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New GIS-embedded methodology for estimating the implications of road network failure due to natural hazards

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Due to their widespread, transportation networks are considerably exposed to natural hazards such as earthquakes, floods or landslides occur. Single-segment dysfunctions can lead to systemic loss of connectivity, generating direct and also significant indirect socio-economic damage, on short and long term. Road segments, for example, can become impracticable due to direct damage (bridge or tunnel collapse, degradation of embankment etc.), debris blockages or traffic jams; methods for identifying the structurally vulnerable links are available, but in order to prioritize intervention it is need to consider the impact of failure, performing cost-benefit analysis and checking the implications of traffic flow disruption through performance indicators. This way, road segments can be classified as critical or less important, and new plans leading to improved resilience can be elaborated. Currently, few methodologies provide end-to-end coverage – from structural to functional damage, also considering the spatial and temporal dimensions required for the analysis.
In order to support the applicative progress in this multidisciplinary field (of transportation network risk analysis), we developed a new methodology capable of implementation in near-real time, relying on i) GIS to define, spatially analyse and represent transportation networks (not solely roads), ii) probabilistic methods for determining the potential of network links to become affected by natural hazards, iii) MonteCarlo methods for simulating multiple scenarios considering the assigned failure probabilities, iv) damage cost estimation capabilities, v) analysis of implications on emergency intervention times and transit disruption, vi) correlations with other vulnerability and risk indicators and vi) planning analysis or intervention prioritisation recommendations. Our proposed model can be seen as an attempt to bring together various researches and methods specific to multiple disciplines, with the goal of creating an easy to understand and modify framework to deliver insights on how particular segment damage can translate into direct and indirect socio-economic implications. Currently, the methodology relies on ArcGis capabilities and is incorporated and disseminated as a ModelBuilder toolbox collection.
Beside describing the methodology, we present results to tests on road networks, at urban (for Bucharest) and regional scale (for 8 Romanian counties), for areas subjected to strong intermediate-depth Vrancea earthquakes with magnitudes greater than 7. Although difficult to validate with real situations, the results are of high importance in the context of the Ro-Risk National Project and as preparedness for future potential events to come, setting also premises for locations to be monitored.