HARRIS GEOSPATIAL SOLUTIONS

CONNOR MCKISSICK

Solutions Engineer

HARRIS® TECHNOLOGY TO CONNECT, INFORM AND PROTECT™

Contact Information

Connor McKissick

Solutions Engineer

jmckissi@harris.com

Harris Corporation

www.harrisgeospatial.com

geospatialinfo@harris.com

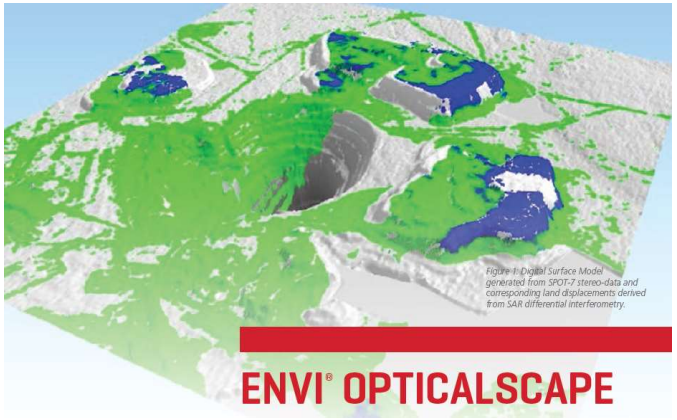
303-786-9900

Today's Agenda

- Overview of Products
- OpticalScape Overview/Demo
- GSF Overview/Demo
- MEGA Overview/Demo

Overview of today's Products

OpticalScape



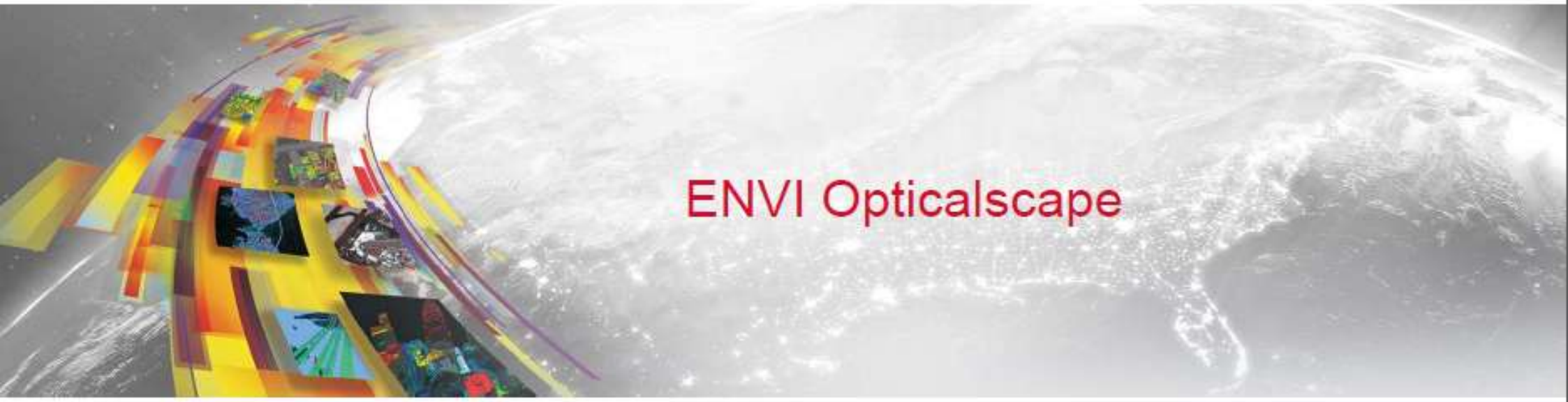
ENVI Opticalscape generates Digital Surface Models (DSMs) and orthorectified images from spaceborne and UAV data while giving users the industry leading tools for imagery exploitation and data fusion.

Machine Learning

Harris Geospatial has developed a suite of deep learning-based tools called MEGA™ that are designed specifically to work with imagery to solve geospatial problems. MEGA excels at automated target detection, land cover classification mapping, and change detection.

GSF

Harris Geospatial Solutions has a legacy of expertise in advanced raster analytics. GSF enables dynamic clustering of these advanced analytical capabilities which means it's easy to for a GEOINT application to scale up or down to meet the demands of an organization.



