



# Deep Learning APPLICATIONS TO Satellite Imagery



cosmiQ  
works®



# CosmiQ Works Research

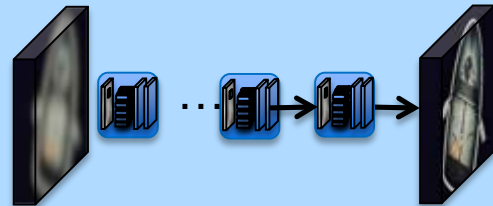
## Machine Learning:

Labeled Data: 

Processing Power:



Algorithms:



Proof-of-concept, **novel** research to demonstrate the art of the possible

## Mission:

- Imagery Analysis at Scale
- Sensor Output Optimization
- Priority Queuing/Prediction
- Multi-INT Analysis
- Frontend Video Processing
- Event Prediction
- Object Detection
- Sensor Requirements

Provide **quantitative** analysis of **strengths**, **weaknesses**, and **gaps** in commercial/open source solutions.

# Intel AI Lab Vision Group

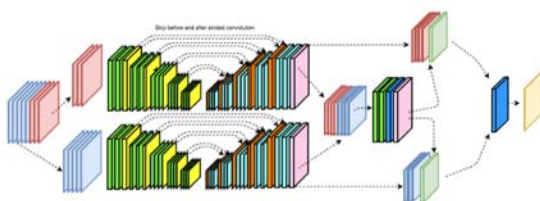
## Applied Research

Novel models for challenging problems in domains such as satellite imagery



## Basic Research

Advancing state-of-the-art in CV.  
Ex: visual attention models,  
video activity recognition



## Novel Datasets

Collecting and contributing novel datasets. Focus on domains blocked by lack of data, challenges in today's algorithms.

