Models and Decision-Support for Post-Disaster Debris Management

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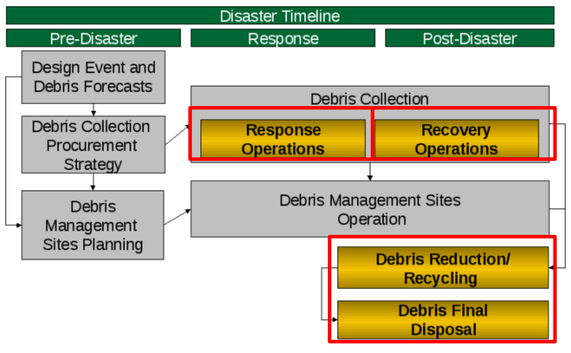
BACKGROUND

- **Post-disaster debris** can be equivalent to years of normal solid waste
- Costly, long and **complicated process**
- **Short term**: Blocks access to critical facilities and resources
- **Long term**: Threat to human health and the environment
- How to efficiently and effectively clear, collect and dispose debris?

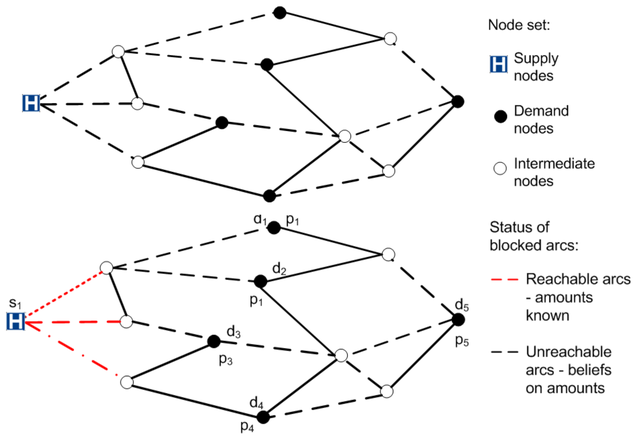


Phases of Debris Operations

- **Clearance**: Unblock roads
  - Prioritize roads to be cleared
  - Connect relief supply to demand points
- **Collection**: Transport debris to collection sites
  - Assign roads to collection teams
  - Minimize collection time and balance workload
- **Disposal/recycling**: Sort debris and decide on final processes
  - Debris processing site location
  - Process selection: wood grinding, concrete crushing, incineration, compaction, etc.
  - Landfilling / recycling tradeoff

MODELS FOR CLEARANCE

- **Inputs**: road network condition, clearance capacity per period, debris amounts, relief supply/demand locations and quantities
- **Output**: Clearance sequence for a set of roads
- **Complete debris information**: All debris amounts assumed to be known
- **Incomplete debris information:** Reachable arcs known, beliefs about unreachable arcs updated as clearance proceeds
- **Regional updates** as arcs in the same region become reachable



Computational Experiments

- Example: Earthquake near Cambridge, MA
  - A 6.5 magnitude earthquake
  - Debris estimates using Hazus (FEMA's methodology for estimating potential losses from disasters, www.fema.gov/hazus)

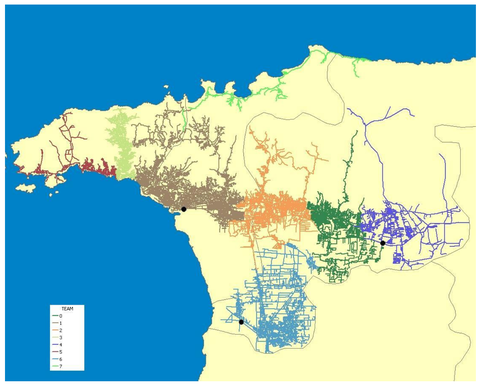
- Road clearance sequence
- Regional updates make a difference, especially when beliefs are inaccurate

MODELS FOR COLLECTION

- **Inputs:** Debris amounts, facility locations and capacities, contractor data
- **Output:** A fair and continuous assignment of the roads to collection teams and expected collection time
- **Objective:** Minimize cost and completion time
- Solve a MIP-based sequential heuristic

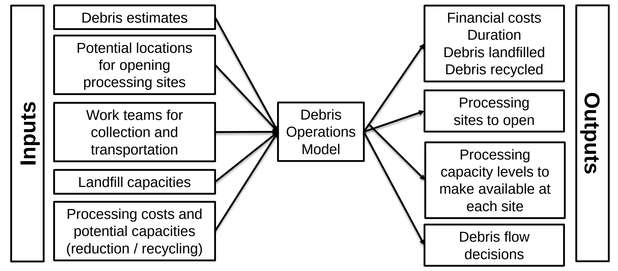
Computational Experiments

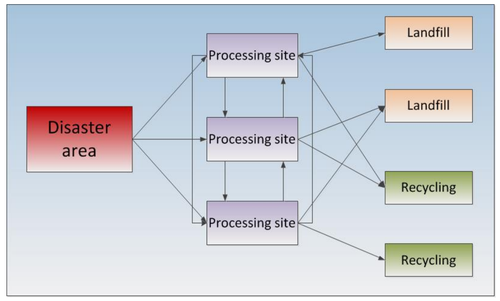
- Scenario analyses run based on disaster scenarios in cities like Miami, Port-au-Prince and various Caribbean countries
- Example: Earthquake in Trinidad and Tobago
  - A potential 7.8 magnitude earthquake off the west coast
  - 8 collection teams: 2 large, 5 medium, 1 small-sized



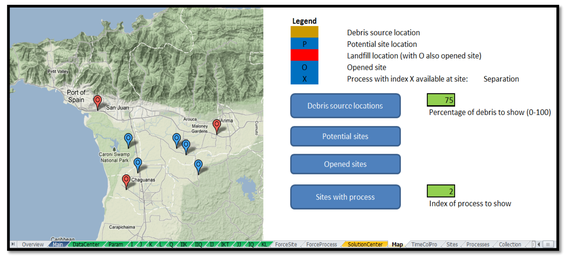
- Resulting team assignments
- Expected completion time: 75 days

MODELS FOR DISPOSAL / RECYCLING





- Current prototype developed using MS Excel, GLPK optimization solver and Google Maps API



- Example: Earthquake in Trinidad and Tobago
  - Systematic debris removal analysis
  - 20% debris recycled
  - Cost savings of 1.6 million if half a year of extra removal time is allowed

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- Debris Operations Tool: Optimizing disaster debris management operations. Available at **debrismanagement.gatech.edu**
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