Team Control Number

1908810

Problem Chosen

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For office use only

T1 _____

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2019
MCM/ICM
Summary Sheet

In this paper we develop a number of models for formulating and evaluating exit strategies for evacuating the Louvre museum in Paris, France. To begin, we argue that the key emergency plan infrastructure is emergency exit directives: signs to exits. We annotate publicly available floorplans to create a graph model on which to test our strategies. Choosing the direction of edges on this graph simulates the placement of emergency exit signs and their directions.

This model progresses as such: the preliminary analysis serves to give an overview of the problem. Next, the agent-based model and the accompanying simulations then validate our ideas. Then, the differential equation model gives a theoretical approach that may be more amenable to quick analysis.

For our preliminary investigation, we use spectral graph analysis on our model floorplan to identify critical connections that might have maximum impact on flow through the graph. We start with an evacuation strategy where exit signs simply point to the nearest exit as a heuristic guess for the best plan to minimize evacuation time. Our two models, predicated on the same assumptions, predict how such a directive structure will affect populations flowing through the Louvre in an emergency and how that will affect evacuation time.

First, an agent-based model simulates individual behavior and crowd interaction at a fine-grained level grounded on queuing theory. People are modeled as discrete units and movements from room to room are stochastically scheduled. Furthermore, within this approach, simulated security personnel movements help to determine how congestion can affect response time.

Second, we also develop an analogous differential-equations-on-a-graph model to create a deterministic approximator of this behavior to more quickly generate information. Using these two models we can analyze chokepoints that impede smooth flow to the exits.

Finally, we suggest optimizing exit sign placement according to the metrics and insights generated by our models. We discuss how factors such as more exits and structural damage to the Louvre can affect swift evacuation and emergency response.