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A multidisciplinary approach for risk analysis of infrastructure networks in response to extreme weather

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Abstract

In recent years, it is becoming more frequent the occurrence of extreme weather events across Europe, such as rain induced landslides, river floods, winter storms and hurricanes. These hazards result in deterioration or fail of critical elements, and in the consequent disruption or disablement of the traffic networks. Therefore, developing tools and guidelines are mandatory to enhance safety and reliability of critical infrastructure networks, and address European policy in the areas of safety and security, inter-modality and emergency response planning. With this goal, the European research project RAIN (Risk Analysis of Infrastructure Networks in response to extreme weather) presents a multidisciplinary approach, involving aspects as diverse as climatology, transportation, or sociology. The RAIN vision is to provide an operational analysis framework that identifies critical infrastructure components impacted by extreme weather events and minimise the impact of these events on the EU infrastructure network. The project focusses on land transport networks, and the energy and telecommunication systems to identify cascading and inter-related effects. Technical and logistic solutions are developed to minimise the impact of these extreme events, which include novel early warning systems, decision support tools and engineering solutions to ensure rapid reinstatement of the network. This paper presents an overview of the RAIN project including results and methods that can be applied globally to determine the impacts of increased extreme weather events.

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Keywords: extreme weather events; critical infrstructure; risk analyisis; European project

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1. Introduction

Minimizing the impact of major weather events upon the EU has become a priority for the European planners in order to avoid disproportionate damage or disruption. This implies to quantify the complex interaction of existing infrastructure systems and their interrelated damage potential in such situations. Moreover, a proper interaction between entities such as emergency planners, utility operators, first responders, engineers and, most importantly, the citizens living in the affected area, is essential and requires a multidisciplinary coordination.

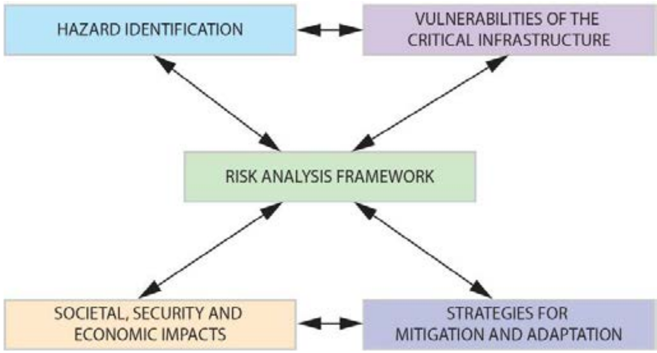

Fig. 1. Diagram of the RAIN project strategy.

The project Risk Analysis of Infrastructure Networks in response to extreme weather, RAIN, will provide an operational analysis framework that identifies critical infrastructure components impacted by extreme weather events and minimise the impact of these events on the EU infrastructure network. The multidisciplinary approach of RAIN project involving experts from transportation, energy, risk assessment, climate prediction, social sciences, civil engineering and telecommunications, guarantees a holistic response plan to transcend borders.

The general framework of this project can be split into five interrelated stages, as Figure 1 indicates.

The first stage implies the hazard identification, that is, identifying the most potential harmful hazards and their intensity thresholds to be considered as “extreme cases”, taking into account regional differences in vulnerability and climate. Afterwards, the frequency of weather hazards throughout Europe for both the present and future climate, until the year 2100, is assessed, by applying methods such as CORDEX (regional level) and CMIP5 (global level).

The second stage is focussed on the analysis of the vulnerabilities of the critical land transport, energy and telecommunication infrastructure. To identify the critical land transport infrastructure, i.e. road and rail transport, it is required a review of critical land transport infrastructure failures and the current means of protecting them. This will allow the understanding of the failures of this infrastructure leading to societal vulnerability and insecurity. Parallel, the critical energy and telecommunication infrastructures are analysed.

Given that the critical transport, energy and telecom infrastructures are highly interconnected and form “systems of systems” that tend to be vulnerable during extreme hydro-meteorological events, the existing modelling approaches, with fault trees and event trees, are not suitable in the extreme situations analysed. For that reason, developing a risk analysis framework for single events and cascading effects of single or multiple hazard events has to be addressed. The cascading effects consider the interdependency identified in critical infrastructure. Several techniques need to be combined including influence diagrams, Bayesian networks, event trees, mapping, GIS, and analysis of human and organizational factors.

The risk analysis framework will permit the examination of the impact of critical infrastructure failure on society, security issues and the economy. The risk procedure will be benchmarked against case studies conducted on critical transport and operational tactical connections (O’Connor et al. (2014); O’Brien et al. (2015)).