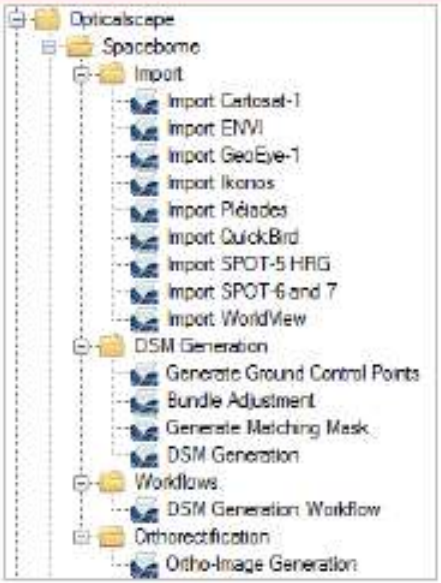
ENVI Opticalscape

ENVI Opticalscape is a new set of ENVI modules that generate Digital Surface Models (DSMs) and orthorectified images from spaceborne and UAV data. These new modules give our users the industry leading tools for imagery preparation and data fusion.

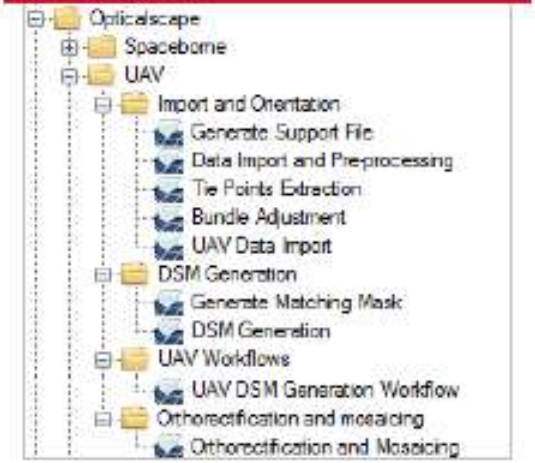
ENVI Opticalscape Modules Overview

ENVI Opticalscape generates DSMs and orthorectified imagery from spaceborne optical stereo and tri-stereo images, and from UAV optical multiple stereo images.

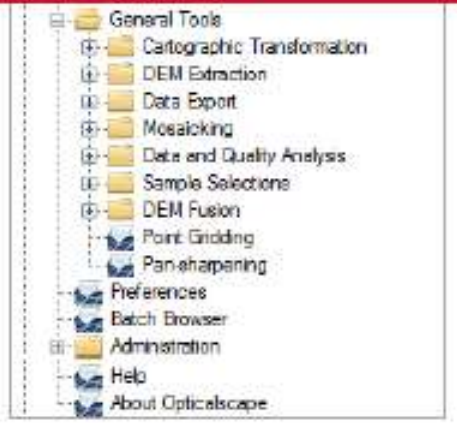
ENVI Opticalscape *Spaceborne Module*



ENVI Opticalscape *UAV Module*



ENVI Opticalscape *General Purpose Tools*



ENVI toolbox integration and ENVITasks enables UAV geoprocessing on both desktop and enterprise platforms.

Opticalscape UAV Module

Capabilities

- Orientation of multiple stereo pair
- Ground Control Point and Tie Point measurement
- Derivation of quasi-epipolar images
- Automated DSM generation and mosaicking
- Generation of orthorectified mosaic

