience engineering approach and the Functional Resonance Analysis Method (FRAM) to understand and model UTS in the context of smart cities and support evidence-based decision-making. This paper proposes an architecture considering:

- different types of available data generated in a smart city,

CC BY

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein

Co-funded by the Erasmus+ Programme of the European Union

- big data collection and semantic aggregation and enrichment;
- a data sense-making process composed of analytics of different data sources such as social media, communication networks, IoT, user behaviour;
- knowledge-based decision-making tools able to combine different information generated by analytics, experience and structural information of the city into a comprehensive and evidence-based decision-making model.

The solution has been applied in the metropolitan city of Florence. This article aims to explore the feasibility of adopting a big data approach to manage resilience in a sociotechnical system such as a smart city. The article focuses on a new conceptualisation of resilience suitable for these purposes and a comprehensive solution developed by the European Commission's RESOLUTE research and development project (http://www.resolute-eu.org). The approach exploits the opportunities offered by the Internet of Everything paradigm to collect, process and transform urban big multimedia data (U-BMD) generated in the system by people and 'things' into valuable knowledge for resilience and sustainability decision-making. The focus is on the urban transport system, understood as the set of infrastructures and transport modes that support the movement of passengers and goods in cities. Today, urban transport systems (UTS) have taken on a safety- and business-critical character, so increasing the resilience of UTS is considered essential for two main reasons:

- they provide essential support to any socio-economic and rescue activity;
- the routes through which people, goods, services and information move are the same ones through which hazards spread.

The growth of population in urban areas, the increasing interdependencies between physical and cyber infrastructures, and the proximity of transport systems to dangerous production facilities, together with threats of climate change and terrorism, pose significant challenges to the UTS as a critical infrastructure system. This thesis aims to present methods and technologies that enable the use of data generated in the smart city.

5) Who could be interested in this material?

The article is aimed at students and those looking for inspiration in implementations of the Internet of Everything (IoE) and big multimedia data in smart cities to manage the resilience of urban transport systems when such measures are applied in SUMP.

6) What is worth mentioning as an innovative factor for the reader?

This paper aimed to present a full-stack approach to the use of U-BMD generated by IoE in a smart city to improve UTS resilience management in a smart city context. The challenge of managing U-BMD is to respond to big data. In the case of disaster resilience, timely decision making under reduced uncertainty is crucial to applying adaptive strategies. To this end, a new conceptualisation of resilience has been defined, suitable for its data-driven operationalisation, and an associated multistage methodology for its implementation, which includes system understanding, identification of information

CC BY

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein

Co-funded by the Erasmus+ Programme of the European Union

requirements, U-BMD collection and integration, U-BMD decision-making process and evidence-based decision support system tools. To understand the system, an FRAM approach was adopted, which can describe system functions and interdependencies. After the UTS model is defined, elicitation of information requirements from operators and decision makers should be performed. The system modelling and the information requirements allow the definition of U-BMD preselection criteria. This initial assessment of U-BMDs is crucial to reduce costs, especially management costs associated with useless data collected just "just in case". U-BMDs are managed through a three-tier platform comprising:

- a U-BMD management layer, where heterogeneous datasets with different stream rates, volumes and formats are collected and combined according to a defined ontology;
- a U-BMD sense-making layer for information extraction, which includes many analyses applied on individual data streams, such as WIFI clustering applied on WIFI access data stream, Twitter Vigilance applied on Twitter streams, Parking analysis applied on parking sensor data stream, etc. ;
- a knowledge generation layer in which ResilienceDS and SmartDS work together to model the UTS system according to the FRAM methodology, to import the model into a decision tree tool with trivalent logic, capable of linking models to data through APIs and queries.

Uncertainty reduction was proven by tracking the evolution of the white part of the IF over time for most of the several formalised functions. The analysis shows that this fact is due to the effect of the formalisation of processes, which increased the awareness of decision-makers and experts, as well as the speed and precision of their evaluation using big data tools.

The end-to-end solution presented in this paper aims to support timely and better informed decision making in emergencies, as well as in daily operations within a complex system as a UTS or smart city, using U-BMD generated in a smart city. The operator can make timely data-driven decisions in emergencies or in the planning phase (e.g. urban design, cost-benefit analysis) on the priorities of activities to ensure the safety of goods and people involved, while exploring which areas are potentially more at risk of an incident, to implement preventive policies. However, it is worth noting that the quality of the results provided by the system is intrinsically linked to the quality of the managed data. The future evolution of such a system can be represented by the Digital Twin. It is possible to create an outgoing virtual representation of the UTS combined with real data. The creation of simulation models that constantly update and change as their physical counterparts change will allow for a better assessment of the decision space for resilience and a deeper understanding of the implications of such decisions.

7) Limitations

The problem was analysed at a high level of generality, but the presented idea (introduced in the city of Florence) could support integration processes within new technologies to

BY

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein

Co-funded by the Erasmus+ Programme of the European Union

support mobility management, especially in crisis events and also in day-to-day mobility management. The conclusions presented may serve as inspiration for Polish cities regarding the problems that may occur during the implementation of shared mobility services.

CC BY

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein

Co-funded by the Erasmus+ Programme of the European Union