

# Editorial: Special Section on Modeling and Simulation in Disaster and Emergency Management

## WORLD OF DISASTERS AND EMERGENCIES

**T**HE COVID-19 pandemic of 2020 has wrought damage globally to a degree that is totally unprecedented in human history. Within three months that the first known death from the illness caused by the so-called novel Coronavirus was reported by state media in China on the 11th of January 2020, close to 1.8 million people worldwide had tested positive, with more than 100,000 deaths reported. By the time the pandemic will have been declared to be under control, millions more are expected to have been infected and tens (possibly hundreds) of thousands more will have perished as a result of the disease.

Not only are the numbers of COVID-19 infected people and deaths staggering. Economies throughout the world have suffered tremendously, with many companies forced to shut down, or at the very least significantly scale down, their production of goods and services as a result of the need for social distancing and self-isolation required to prevent the unmitigated transmission of the disease. All this has led to hundreds of millions worldwide losing their employment or other sources of livelihood. Governments of all nations, large and small, developed and underdeveloped, have needed to pump into their economy and onto their struggling citizens whatever financial resources they could manage to generate.

Prior to the COVID-19 outbreak, we have earlier witnessed many other disasters and emergencies, both major and minor. From natural disasters (e.g., earthquakes, hurricanes, tornadoes, tsunamis, landslides) to epidemics (e.g., SARS, H1N1, Ebola), and from man-made civil disasters (wars between nations, large-scale terrorist attacks, internal civil disturbances and population displacements) to industrial disasters (nuclear plant meltdowns, chemical plant explosions, oil spills).

Mathematicians, engineers, scientists, other scholars and researchers have sought to develop mathematical models of various aspects of managing disasters and emergencies—antecedents or causes, risks, prevention, mitigation, preparedness, response, and recovery. In most instances, because of the many variables and often unknown parameter values, the relationships and constraints, and even multiple and competing objectives, the models developed to address concerns and problems in disaster and emergency management are understandably extremely complex and not open to straightforward analytical solution. It is within this context that modeling and simulation

(M&S) has proven to be a useful and widely used tool for the study of disaster and emergency management (DEM).

## ABOUT THIS SPECIAL SECTION

This Special Section on Modeling & Simulation in Disaster & Emergency Management: Planning, Strategy Formulation, Decision-Making, and Training consists of 12 articles. The special section was initiated two years ago, with the call for papers issued in April 2018.

This special section was intended for publication of revised, extended versions of some of the best papers presented at the component thematic conferences of the 15th International Multidisciplinary Modeling & Simulation Multiconference (I3M 2018), held in Budapest, Hungary, on September 17-19, 2018. Nonetheless, submission of other papers outside of I3M 2018 was allowed and encouraged.

After undergoing blind review by an international panel of scholars and scientists, subject to this journal's rigorous standards, the following five papers from the 17th International Conference on Modeling & Applied Simulation (MAS 2018), the 8th International Defense & Homeland Security Simulation Workshop (DHSS 2018), and the 7th International Workshop on Innovative Simulation for Healthcare (IWISH 2018) were accepted for publication in this special section.

- [1] *The Employment of Unmanned Aerial Vehicles for Analyzing and Mitigating Disaster Risks in Industrial Sites*, by Giuseppe Aiello, Fabrizio Hopps, Domenico Santisi, and Mario Venticinque (first presented at MAS 2018 as 'Drone based inspection services in industrial contexts: risk assessment and market opportunities').
- [2] *Supply Chain Modeling in the Aftermath of a Disaster: A System Dynamics Approach in Housing Recovery*, by Rafael Diaz, Joshua G. Behr, Francesco Longo, and Antonio Padovano (first presented at MAS 2018 as 'A methodological framework to implement lean in dynamic and complex socio-technical systems').
- [3] *Simulation and Visualization of Volcanic Phenomena Using Microsoft HoloLens: Case of Vulcano Island (Italy)*, by Ali Asgary, Costanza Bonadonna, and Corine Frischknecht (first presented at DHSS 2018 as 'Holovulcano: Augmented Reality simulation of volcanic eruptions').
- [4] *Simulation-Based Analysis of a Real Water Distribution Network to Support Emergency Management*, by

Luisa Lavalle, Tatiana Patriarca, Bernard Daulne, Olivier Hautier, Alberto Tofani, and Ester Ciancamerla (first presented at DHSS 2018 as ‘Model and simulation of a real water distribution network to support emergency plans).

- [5] *A Tool-Based Framework to Assess and Challenge the Responsiveness of Emergency Call Centers*, by Eva Pettidmange, Franck Fontanili, Elyes Lamine, Matthieu Lauras, and Uche Okongwu (first presented at IWISH 2018 as ‘Skill-based routing problem in Emergency Call Centers: toward an improvement of response time’).

The following seven additional papers, not associated with the I3M 2018 multiconference, make up the rest of the papers accepted for publication.