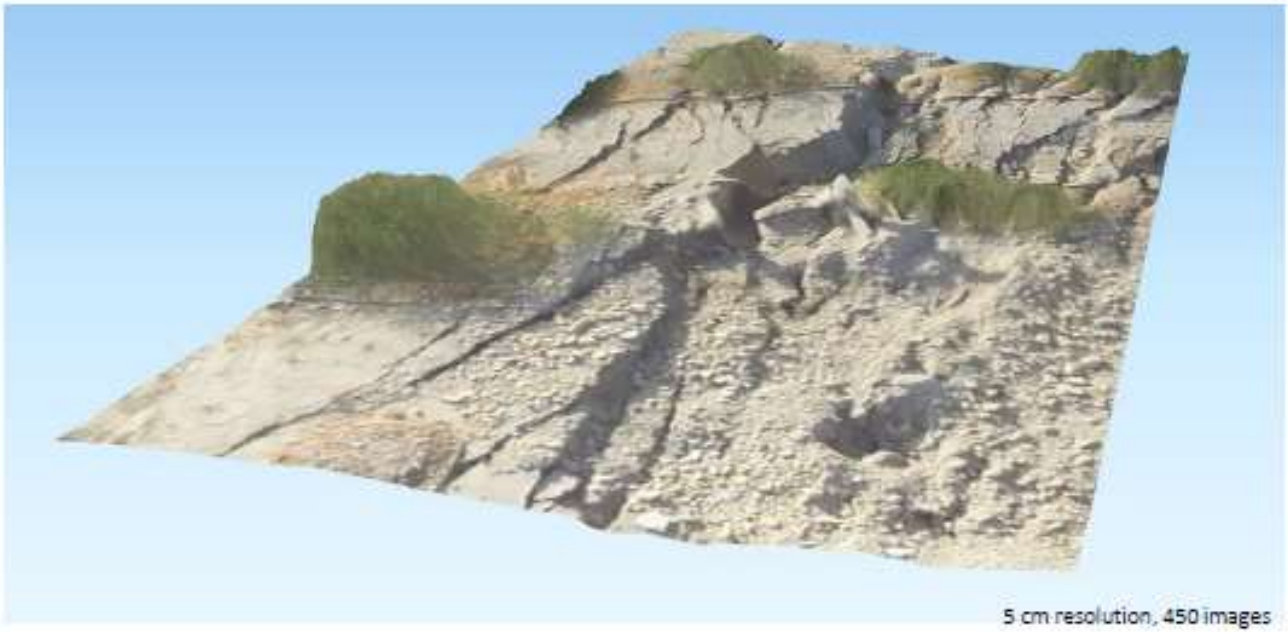
Output options

- Digital Surface Model in point cloud (.las) and raster format
- Orthorectified image mosaic

Global solution of the bundle adjustment reduces camera positioning propagation errors

Hybrid matching solution optimizes the surface reconstruction

- Multi-primitive and Semi-Global Matching (SGM)



5 cm resolution, 450 images

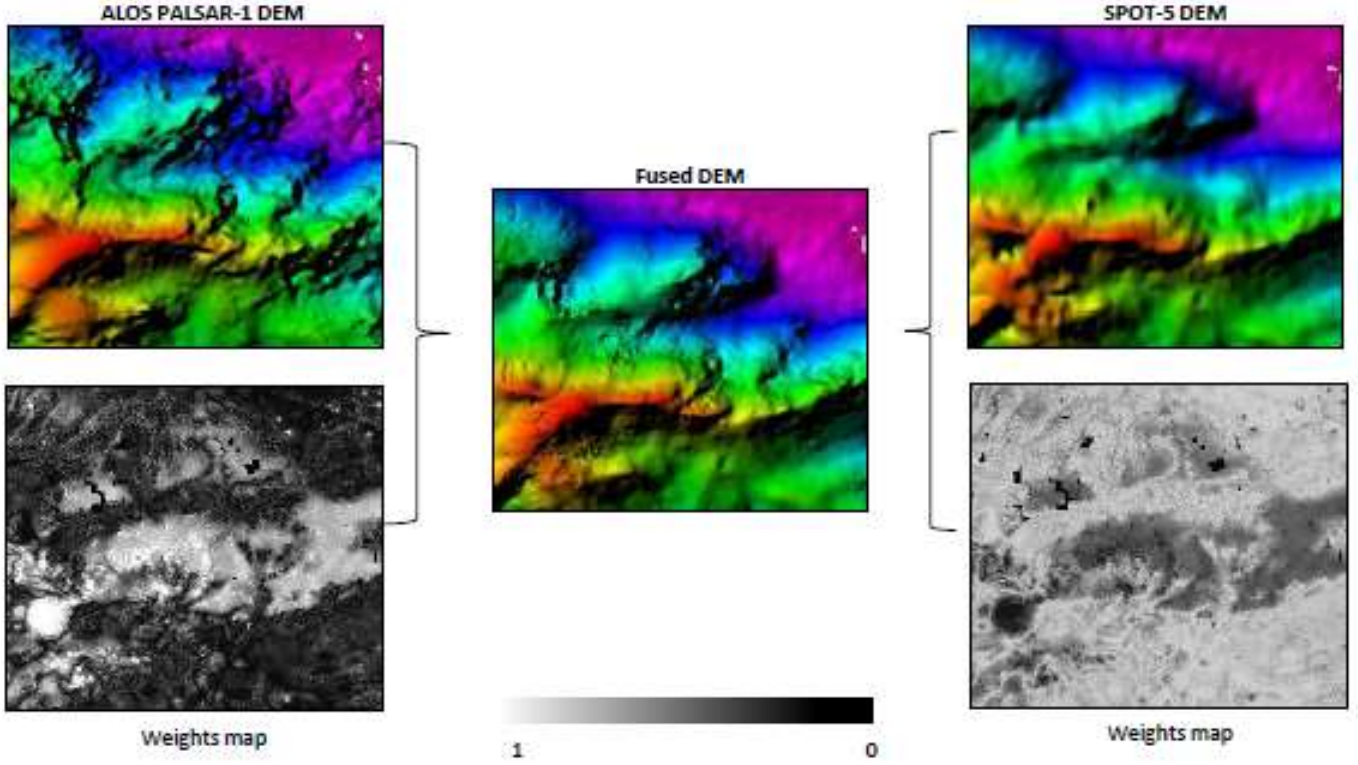
Fusion of Opticalscape and SARscape Products

Harris Geospatial Solutions and sarmap bring you industry leading data fusion capabilities.

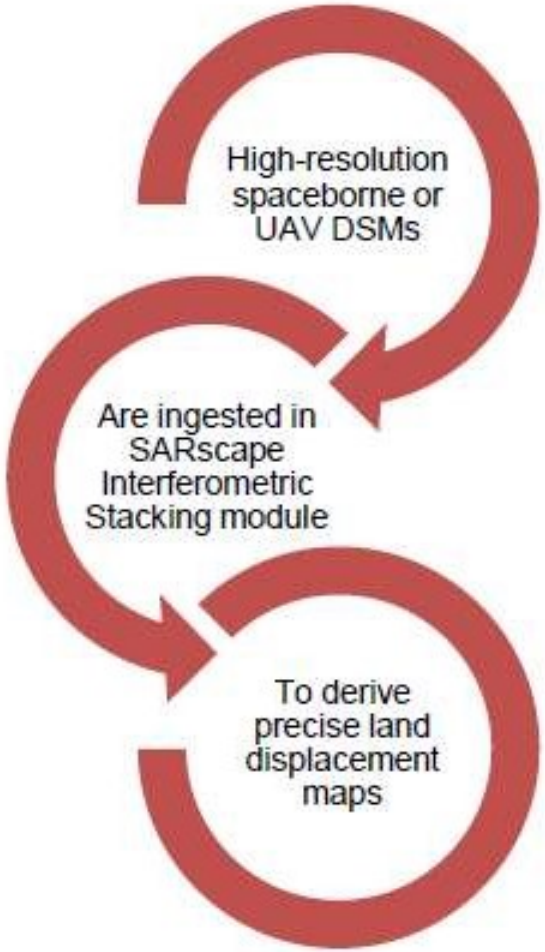
Fuse DEM data generated from other sensors and techniques

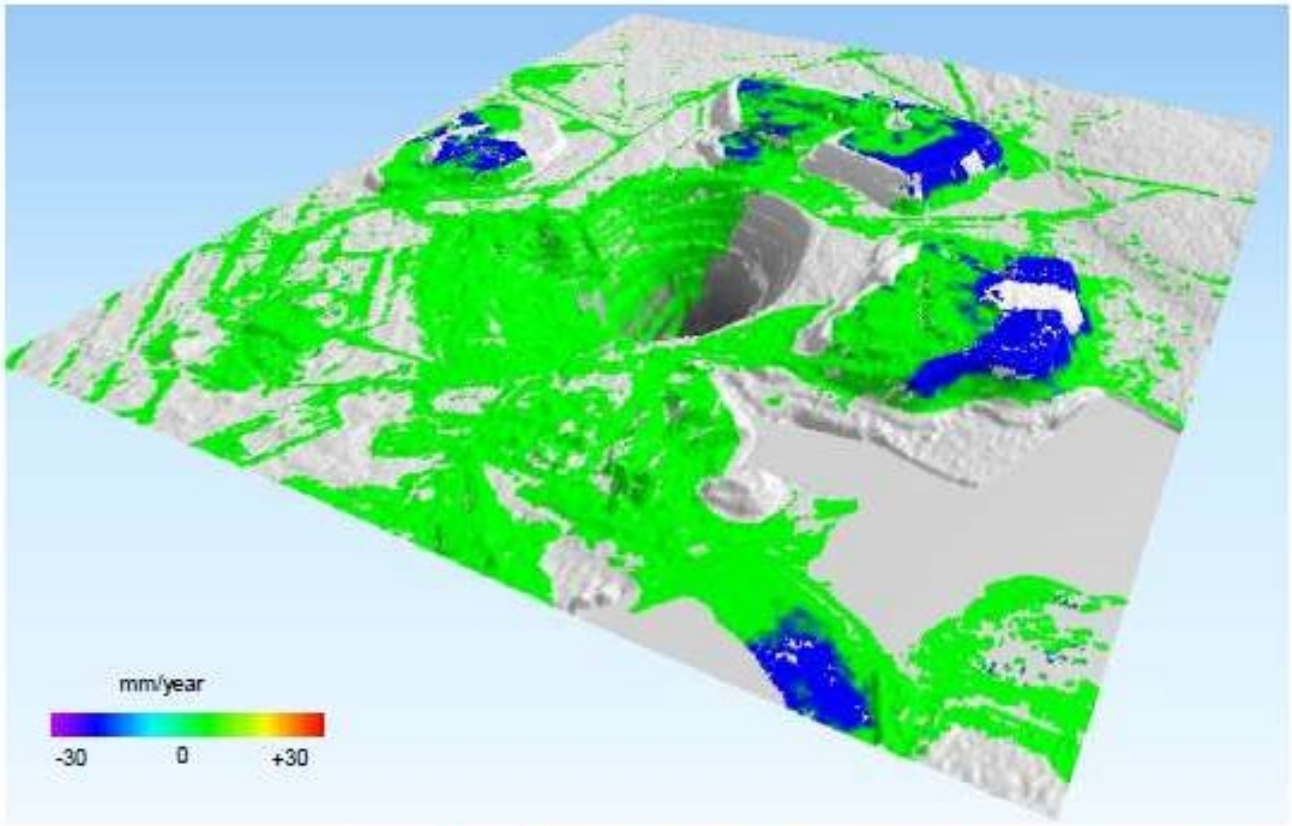
- *SAR and optical sensors*
- *SAR interferometry and SAR stereo techniques*

