Sheltering the Vulnerable Population of Virginia Beach in the Event of a Flood Disaster

Problem Proposal

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Problem Description: The city of Virginia Beach is cited as one of the top 10 flood-risk regions in Virginia [4]. Virginia Beach has been affected by major flooding events due to rainstorm, hurricane, and tropical storms. The risk is projected to increase over the next 30 years [1]. Giving sufficient attention to vulnerable populations from nursing homes and hospitals is highly important to saving lives in a natural disaster [2]. The team will model the logistics of a shelter network for vulnerable populations (aged care facilities and hospitals) under uncertainty and constrained resources. The objective will be to minimize the time and risk associated with an evacuation effort focused on vulnerable populations during a flooding event. This model will help to identify safe zones, shelter facilities, and transportation systems to move these vulnerable populations to shelters during a flooding event. Some key parameters will include population size and distribution, flooding time advance notice, flooding extent, number of vehicles available, and shelter facility locations and capacity.

Requirements:

Safe Zone Facility Shelter Requirements:

Requirement	**Metric**
Facility must comply with jurisdictional flood shelter safety requirements [3].	Topographic Elevation (feet above base flood elevation); FEMA Flood Damage-Resistant Materials Rating (4+)
Safe Zones combined capacity must be able to accommodate at least 10,000 people.	Summated Facility Capacity (number of people)
Facility must have multiple routes of entry/exit	Number of roads connected to facility (numerical)
Facility must have sufficient resources to care for aged people and hospital patients.	Number of trained personnel; Quantity of medical equipment and supplies
Facility must have bedding and bathroom capabilities for capacity	Blanket, Cot, Toilet Count (Numerical)
Facility must have back-up source of electricity for a week	Source Availability (Boolean)
Facility must have adequate food and medical rations to last a week for capacity	Facility Capacity * 2 meals a day * (1 Red Cross medical kit per 50 people) (numerical)

Facility is adequately staffed	Minimum of 1 staff member (national guard, capable volunteer, etc.) for every 50 evacuees
Facility should have an outside source of resources	Coordination with local businesses (Amazon, Wal-Mart, etc.) as necessary for resources indicated above

Modeling & Simulation Requirements:

- The simulation must determine the time it would take to evacuate 90% of the vulnerable population to safe zones and track their arrival.
- The simulation must effectively model the events that are caused by floods
- The simulation should determine the optimal facility locations that can safely house the vulnerable population during a disaster.
- The simulation should help identify ideal characteristics of shelter facilities
- The simulation must be dynamic to be used in different scenarios and localities

Our Approach: Using IBM ILOG CPLEX® optimization and Arena® Discrete Event Modeling Simulation Software, the team will assess the feasibility for an evacuation route and facility system to rapidly and safely move people from aged care facilities to shelters. Inputs include routes and safe zones based on prerequisite data. The simulation will account for risks and disruptions caused by road closure, condition of shelter facilities, vehicle availability, fuel supplies. For example, a road may be closed off due to flooding, requiring vehicles to use an alternate route. The model would measure the impact on the total system in terms of time-to-evacuate (the amount of time to move some percentage of the vulnerable population ex. ~90%). This model will provide a system-level view of a shelter network under a variety of configurations and circumstances, providing a way to better manage the risks of transporting and sheltering vulnerable populations.

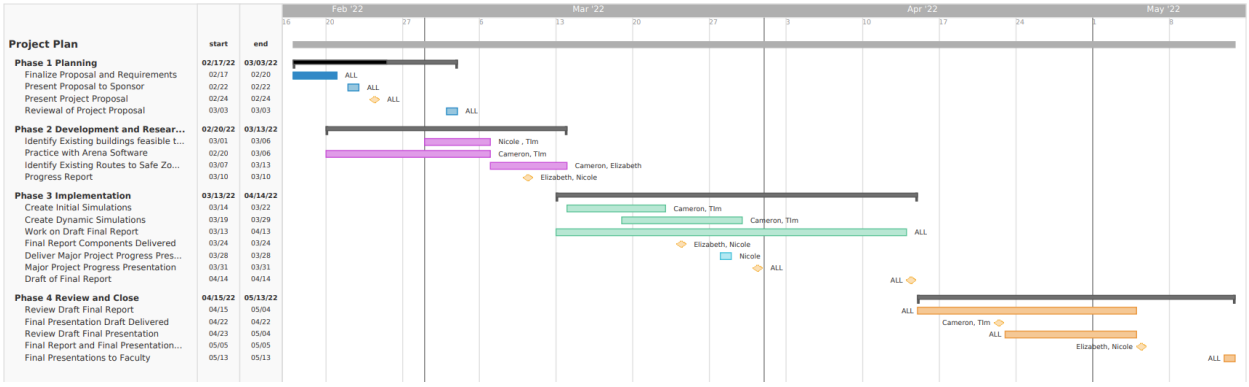
- Modeling Objective: Minimize total cost (time/risk) of transportation and sheltering system during evacuation event.
- Scenario Parameters: Routes, transit costs (time or risk), facility size and capacity, pickup locations, gas station locations
- Variables: Number/type of evacuees, number/type of vehicles available, road closures, delays, disruptions to resource availability, time dependence
- Constraints: Maximum time-to-evacuate, facility capacity, minimum number of exit/entry routes per facility, maximum number of care-dependent evacuees per facility (for example, patients who need 24/7 medical care), minimum amount of fuel required, stochastic disruptions (see “Variables”)

