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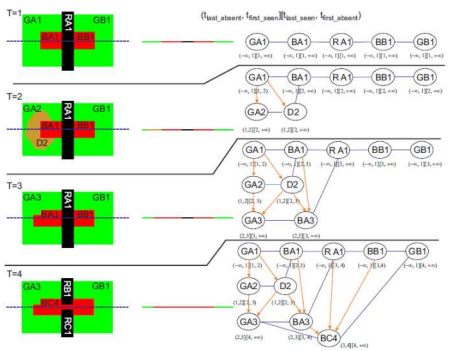

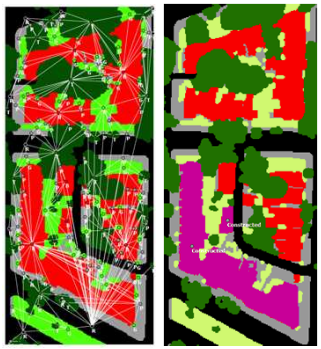

DigitalGlobe

Thoughts on Multi-Modality Data Analysis

FILL-IN CORRECT SAND NUMBER

Randy C. Brost and Diane Woodbridge

March 2, 2015

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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Combining Different Modalities

1. Georegister data to have spatial location as the common semantic space.
2. Take the best information provided by each data source and build semantic hierarchies.

Example Data Sources

RGB+IR Optical Image

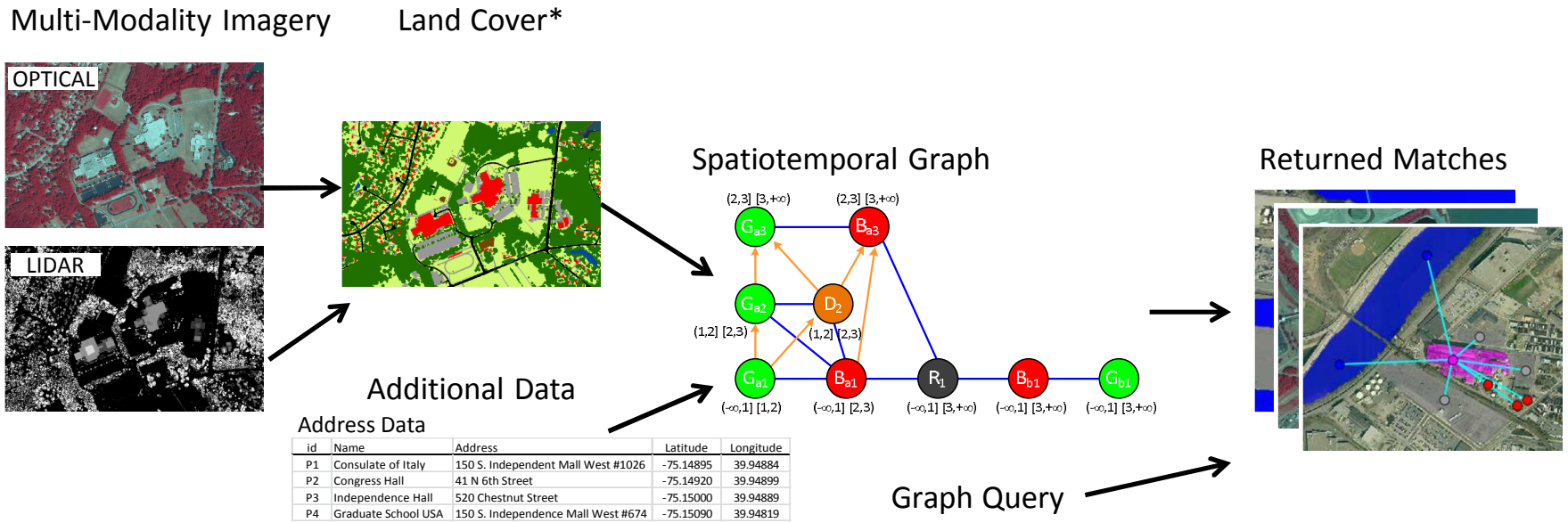
LiDAR Height Map

GIS Road Polygons

Land Cover Map

Location Database

Social Network Data, etc.



id	Name	Address	Latitude	Longitude
P1	Consulate of Italy	150 S. Independent Mall West #1026	-75.14895	39.94884
P2	Congress Hall	41 N 6th Street	-75.14920	39.94899
P3	Independence Hall	520 Chestnut Street	-75.15000	39.94889
P4	Graduate School USA	150 S. Independence Mall West #674	-75.15090	39.94819

* O'Neil-Dunne, et al, An object-based system for LiDAR data fusion and feature extraction, Geocarto (28), pp. 227–242, 2012.