Improves the accuracy of the final DEM, since the fusion considers the sensor characteristics rather than simply averaging the different heights



Integration of Opticalscape and SARscape products



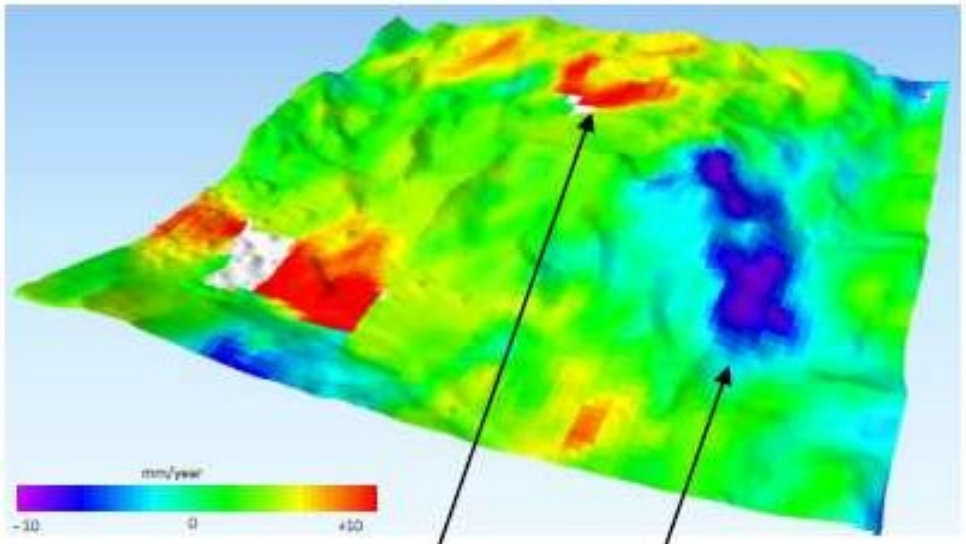


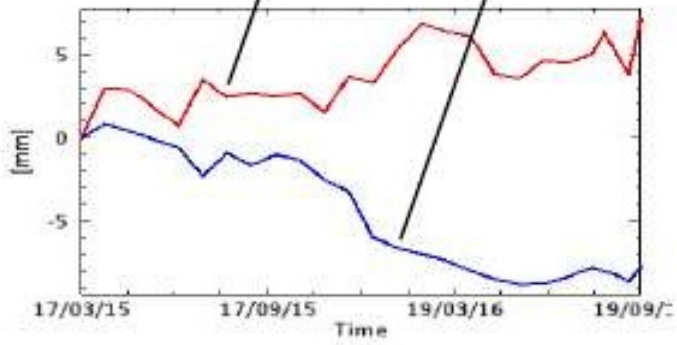
Digital Surface Model generated from SPOT-7 stereo data and corresponding land displacements derived from SAR differential interferometry

Integration of Opticalscape and SARscape products

Drone (UAV)

Satellite (spaceborne)





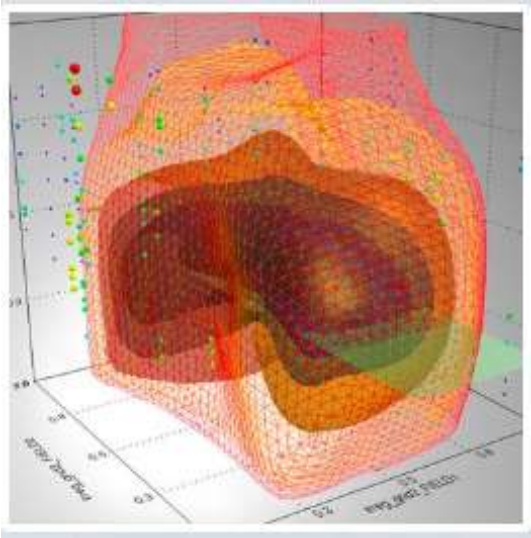
Land displacement map (top right) and corresponding temporal profile (bottom right) from March 2015 to September 2016 has been derived from Sentinel-1, 24 days interferometric acquisitions using SARscape.

Note that for the generation of accurate displacement maps the availability of detailed Digital Surface Models – in this case drone-based DSM has been used (top left) – is essential.

OpticalScape Demo

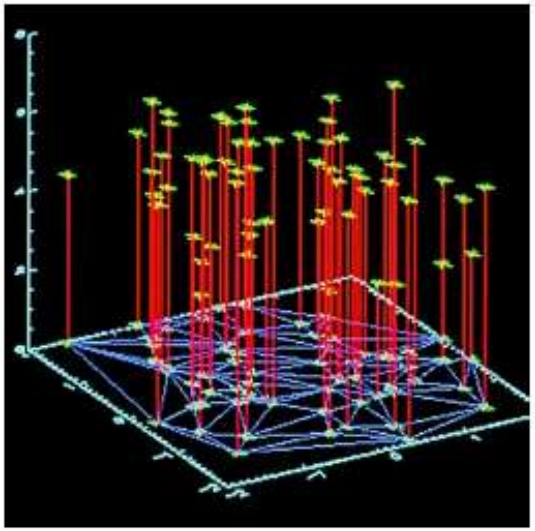
Geospatial Services Framework (GSF)

Data Support



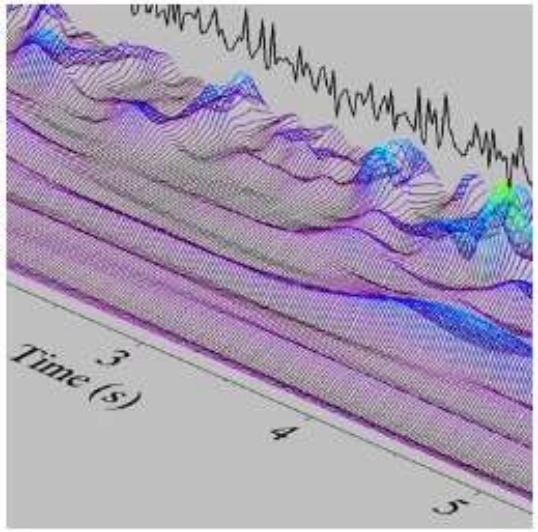
GSF is a flexible framework that can input and analyze virtually any remotely sensed data. Organizations that have already made investments in commercially available data from Harris, DigitalGlobe, Airbus, etc. including LiDAR, multispectral/hyperspectral imagery, or SAR can easily use those existing data within GSF. Additionally, organizations can upload their own data gathered from other sources such as drones or UAV.

Analytics at Scale



GSF uses the full power of cloud and enterprise architecture and can quickly run automated analytics on existing data stores or new and incoming data. Available analytics include Harris' advanced machine learning capabilities, algorithms an organization is already using, and any of the powerful analytics available within ENVI software such as feature extraction, classification, object identification, and more.

Access to Results



Results from analytical routines performed within GSF are easily pushed to web clients. Web clients can be tailored according to organizational need and can provide as much, or as little, detail that is needed by end users.

Geospatial Services Framework (GSF)

Geospatial Services Framework Overview

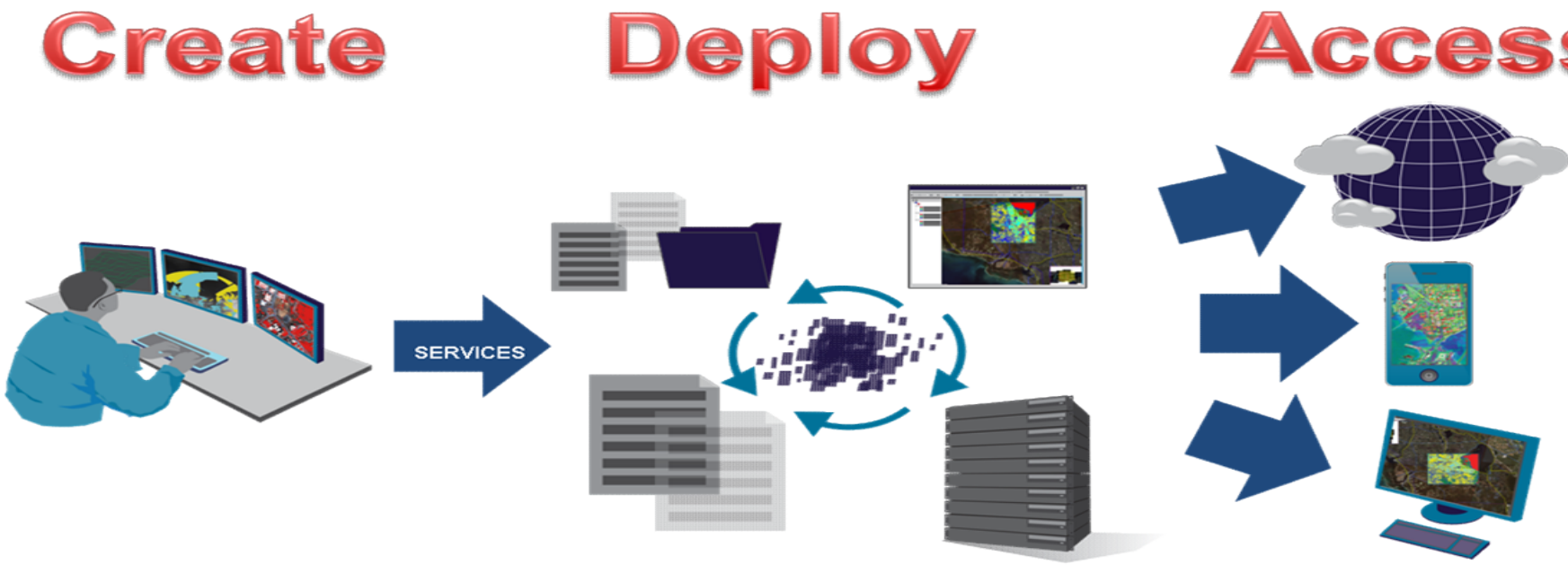
- REST-based API built on node.js
- Dockerized
- Works with NGA Scale
- Operates on the concept of processing “engines”
  - ENVI Engine
  - IDL Engine
  - Python Engine

Highlights

- Modular and highly configurable via JSON
- Flexible Configuration Support – Distributed | Shared | Cloud
- Dynamic Clustering for Scalability
- Event-based Architecture

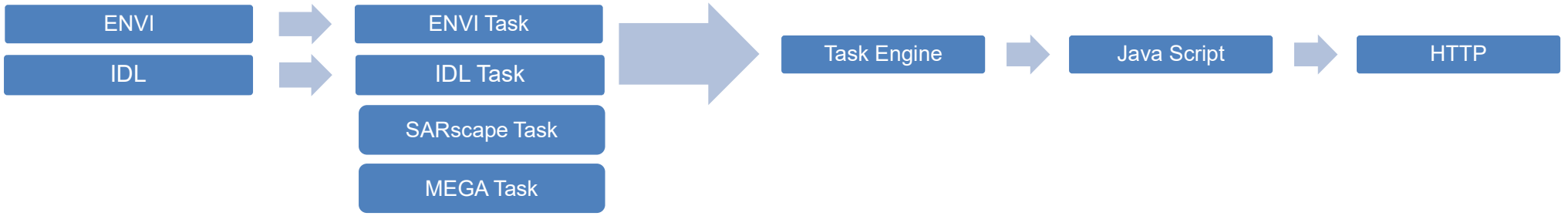
Geospatial Services Framework (GSF)

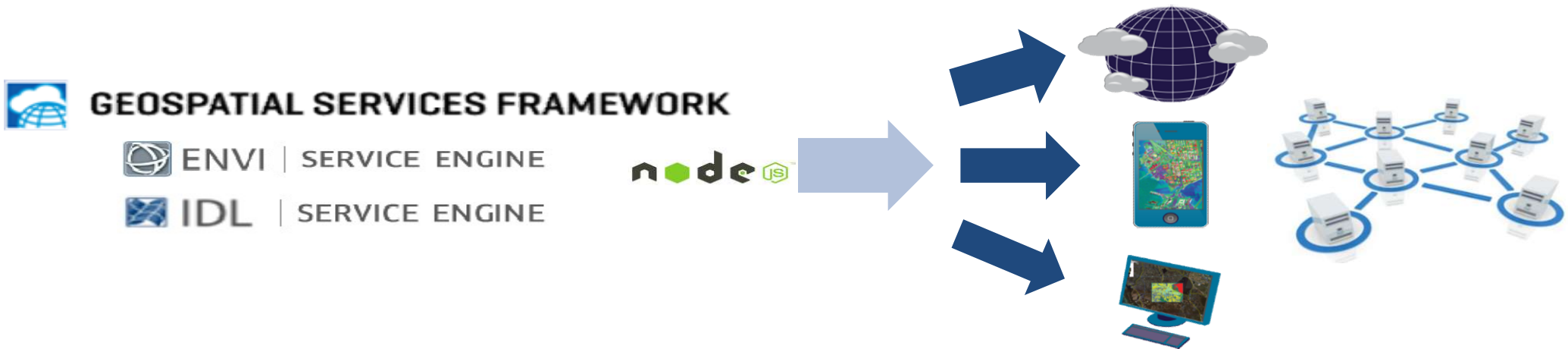
Enterprise Deployment Option of ENVI Tasks



