The Geo-Atom for GEOINT: A Network Science Application

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Introduction

- Delivering timely and accurate geospatial intelligence (GEOINT) requires collecting data from multiple sources.
- Using multiple data models leads to challenges such as ensuring systems interoperability, performing data fusion, and delivering a common operating picture (COP).
- The geo-atom geospatial data model defines an association between a location in space–time and a property[1] and incorporates both discrete object (i.e. vector) and continuous field (i.e. raster) data[2].
- A hurricane emergency evacuation scenario in Houston, Texas demonstrates how adoption of the geo-atom can help address challenges related to collecting, processing, and disseminating GEOINT.

Research Overview

The basis for this scenario is a map of hurricane evacuation routes and evacuation zones developed by the Harris County Office of Homeland Security and Emergency Management[3] (Figure 1). The data from this map is fused with other geospatial datasets to create a network science model that can predict areas of traffic congestion, and the geo-atom is used to develop the model and deliver a COP to emergency management decision-makers.

"…the connection between GEOINT and modeling has emerged as a capability that decision-makers and response teams can rely upon to increase the correctness, reliability, and timeliness of their decisions."[4]
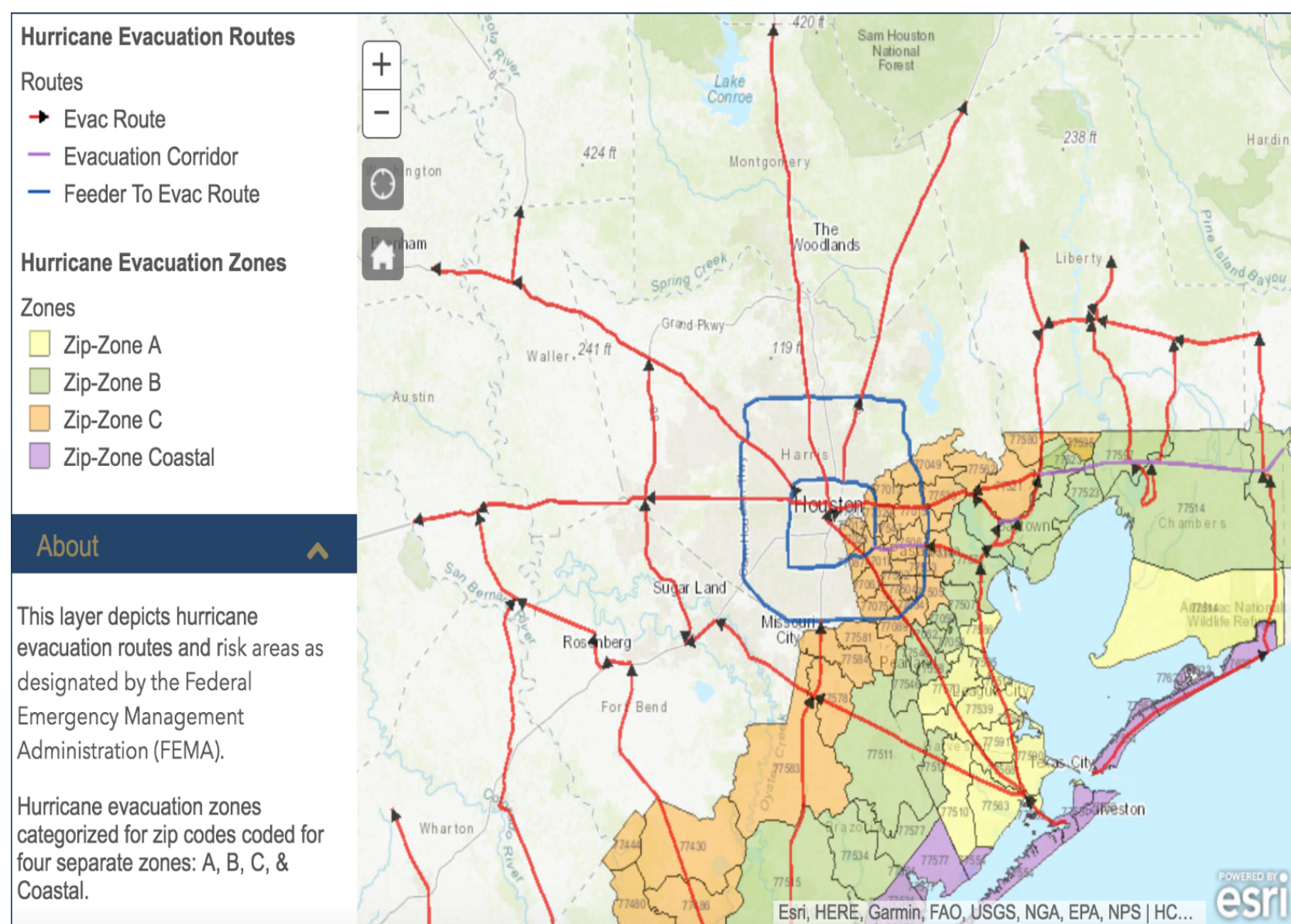

Figure 1: Hurricane evacuation routes and zones[3]

- Geospatial data from several sources is used to develop a network science model.
- This model is applied to a section of the road network in the Houston area to predict areas of traffic congestion during a hurricane evacuation.
- The geo-atom is used to add new real-time variables to the network flow model.
- Model outputs demonstrate how factors such as flooding and large debris might affect traffic flow.
- Results are disseminated as geo-atom data and are displayed on multiple software platforms to demonstrate interoperability.