Data Reliability

Example Data Sources

LiDAR Height Map

RGB+IR Optical Image

GIS Road Polygons

Landcover

Location Database

Social Network Data, etc.

Confusion Matrix*

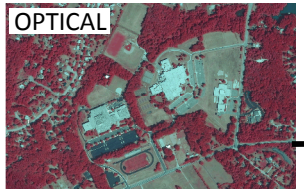
	Reference data							
Classified data	Tree canopy	Grass/ shrub	Bare soil	Water	Buildings	Roads/ railroads	Other Paved	User's
Tree canopy	**647**	7	0	2	5	6	3	97%
Grass/shrub	8	**641**	15	0	2	8	25	92%
Bare soil	0	3	**28**	4	0	1	4	70%
Water	3	1	0	**158**	0	0	0	98%
Buildings	8	5	0	0	**505**	0	9	96%
Roads/railroads	2	3	0	0	0	**289**	4	97%
Other paved	8	21	6	1	12	5	**487**	90%
Producer's	96%	94%	57%	96%	96%	94%	92%	**2755**

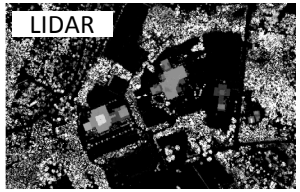
Confidence levels

Propagate uncertainty

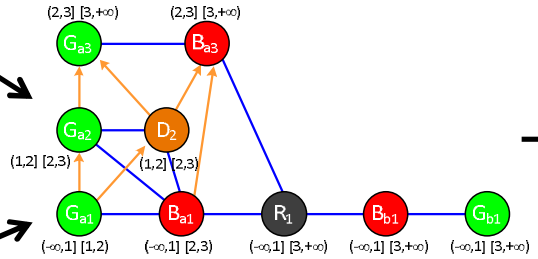
Multi-Modality Imagery

Land Cover*

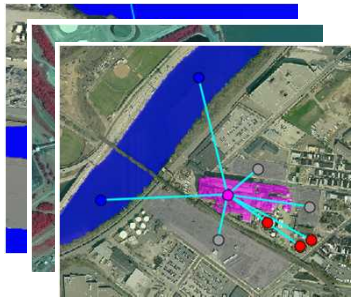




Spatiotemporal Graph



Returned Matches



Additional Data

Address Data

id	Name	Address	Latitude	Longitude
P1	Consulate of Italy	150 S. Independent Mall West #1026	-75.14895	39.94884
P2	Congress Hall	41 N 6th Street	-75.14920	39.94899
P3	Independence Hall	520 Chestnut Street	-75.15000	39.94889
P4	Graduate School USA	150 S. Independence Mall West #674	-75.15090	39.94819

Graph Query

* O'Neil-Dunne, et al, An object-based system for LiDAR data fusion and feature extraction, Geocarto (28), pp. 227–242, 2012.

Expected discrepancies among the sources/ Purposely misleading information/ Changes over time

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Discrepancies due to phenomenology

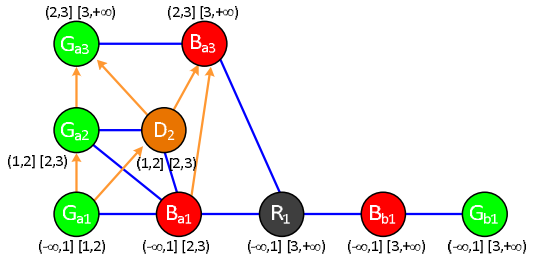
- LiDAR: True position, shadows.
- Optical: Perspective effects, shadows.

Discrepancies due to denial and deception

- Overhead Images: Camouflage, Covering.
- Social Network Data:
  - Geotag at upload position instead of image capture position.
  - Fake profile, comment, location data.