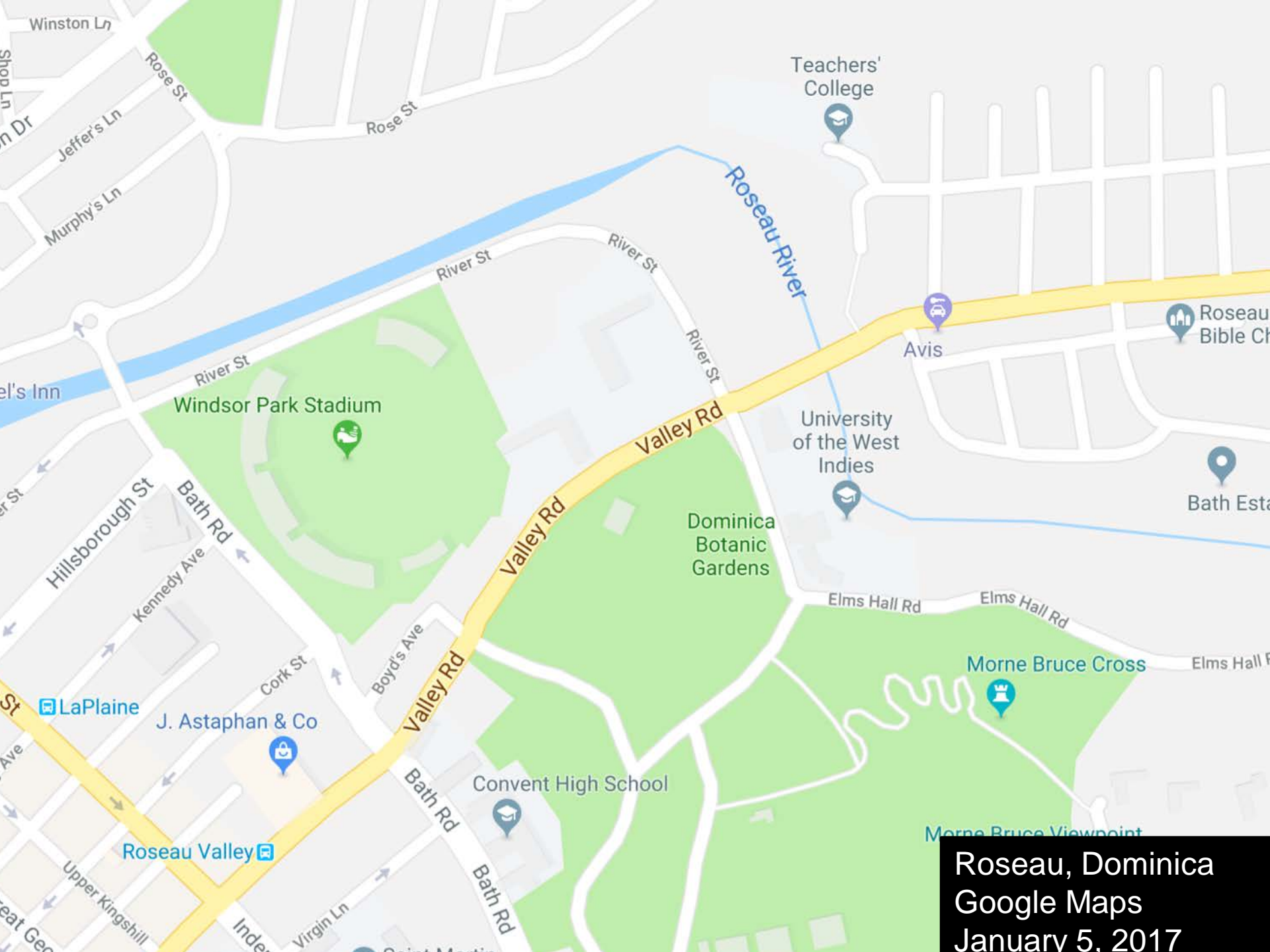
## Hardware

Models designed for the Intel Nervana™ Neural Network Processor  
Algorithms and optimizations to enable Intel architecture