Project Plan w/ Team Member Assignments: Gantt Chart

Events:

- Finalize Proposal and Requirements 2/20 **(ALL)**
- Present Proposal to Sponsor 2/22

- Present Project Proposal 2/24 **(ALL)**
- Identify Existing buildings feasible to be safe zones based on needs **(Nicole and Tim)**
- Practice with Arena Software **(Tim and Cameron)**
- Reviewal of Project Proposal 3/3 **(ALL)**
- Identify Existing Routes to Safe Zones from initial starting points **(Cameron and Liz)**
- Create Initial Simulations **(Tim and Cameron)**
- Progress Report 3/10 **(Nicole and Liz)**
- Create Dynamic Simulations **(Tim and Cameron)**
- Work on Final Report **(ALL)**
- Final Report Components Delivered 3/24 **(Liz and Nicole)**
- Deliver Major Project Progress Presentation to Professor 3/28 **(Nicole)**
- Major Project Progress Presentation 3/31 **(ALL)**
- Draft of Final Report 4/14 **(Liz)**
- Final Presentation Draft Delivered 4/18 **(Nicole)**
- Final Report and Final Presentation Delivered 5/5 **(Liz)**
- Final Presentations to Faculty 5/13 **(ALL)**



**see attachment on last page for larger version of project timeline.*

<u>Risks and Risk Mitigations:</u>

Risk Number	Risks Description	Risk Mitigation Plan
R01	If there is a lack of data to properly model our system on then we cannot effectively optimize the best safe zones and facilities.	All open source data available will be utilized. If needed, additional data will be requested from local government agencies. If data is unavailable, logical assumptions will be made accordingly.

R02	If the vulnerable population chooses not to evacuate to the determined facilities then the evacuation plan will not be able to be utilized to its full effectiveness.	Run multiple simulations with predetermined percentages of the vulnerable population either evacuating to safe zones (i.e. 60%, 75%, and 90% of the vulnerable population evacuating to the safe zones).
R03	If there are only facilities that restrict access to the general public and cannot be utilized as a safe zone then the simulation will not be able to pick the most optimal Coordination with authorities for use of zones	If this type of facility is identified as a safe zone, an assumption will be made that it is usable and open to the general public. This model is for utilization by local government/leaders, so these facilities will be available for use.
R04	If there is a lack of large facilities in the Virginia Beach area then the reliability and effectiveness of the model will be compromised.	We will operate on the assumption that in this case, the National Guard will be available to set up facilities to meet the requirements (tents, toilets, etc.).
R05	If there is an unexpected disaster of uncertain magnitude and velocity then the requirements of the facility may not be effective in providing a safe zone for the vulnerable population.	The simulation will model routes to safe zones at intervals prior to the predicted magnitude of the disaster. (i.e. 72 hours from predicted landfall based on NOAA forecast). Unexpected disasters will not be included in the model.

Signature of Sponsor: Gregg L Tayon **Date:** 2/28/2022

References:

[1] Flood Factor, *Flood risk overview for Virginia Beach,* FloodFactor.com. Retrieved February 6, 2022, from https://floodfactor.com/city/virginia-beach-virginia/5182000_fsid.

[2] Hammad, Ahmed W. A.; Mojtahedi, Mohammad; Munawar, Hafiz Suliman; Waller, Travis S. "An AI/ML-Based Strategy for Disaster Response and Evacuation of Victims in Aged Care Facilities in the Hawkesbury-Nepean Valley: A Perspective." 14 January 2022.

[3] United States, Department of Homeland Security, *Flood Hazard Siting and Elevation Criteria for Residential Safe Rooms,* March 2021, https://www.fema.gov/sites/default/files/documents/fema_res-safe-room-flood_fact-sheet_2021.pdf.

[4] Web Staff, WTKR (2021, April 17), *Virginia Beach ranks top for cities at serious risk of flooding in Virginia*, WTKR.com. Retrieved February 6, 2022, from https://www.wtkr.com/news/virginia-beach-ranks-top-for-cities-at-serious-risk-of-flooding-in-virginia#:~:text=Virginia%20Beach%20ranks%20top%20for%20cities%20at%20serious%20risk%20of%20flooding%20in%20Virginia&text=The%20First%20National%20Flood%20Risk,to%20nearly%20390%2C000%20by%202050.

[5] World Population Review, *Virginia Beach, Virginia Population 2022*, WorldPopulationReview.com. Retrieved February 6, 2022, from https://worldpopulationreview.com/us-cities/virginia-beach-va-population.

Project Timeline: