

## Emergency Siren Coverage Area and Optimization Analysis

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#### Siren Planning Resources BRRC dBA BLUE RIDGE CR-F Demo Google Earth AAA File Edit View Tools Add Help V Search 1 🙀 🖉 🎜 🧭 🗉 78 Search ex: Pizza near Clayville, NY Get Directions History V Places My Places Image: My Places Temporary Places Image: State St NIE created using GPS Visualizer ۴ Siren Map 😑 🗹 🚭 Terrain Study NIT Contrain Study - N to S 🕑 👶 Terrain Study - E to W NLE NLF Terrain Study - NW to SE Terrain Study - NE to SW F DAE \* \* 🖬 ▼ Layers Earth Gallery >>> 😑 🔳 🮯 Primary Database 🕀 🔳 🖗 Borders and Labels 45 Places AMERICAN SIGNAL CORPORATION 🛞 🔲 🖩 Photos DCH Roads DDD . Z a SD Buildings 🖲 🚺 💽 Ocean 🖲 🛄 🔆 Weather CCD CDH Gallery Gobal Awareness Gobal Awareness Dobal Awareness OCECE DCG CDG COF DCF ODD THERE WE TOT CON © 2013 Google Data SIO NOAA U S Navy, NGA, GEBCO Image U S Geological Survey Image © 2013 Digital Globe Google earth magery Date: 12/25/2009 lat 8.981842° lon -79.580820° elev 0 ft eye alt 2816 ft 🔿 Tour Guide



#### Eventual implementation in Bahrain



## Problem Statement

- <u>Recommend the best locations</u> to put new sirens
- <u>Siren variables</u>:
  - Siren power (in decibels)
  - Siren height
- Environmental variables:
  - Ambient temperature
  - Ambient humidity
  - Terrain

- Wind direction
- Wind speed

### Solution

#### Input Layers

- Study area polygon
- DEM -
- Buildings with height attributes
- Existing siren points

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### Solution

#### Input Integer Values

- Temperature
- Humidity -
- Wind speed
- Wind direction
- Siren power
- Siren frequency
- Siren height above surface
- Cloud coverage

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### **Overview of Analysis**

Implement a sound propagation engineering model



Implement Rana's coverage optimization analysis

### How to Find Sound Pressure at a Point:



### Sound Propagation Engineering Model

- Wind Farm Noise Propagation Prediction Model by (Bass, Bullmore, and Sloth, 1998)
  - Based on the IEA model (a sub model of the ISO-9613-2 model)

CONCAWE upwind attenuation factor

### Attenuation Factors Considered in This Model



### Sound Propagation Engineering Model Accuracy

• Wind Farm Model Accuracy:

- 2dB(A) of the level not expected to be exceeded for at least 85% of the time
- CONCAWE Model:
  - 95% confidence intervals: 6.9 dB (category 3, lowest accuracy) 4.5 dB (category 6, highest accuracy)

#### Create grid of receiver points that covers the study area



### Add any existing siren points



### Integrate Data

#### • DEM

- Building polygon layer
  - with height attributes
- Integer Data
   Building Height (ft)
   Temperature
   Humiat \$\$^{-25}\_{51}\_{50}\$

  - 25.1 50 • etc.
    - <u>50.1 100</u>





#### Solve the Sound Pressures at Each Receiver Point

 Generate sound pressure level in each receiver point (in dB)

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<b>.</b> 82	<b>.</b> 74	75	86	87	86	<b>.</b> 75	84	83
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•82	•84	•75	•87	•87	•86	•75	•84	82



# Generate sound pressure level in each receiver point

**Receiver Point Sound Pressure** 

30 - 45 dB
45.1 - 60 dB
60.1 - 100 dB



#### Generate coverage area for existing sirens

 Subtract from area of consideration



#### Implement Optimization Analysis

- Apply Sanjay Rana's Stochastical Rank and Overlap Elimination (S-ROPE) method
  - Rank each source in a grid of potential sources
  - Overlap elimination select highest ranked, eliminate overlapping sources
  - Repeat until area is completely covered.
  - Repeat entire process many times using different, random (**stochastic**), first point.

#### Generate grid of potential siren locations

 Find coverage area for each potential siren



#### Find Coverage Area of Each Potential Siren Point



### Choose Highest Ranking Siren



### Output final results

 Output recommended siren locations



 Store sound pressure information in sight line feature layer





### Summary







### Future Work

 Add additional attenuation factors like buildings.

- Use advanced calculation model.
- Create visualization of the results in CityEngine

#### Thank You

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#### References

- Rana, S. (2006). Isovist Analyst An ArcView extension for planning visual surveillance. ESRI International User Conference. San Diego, CA: ESRI. Retrieved February 2014, from <u>http://eprints.ucl.ac.uk/2104/</u>
- Manning, C. J. (1981). The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighboring Communities. CONCAWE.
- Bass, J., Bullmore, A., & Sloth, E. (1998). Development of a Wind Farm Noise Propagation Prediction Model.
- International Standard for Organization. (1996). ISO-9613-2 Attenuation of sound during propagation outdoors Part 2: General method of calculation. International Standard for Organization.
- Economou, P., & Charalampous, P. (2012). A Comparison of ISO-9613-2 and Advanced Calculation Methods Using Olive Tree Lab-Terrain, An Outdoor Sound Propagation Software Application, Predictions Versus Experimetal Results. Proceedings of the Institute of Acoustics, 34. Retrieved from http://www.mediterraneanacoustics.com/portals/0/IOA%20Paper.pdf