# PhD in Civil and Environmental Engineering

# Research Title:
# Vulnerability of urban environments to terrorist attacks

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| **Funded by** | Università Italo-Francese – Progetto VINCI 2017 |

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| **Context of the research activity** | The current political situation, the intrinsic fragility of urban topology, and the rapidity with which the gaseous substances spread in the air, greatly fear the possibility of terrorist attacks aimed at dispersing toxic/pathogenic substances in the city networks. Current methods for studying these attacks, understanding their dangers, and mitigating them are based on complex fluid dynamical mathematical models that require huge computational resources to be adopted. This project pursues a different strategy and aims to adapt the most recent developments in complex network theory to develop a method of assessing the vulnerability of cities to these attacks. The key idea is to "read" directly in the topology and the characteristics of the urban grid the most vulnerable points and to quickly evaluate how to reduce them. This will allow one to systematically study many cities and for each to prepare the specific defense strategies in case of attacks.<br>The present research project will be carried out in collaboration with prof. Pietro Salizzoni, Ecole Central de Lyon (France) |

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| **Objectives** | Our goal is to provide a reliable and quick way to understand the points of a city most vulnerable to a terrorist attack aiming to spread a toxic cloud in the air. The key aspect of our approach is that this goal is achieved not through a long and demanding numerical simulation of dispersion and diffusion processes, but (i) building a complex multilayer weighed network - where geometric, fluid-dynamic pathways are compiled into suitable weights of network links - and (ii) assessing vulnerability through new complex analysis methods. In other words, our aim is to avoid simulating the details of the propagation dynamics, but to deduce the effects of propagation directly from the static data that are appropriately selected and embedded into the network; that is, how is the network topology determines the motion and spreading of the toxic cloud. This approach (i) will allow one to avoid long numerical simulations |

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| | that only a few research centers can do due to their complexity and (ii) will equip our major cities with a tool that will allow them to answer such questions:<br><br>(I) what urban structure is most vulnerable to terrorism attacks?<br><br>(II) what are the most vulnerable areas of the city? And how do they change when the meteorological conditions or the attack point change?<br><br>(III) what actions can be taken to mitigate risks at the most vulnerable points? Is it possible to "segment" the city from the point of view of its connectivity (similar to what happens in large water or electricity networks) in order to control propagation or reduce its vulnerability?<br><br>(IV) what are the city areas to be most controlled during events (sport, performers, politicians, etc.) that attract many people along streets ?<br><br>(V) how will the vulnerability change in the light of future different urban planning plans?<br><br>Note that the focus of this project is terrorist attacks, as they are particularly dreadful and, unfortunately, current. However, the method that will be developed during the PhD program is equally useful for studying the effects and city vulnerability to accidental releases of substances, such as those related to industrial plants or the carriage of dangerous goods.<br><br>The present complex network approach for studying the vulnerability of urban topologies shares remarkable conceptual points with recent developments in water distribution system analysis. Therefore, useful and suitable conceptual links will be explored between these two research topics. |

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| **Skills and competencies for the development of the activity** | The research project is inherently multidisciplinary, and a wide range of competences can fit well the requirements for developing the activities, including: big-data analysis, fluid mechanics, water distribution networks, and network analysis. The applicant must be proficient in spoken and written English.<br>The applicant will have to spend one year in Lyon (France) |