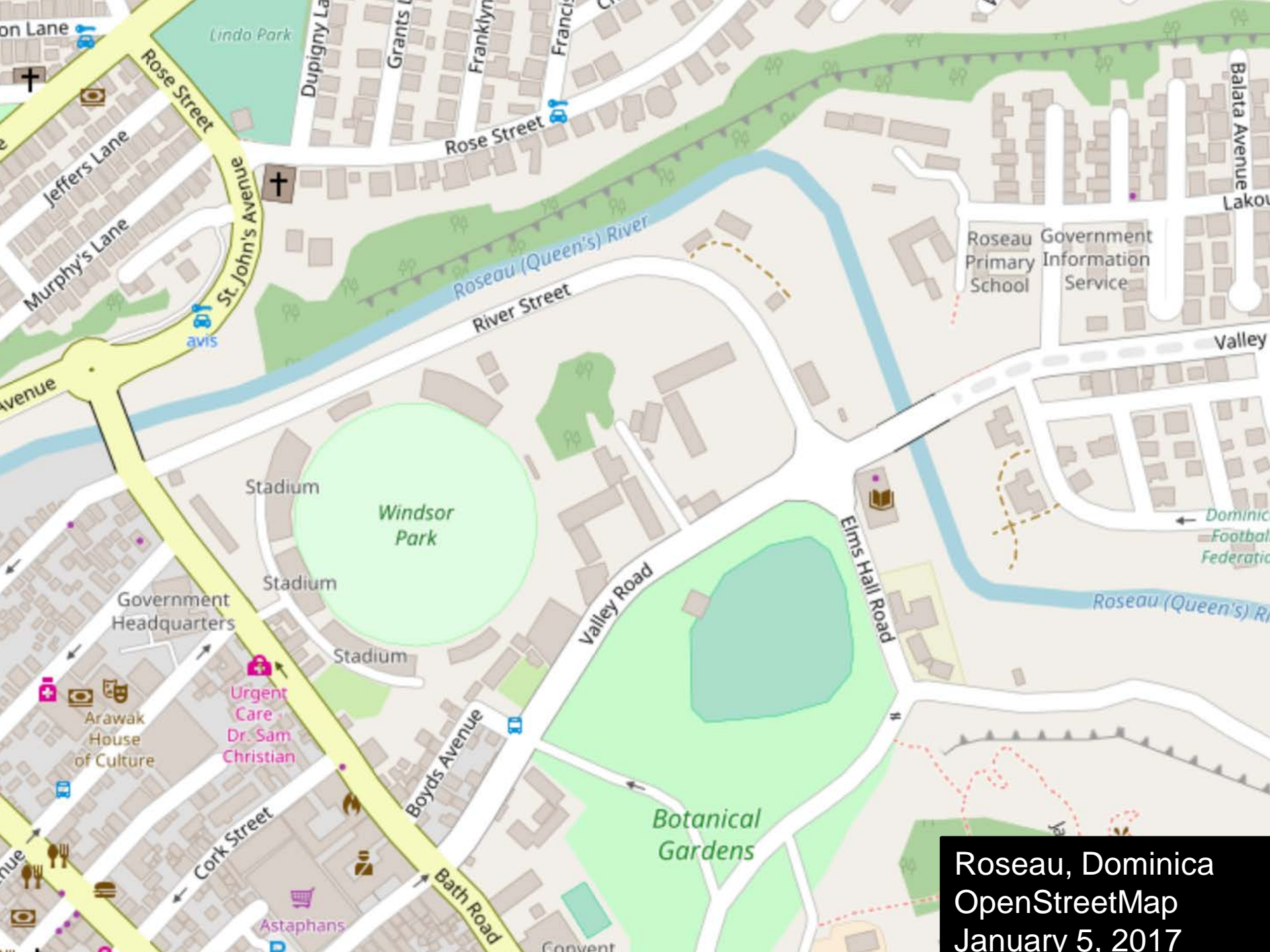


# Why Remote sensing?





Roseau, Dominica  
Google Maps  
January 5, 2017



Roseau, Dominica  
OpenStreetMap  
January 5, 2017





Roseau, Dominica  
Worldview-2 50 cm  
May 1, 2017





DigitalGlobe

Roseau, Dominica  
Worldview-2 50 cm  
September 22, 2017





# #3589 - Hurricane Maria | 2017 - Dominica

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Dominica has been extremely impacted all over the island by Category 5 Hurricane Maria, with winds over 200 km/h (lot of damages including government buildings).

**Only buildings** should be mapped!

Realign roads to avoid crossing buildings.

Note that this follows the former unfinished [Project #1174](#) started in 2015 (now archived) also covering the whole island with similar goals on buildings and minor roads, but that could not be correctly validated at that time due to imagery issues (only a thin coastal band could be validated, minor roads could not be traced at all). With the new project in 2017 after more massive damages than in 2015, most buildings could be traced and validated and most missing roads were added.

Status:	ARCHIVED	Created by:	Verdy_p
Last updated:	a month ago	Difficulty:	BEGINNER
Priority:	LOW	Type(s) of mapping:	BUILDINGS
Organisation:	HOT	Campaign:	Disaster Response
Mapper level required:	No	Validator role required:	No

[Instructions](#)[Map](#)[Validate](#)[Questions and Comments](#)

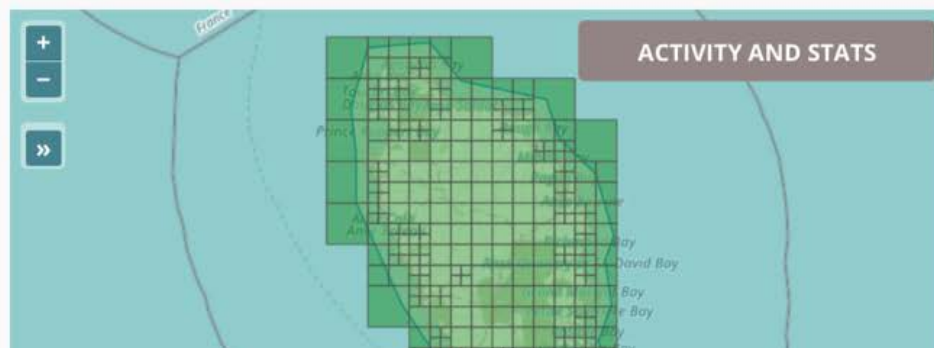
## Instructions

### Entities to map

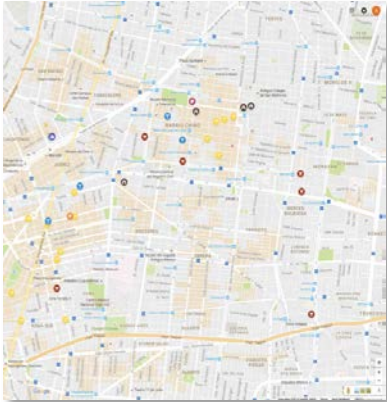
Buildings only (for now)

### Changeset Comment

#hotosm-project-3589 #HurricaneMaria #Dominica



# Remote Sensing Applications Matter



Foundational Mapping



Autonomous Navigation

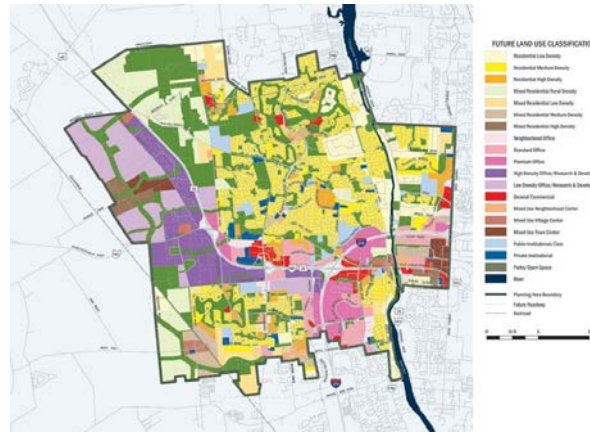


Composite (before)  
Anomaly (after)