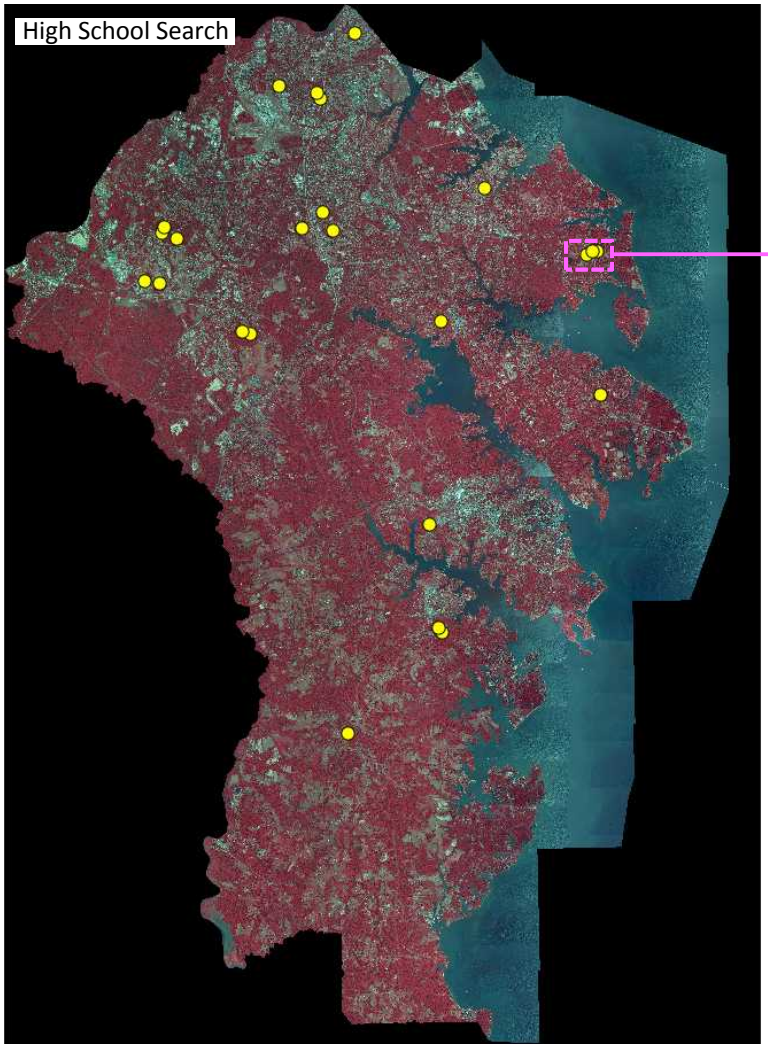
Changes over time

- Explicit representation, assuming durable features seen twice are invariant between observations.

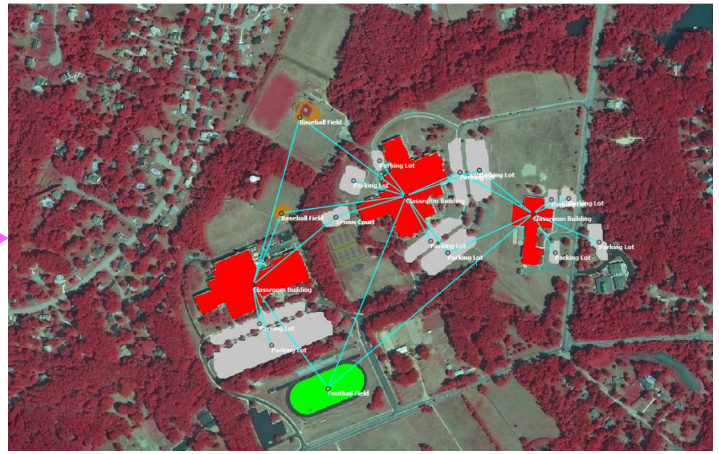


- Changes may be physical (ex. adding a wing to a building), or semantic (ex. a business is sold).