- [6] *Discrete-Event-Based Simulation Model for Performance Evaluation of Post-Earthquake Restoration in a Smart City*, by Abhijit Gosavi, Giacomo Fraioli, Lesley H. Sneed, and Nathaniel Tasker.
- [7] *Assignment of Medical Staff to Operating Rooms in Disaster Preparedness: A Novel Stochastic Approach*, by Seyed Mahdi Shavarani, Mahmoud Golabi, and Bela Vizvari.
- [8] *Measuring and Maximizing Resilience of Transportation Systems for Emergency Evacuation*, by Yan Wang and Junwei Wang.
- [9] *Seismic-Resilient Bulk Power Grids: Hazard Characterization, Modeling, and Mitigation*, by Mostafa Nazemi and Payman Dehghanian.
- [10] *Selecting a Cargo Aircraft for Humanitarian and Disaster Relief Operations by Multicriteria Decision Aid Methods*, by Luiz Octávio Gavião, Annibal Parracho Sant’Anna, Gilson Brito Alves Lima, Pauli Adriano de Almada Garcia, Sergio Kostin, and Boris Asrilhant.
- [11] *Time Estimation and Hotspot Detection in the Evacuation of a Complex of Buildings: A Mesoscopic Approach and Case Study*, by Jony A. Zambrano, Jorge A. Huertas, Ethel Segura-Durán, and Andrés L. Medaglia.
- [12] *A Geospatial Framework Using Multicriteria Decision Analysis for Strategic Placement of Reserve Generators in Puerto Rico*, by Susan M. Kotikot, Bandana Kar, and Olufemi A. Omitaomu.

Nine of the above papers fall within the context of natural disasters – earthquakes [6], [9], hurricanes [2], landslides [8], volcanic activity/eruptions [3], wildfires [11], and various natural disaster types [7], [10], [12]. Two papers are in the context of man-made disasters – an industrial disaster [1] or terrorist attack [4] – although it may be argued that wildfires [11] may well be classified as man-made as they are ignited, intentionally or unintentionally, by humans. One paper deals with management of emergency call centers for medical emergencies [5]. Table I provides a summary of the 12 papers according to these various contexts.

Case studies investigated are based on the following varied mix of scenarios:

- [1] pre-disaster risk assessment of above-ground storage tanks for petroleum products within a power plant in a town near Palermo, Italy;

TABLE I  
SUMMARY OF PAPERS BY DISASTER/EMERGENCY CONTEXT

Disaster/Emergency Context	Papers
Natural disasters	
- Earthquake	[6] [9]
- Hurricane	[2]
- Landslide	[8]
- Volcanic activity/eruption	[3]
- Various	[7] [10] [12]
Natural/man-made disasters	
- Wildfire	[11]
Man-made disasters	
- Industrial disaster	[1]
- Terrorist attack	[4]
Emergency management services	[5]

- [2] housing recovery following hurricane destruction in a region along the U.S. mid-Atlantic coast;
- [3] training using interactive holographic visualization of volcanic phenomena at La Fossa Volcano on Vulcano Island, Italy;
- [4] cyber-attack on a water distribution system in Belgium;
- [5] responsiveness of a pre-hospital emergency call center in France;
- [6] post-earthquake restoration in a ‘smart city’ in Missouri, USA;
- [7] assignment of medical staff to hospital operating rooms following a major earthquake in Tehran, Iran;
- [8] transportation system for landslide evacuation in Hong Kong;
- [9] resilience to major earthquakes of power generation systems in the U.S.;
- [10] selecting a cargo aircraft for humanitarian disaster and relief operations in Brazil following a large-scale natural disaster;
- [11] evacuation of a complex of buildings in a university campus in Bogotá, Colombia, due to a wildfire;
- [12] strategic placement of reserve power generators in Puerto Rico to mitigate power loss from destruction of energy infrastructure following various natural disasters (e.g., earthquakes, landslides, hurricanes, storm surges).

Mitigation, preparedness, response, and recovery are the four widely identified phases in the so-called DEM cycle. It is usually difficult to associate a paper with exactly one of these phases. One may consider four papers as being relevant to both mitigation and preparedness [1], [9], [11], [12]. Two papers pertain only to the preparedness phase [3], [8], and another three papers are relevant to both preparedness and response [4], [5], [10]. Two others appear to be connected only to response [6], [7]. Finally, one paper is relevant to recovery only [2]. The 12 papers are summarized in Table II according to their relevance to phases of the DEM cycle.

There is a fairly diverse set of M&S frameworks, approaches, and tools applied in the 12 papers. Simulation optimization is applied as a framework in some papers, with stochastic simulation

TABLE II  
SUMMARY OF PAPERS BY RELEVANT DEM PHASES

DEM Phases	Papers
Mitigation and Preparedness	[1] [9] [11] [12]
Preparedness only	[3] [8]
Preparedness and Response	[4] [5] [10]
Response only	[6] [7]
Recovery only	[2]

carried out using discrete event models [6], [11], Monte Carlo simulation [9], a genetic algorithm [8], or three methods in parallel (simulated annealing, particle swarm optimization, and genetic algorithm) [7]. Two papers use system dynamics [2], [4], with the latter using a commercial simulator for analysis and planning of networks, while two papers apply multi-criteria decision analysis [10], [12]. One paper uses discrete event simulation as a simulation tool within a process and data mining environment [5]. Another deals with simulation using virtual and mixed reality with HoloLens as a technological tool for training [3], while one other paper involves the use of unmanned aerial vehicles to simulate risk within a high-risk industrial site [1]. Agent-based modeling, which is also commonly used in M&S for disaster and emergency management (e.g., when human behavior modeling is involved), is absent from the set of 12 articles in this special issue.

We sincerely thank the numerous scholars, scientists, and researchers who have served as reviewers (listed below) of the articles that were submitted for consideration.

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