Anomaly Detection



Response Scenarios



Land Use Classification

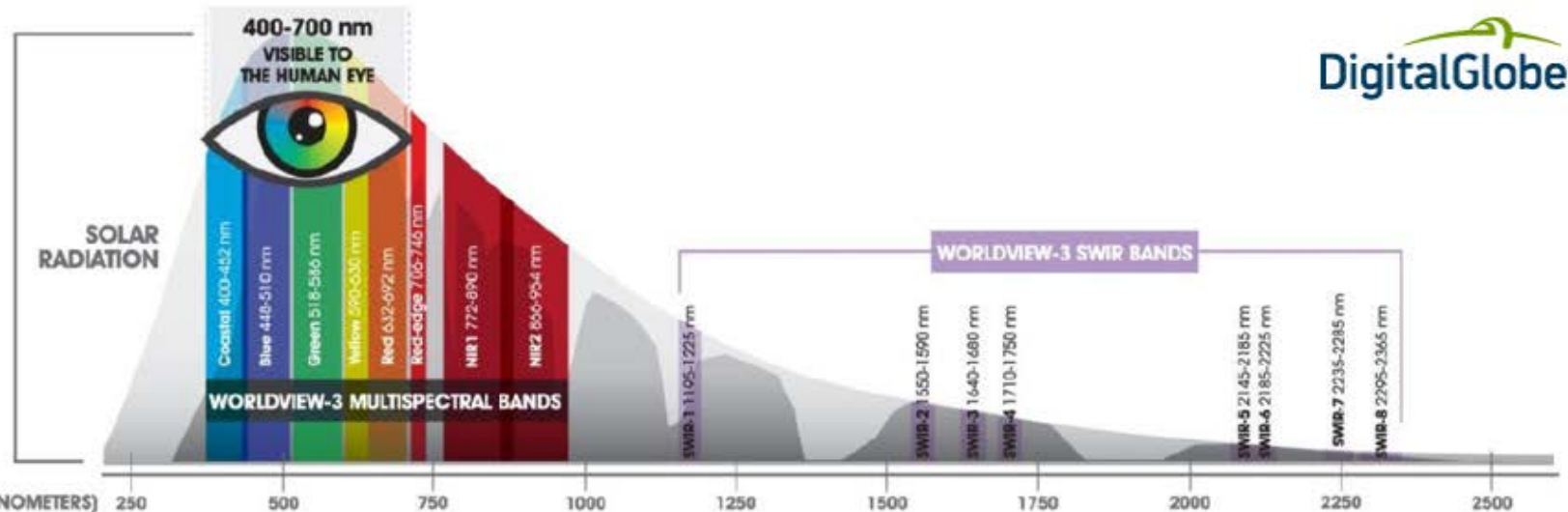


Object Localization



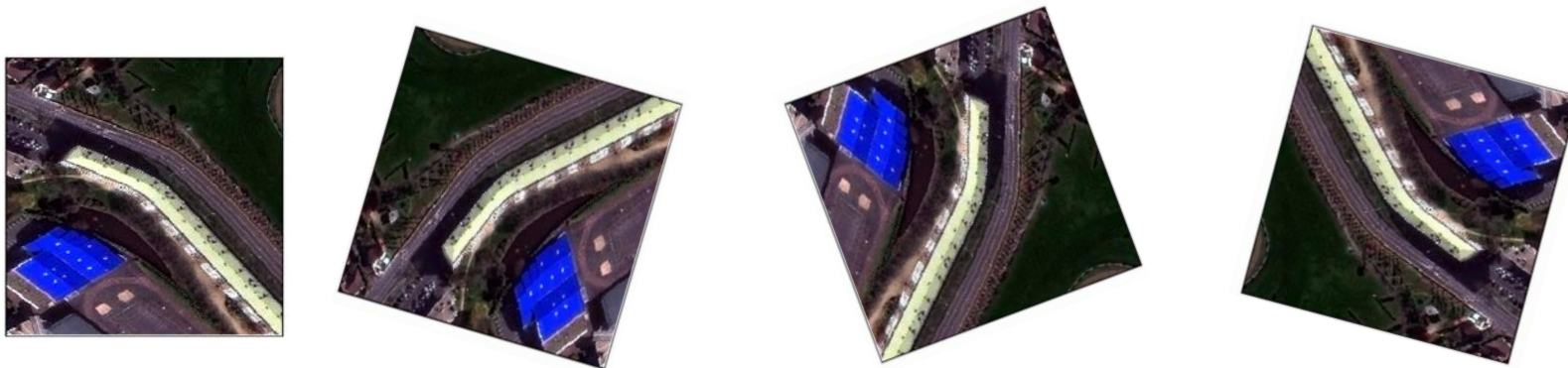
# Remote Sensing Data Exposes Unique Algorithmic Challenges