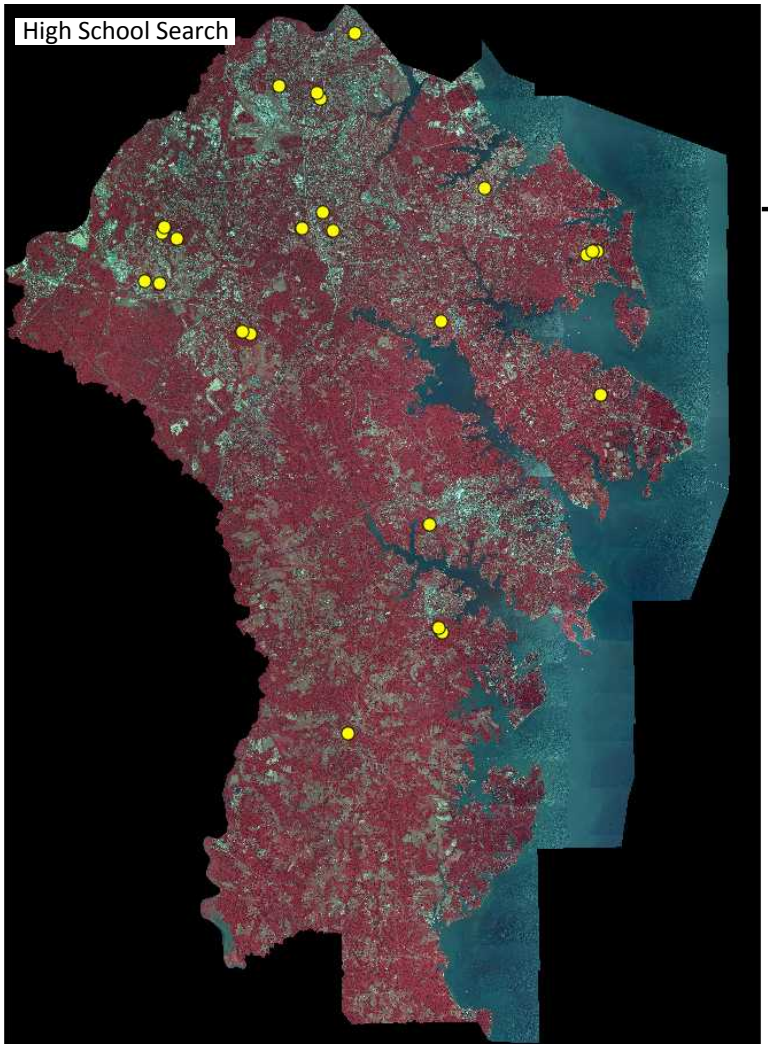
Presenting Results / Computing Uncertainty



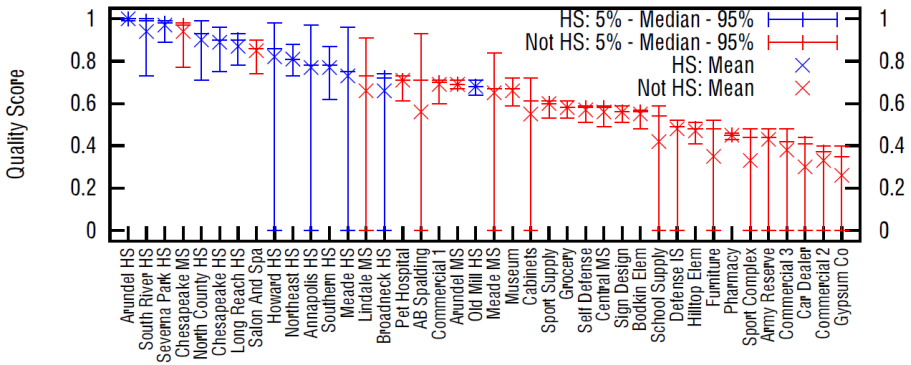
Geospatial results:



Presenting Results / Computing Uncertainty



Uncertainty Calculation
(Ex. Elicitation Model, Bayes, Distance-based Model)



