Working Title: Multi-Layer Infrastructure Repairs in a Post-Disaster Context

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Abstract

Keywords

1. Introduction

Hurricanes provide a growing concern in the operation of power grids in coastal areas. This paper was undertaken to address the gap in the literature where previous efforts don't consider how network layers depend on each other. To affect repairs on a damaged power grid element, the element must be accessible to the crew attempting to repair it, which implies that the road grid is a part of the repair efforts. In the process of a hurricane, the road grid will sustain substantial damage from flooding and debris on the road surface, which necessitates road grid repairs as well. To handle the issues of repairing power grids efficiently, consideration for repairs of both aspects should be considered jointly.

1.1 Existing Literature

Damage from hurricanes on infrastructure elements is well studied. All of [11], [10], and [6] have looked at the damage to power grids in varying capacities and methodologies. Damage to the road network is studied more in the context of repairing damage. [1] addresses concerns of accessibility to locations in the wake of road damage. [5] focuses their work on the ability to move disaster supplies around.

In the context of power grid repair, it comes from two major areas: Network interdiction and work similar to this paper. [9] is a paper emblematic of work on interdiction and provide the basis for the linear programming formulation of DC power flow used in this paper. [12] provides further literature review of the interdiction problem. [2] addresses a problem similar to this work, though without addressing travel times at all. [3] and [7] both address repairs to power grids in the context of resilience. Most similar to this paper is [4] in that they consider DC power flow and repair with travel times jointly. The key distinction is that they presume that the road operates under nominal conditions rather than including repair of the road grid into the problem.

2. Model

2.1 Assumptions

While considering coordinated repair using the mixed-integer programs below, we assume complete information about damage to both networks, complete information about repair times, and no variation in repair times. In the course of modeling the problem, we assume that a DC-flow model of power grid operation is close enough to real network behavior to draw useful insights [8]. We also assume in the power grid repair model that a minimum spanning tree can approximate routing elements NEEDS CITATION

2.2 Road Model

2.3 Power Model

We begin modeling the power half of the problem by defining the relevant parameters and ssts

N	set of nodes, indexed by i
E	set of power lines, indexed by e
R	the set of road segments
T	the planning horizon, indexed by t
$O(i)$	set of lines with origin i
$D(i)$	set of lines with destination i
$o(e)$	origin node of line e
$d(e)$	destination node of line e
$\underline{L_e}, \overline{L_e}$	capacity lower and upper bounds for the power line e
Δ_i	time to repair node i
δ_e	time to repair line e
$C_{SP(i)}$	length of the shortest path to node i from the central depot
D_i	power demand at location i in the pre-disaster steady state
P_k	maximum power generation for generator k
B_e	line susceptance for power line e
I_e, I_i	initial condition of line e and node i, respectively

3. Results

3.1 Methods

4. Conclusions

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