Multiple sensor and spectral inputs



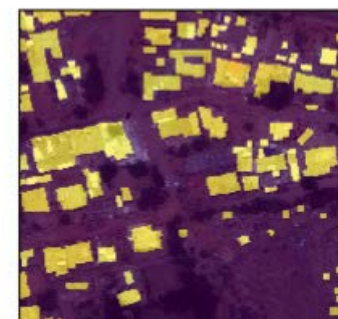
# Remote Sensing Data Exposes Unique Algorithmic Challenges

Require rotational invariance – No gravity to frame objects



Require scale invariance and efficient localization – targets drawn from the same class might range greatly in size

High resolution imagery poses hardware constraints – memory limitations





# Labeled Remote Sensing Data is Becoming Readily Accessible



**Draper Satellite Image Chronology**

competition - Can you put order to space and time?



**Dstl Satellite Imagery Feature Detection**

competition - Can you train an eye in the sky?



**ADCG SS14 Challenge 03 - Satellite Image Land Pa...**

competition - A multi-class classification problem to detect v...



**EPFL ML Road Segmentation**

competition - Road extraction from satellite images



**Anomaly Detection Challenges 2015 - Challenge 2**

competition - Solve the problem of classification using satellit...



**Here Comes the Sun**

competition - Find Solar Panels in Satellite Imagery



**How's the weather?**

competition - Predict the amount of rainfall at a location from ...



**EPFL ML Road Segmentation**

competition - Project 2: Road extraction from satellite images



**Planet: Understanding the Amazon from Space**

competition - Use satellite data to track the human footprint i...



SpaceNet is a partnership initiative that fosters research and innovation in the development of machine learning algorithms to automatically extract information from remote sensing data.



Released Data Sets



Open Sourced Algorithms



Public Competitions



Open Sourced Tools

<https://spacenetchallenge.github.io/>



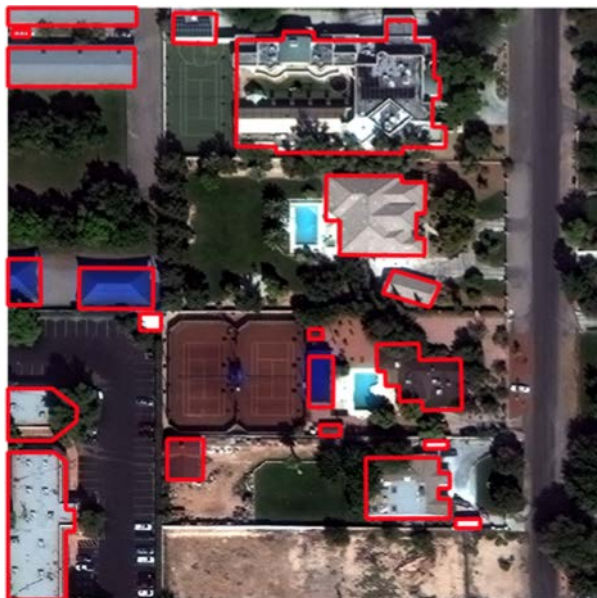
## Source Data – 16-bit GeoTIFF

- 0.30 m Panchromatic band GeoTiff
- 1.2 m 8-Band multi-spectral GeoTiff
- 0.3m Pan sharpened RGB GeoTiff
- 0.3m Pan sharpened 8-band multi-spectral GeoTiff