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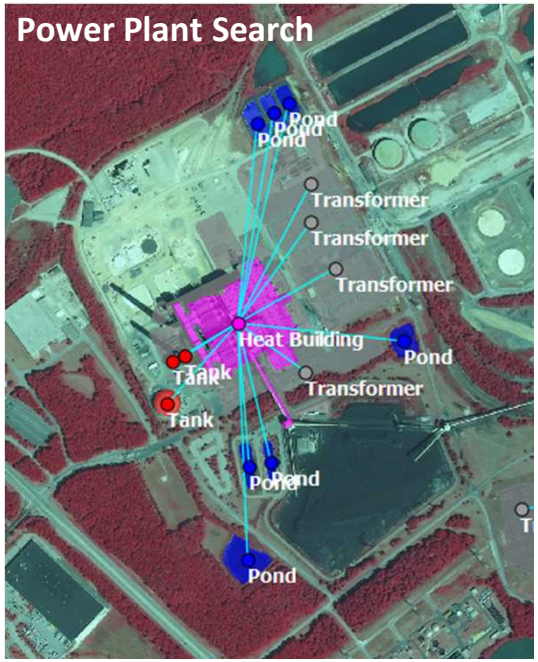
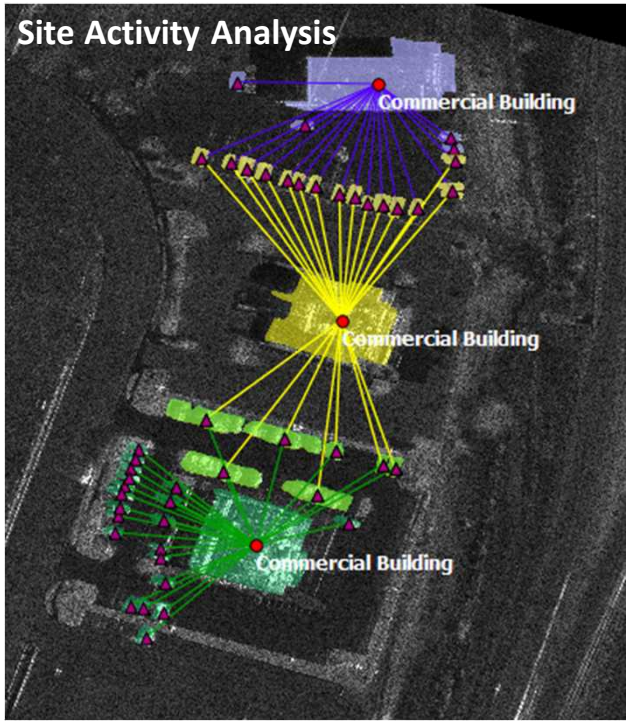
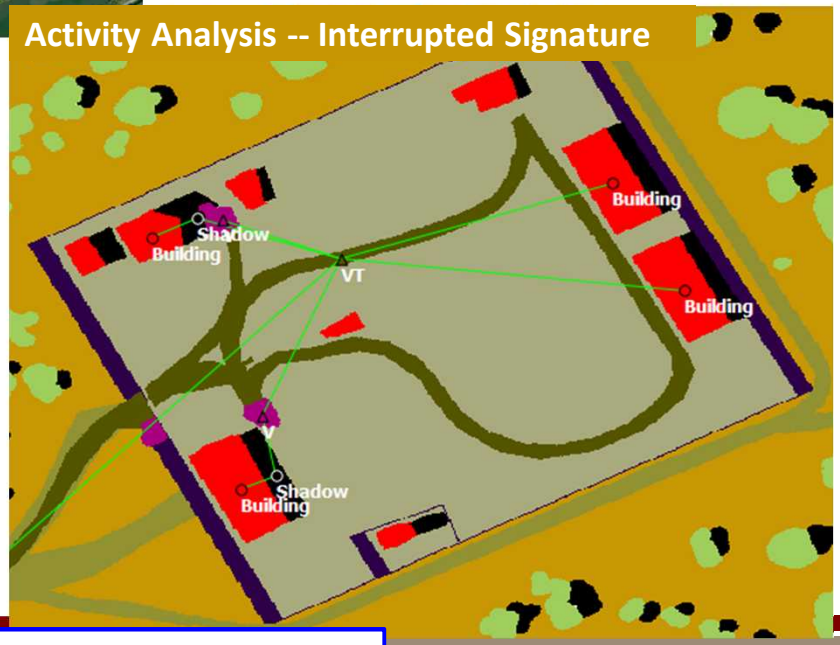
BACKUP SLIDES

Diversity of Problems







All of these were solved by the same code.