Methods

- Create a network topology using nodes to represent either the start or end point of an evacuation route or a road intersection and arcs to represent the roads shown in Figure 1.
- The location and number of people that require evacuation is determined using a zip code shapefile, and the distance of each road segment is calculated using GIS.
- A network science model[5] is solved using these data, and the outputs show where areas of traffic congestion may occur.
- New variables that represent real-time flooding data are incorporated into the network science model as geo-atom data (Figure 2).

An example of record for a flood event is:
$$flooding = \{(30.012, -95.806), water\ depth\ (cm), 170\}$$

$$g = \{p, A, a(p)\}$$

where

$$g = flooding$$
$$p = (WGS84\ Latitude, Longitude)$$
$$A = water\ depth\ (cm)$$
$$a(p) = 170$$

Figure 2: Geo-atom specification

- The network science model was then solved again with these new variable inputs and produced results showing how evacuation traffic congestion could change if areas of the roadway became flooded.

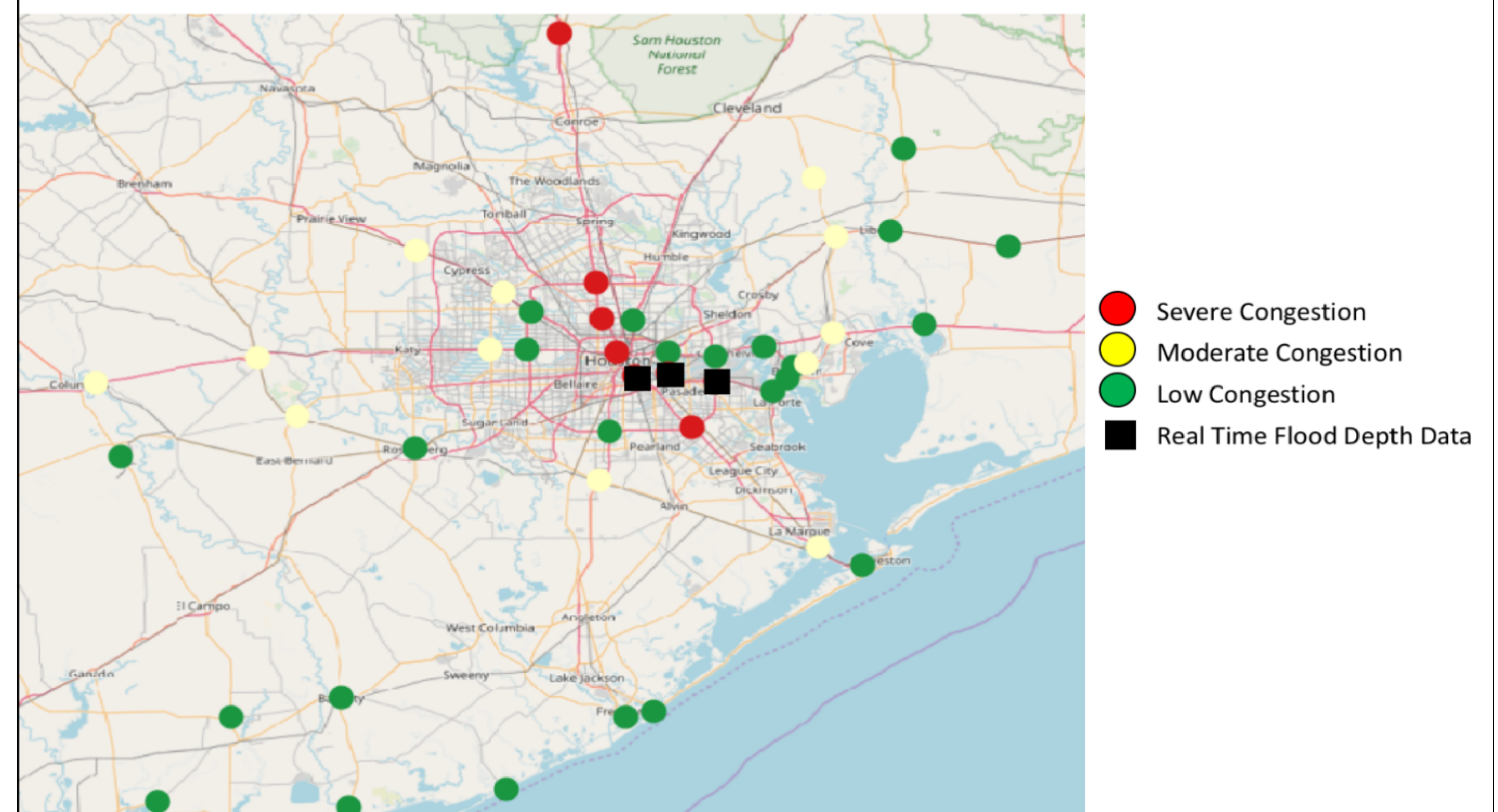## Conclusions & Research Significance

Figure 3: Results of the integrated geo-atom and network science model

- Figure 3 shows areas of traffic congestion forecast by the network science model that utilizes the geo-atom to incorporate real-time flood depth data.
- Emergency managers could use such results to decide how to re-direct vehicles in response to a hazard such as flooding, or to help identify locations for alternative evacuation routes.
- The model results can be disseminated as geo-atom data to enhance systems interoperability and enable visualization on multiple geospatial platforms.

References

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5. Brachman, Micah L., and Suzana Dragicevic. "A Spatially Explicit Network Science Model for Emergency Evacuations in an Urban Context." Computers, Environment and Urban Systems 44 (March 1, 2014): 15–26.