### Building Footprint Competition Data:

200m x 200m GeoTiff Chips of all source data

Associated GeoJSON with polygon geometries for all building foot prints



### Road Centerline Competition Data:

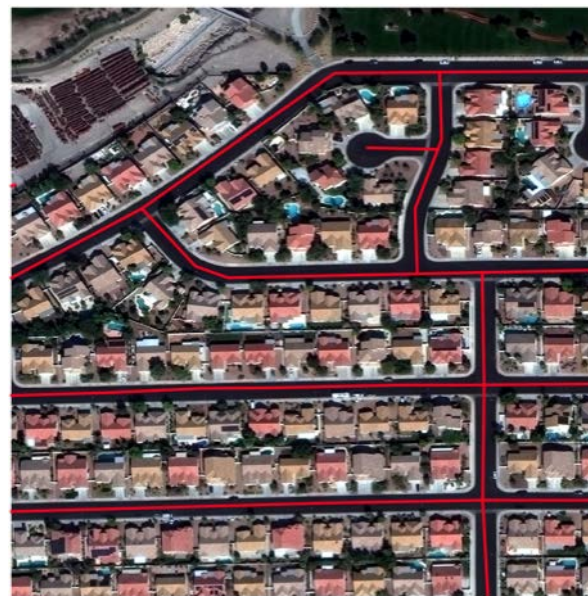
400m x 400m GeoTiff Chips of all source data

Associated GeoJSON with line string geometries for all roads as well as associated metadata:

Road Type

Road Surface Type

Number of Lanes



# Comparison of SpaceNet to OpenStreetMap

- Use OSM road labels to render training masks
- Train segmentation model with these masks
- Apply identical post-processing

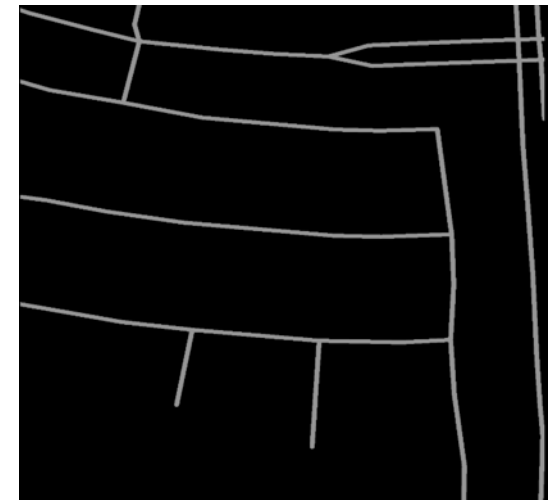
	APLS - Vegas
SpaceNet Labels	0.71
OSM Labels	0.59



OSM Prediction



SpaceNet Prediction



OSM Training Mask



# Working with the Data

Reading GeoTIFFs not as easy as PNGs/JPEGs

- OpenCV **imread** segfaults
- PIL doesn't support inputs > RGB-A

Require special geospatial data library – GDAL

- Documentation for Python GDAL bindings not well maintained
- We recommend RasterIO - <https://rasterio.readthedocs.io/en/latest/>



**with xeon platinum  
processors and intel  
optimized tensorflow**

**Log in to IP on  
Laptop w/  
PASSWORD: intel**



# Upcoming Competitions

SpaceNet is tentatively planning on launching two new competitions in 2018

- SpaceNet 4, Off Nadir Analysis: Summer 2018
- SpaceNet 5, Roads Part 2: Winter 2018



## Off Nadir Imagery Analysis

A foundational step to analyzing higher temporal data sets



## Roads Part 2

Incorporation new data to increase potential utility

# Open PROBLEMS

- How to best fuse multispectral inputs?
- How to tackle small object localization?
- Best way to handle rotational invariance ?
- Temporal analysis ?
- Can we extract road-networks directly?
- Interpretable land-use classification?
- Image scaling – how do we process full resolution images?
- Is re-chipping, sliding window, or downsampling necessary?



# Additional Datasets

- SpaceNet Dataset <https://registry.opendata.aws/spacenet/>
- Functional Map of the World <https://www.iarpa.gov/challenges/fmow.html>
- xView Detection Dataset <http://xviewdataset.org/#dataset>
- Kaggle Amazon Rainforest Challenge <https://www.kaggle.com/c/planet-understanding-the-amazon-from-space>
- Kaggle Satellite Imagery Feature Detection <https://www.kaggle.com/c/dstl-satellite-imagery-feature-detection>
- Kaggle Image chronology <https://www.kaggle.com/c/draper-satellite-image-chronology>
- UC Merced Land Use Classification <http://weegee.vision.ucmerced.edu/datasets/landuse.html>