Some image data UVM.

Building and Tree Segmentation

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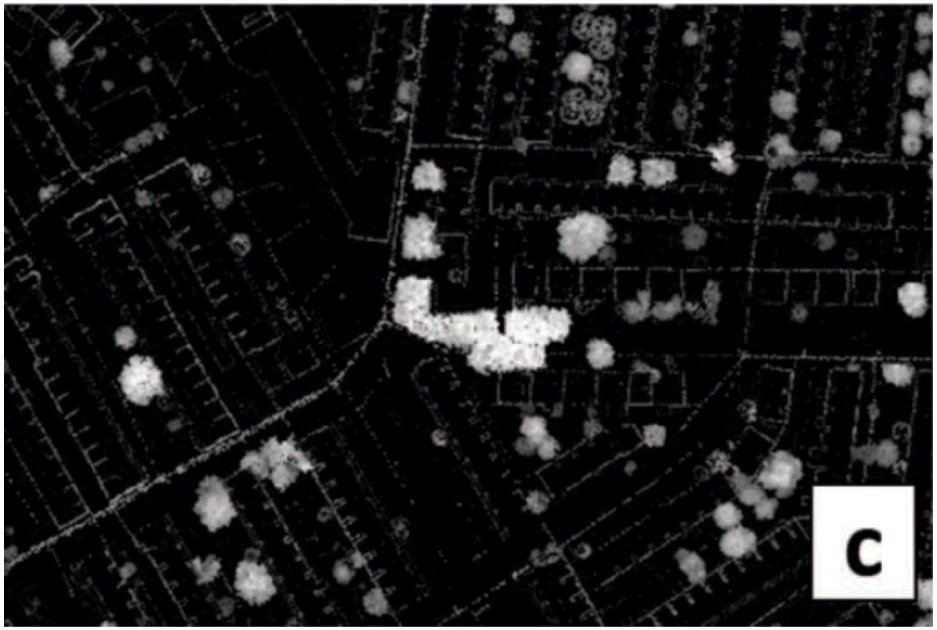
Distinguishing buildings and trees:

Z Height



Z Deviation

From O'Neil-Dunne, et al, “An Object-Based System for LiDAR Data Fusion and Feature Extraction,” Geocarto International, 2012.

Image data provided by UVM.

Power Plant Results: True Positives

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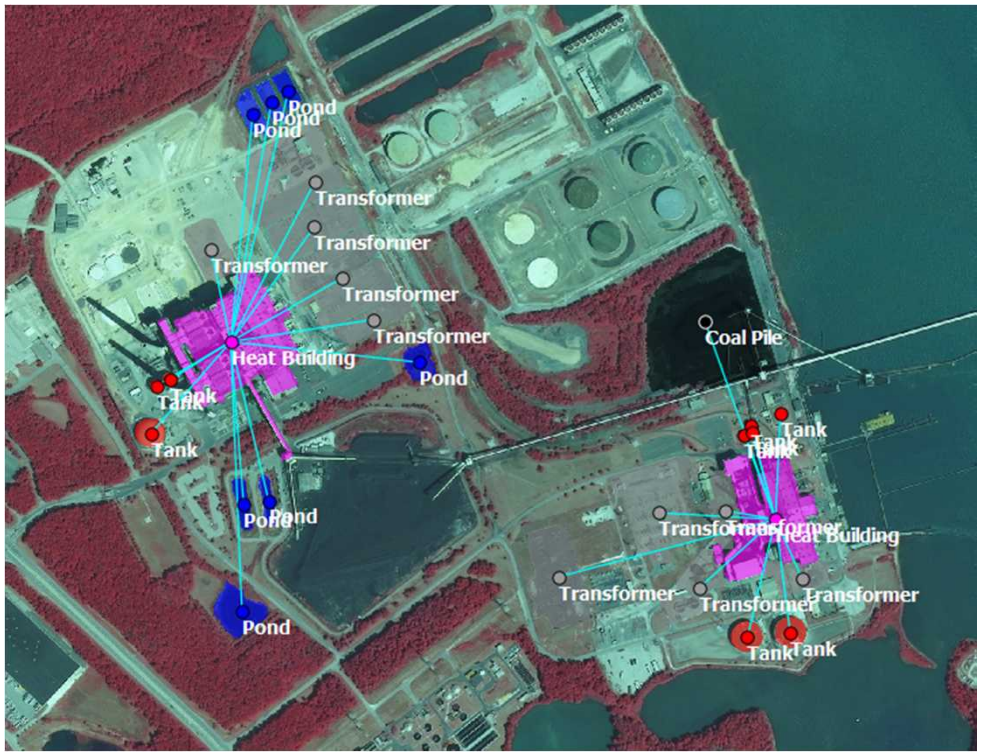

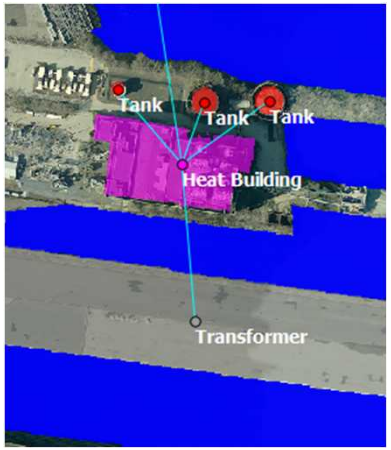

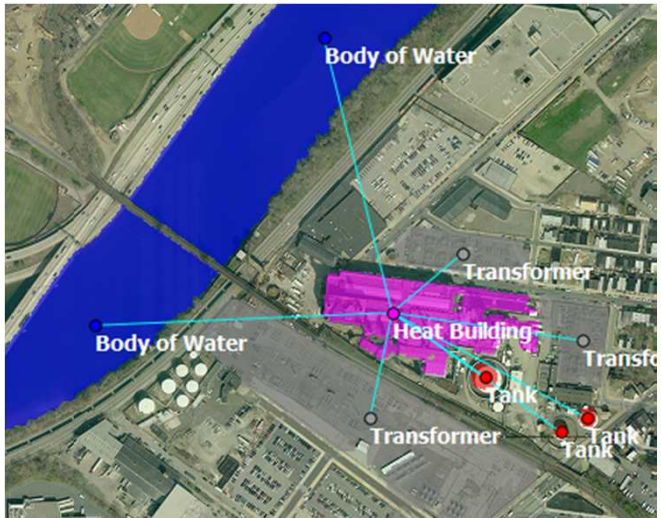

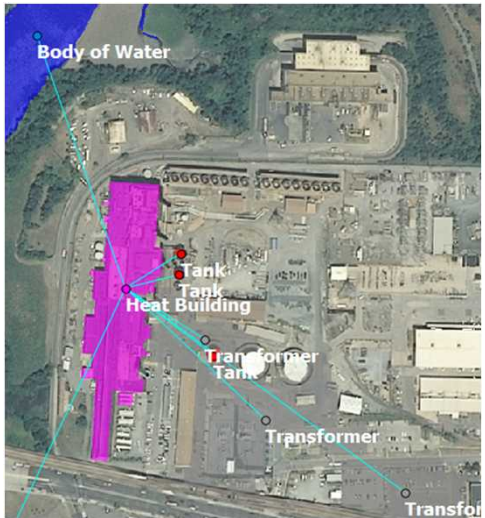

Image data provided by the UVM.

Power Plant Results: False Positives

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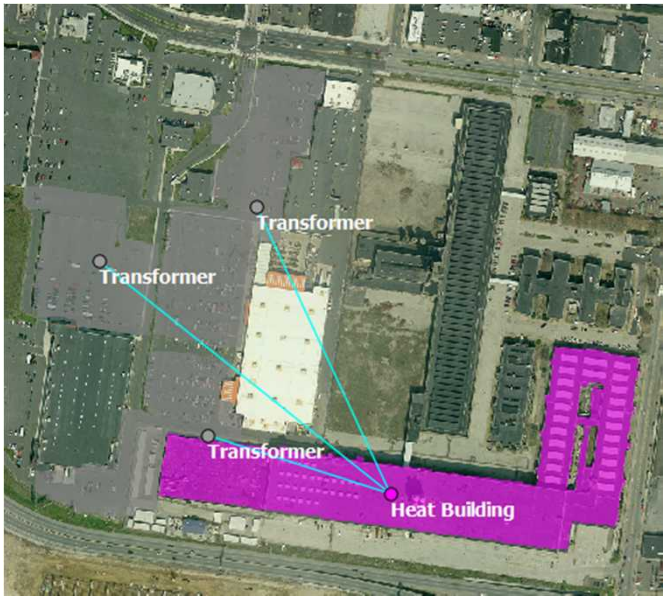
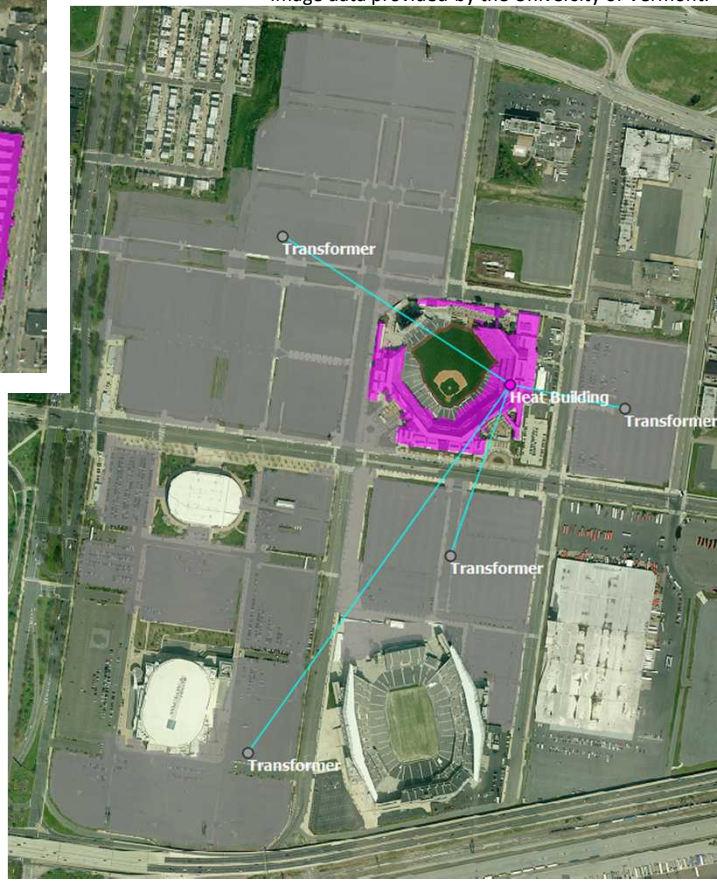
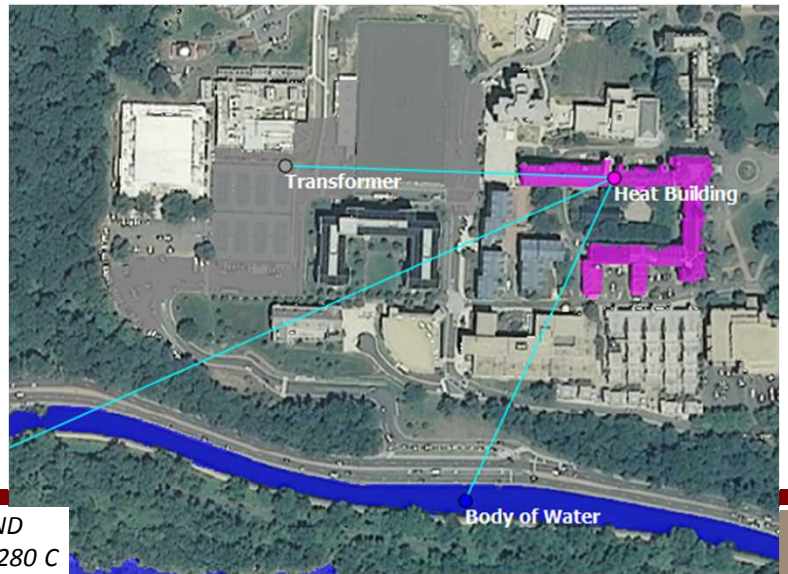


Image data provided by the University of Vermont.





A better transformer filter would eliminate these.