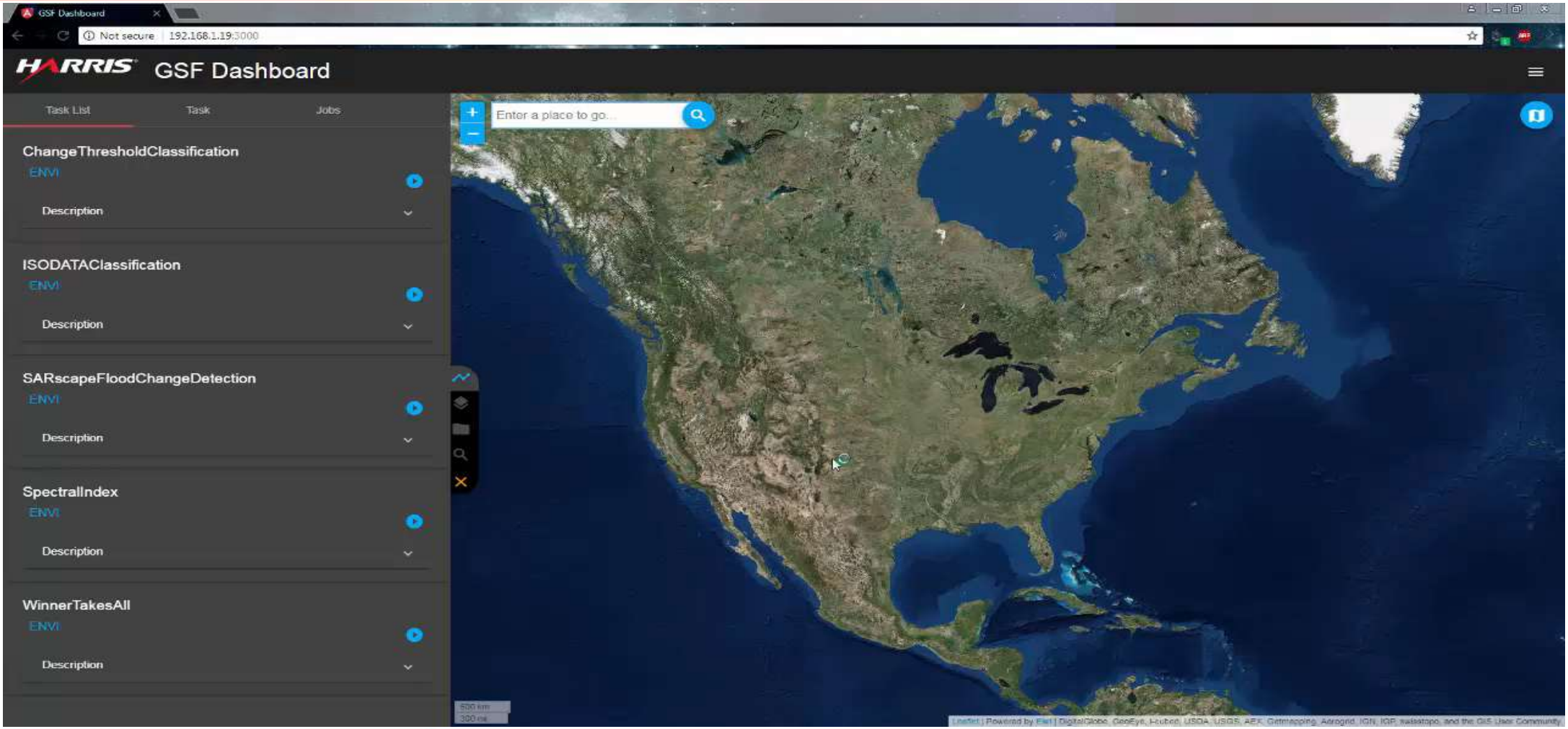
Inside Geospatial Services Framework (GSF)

GSF Task Engines

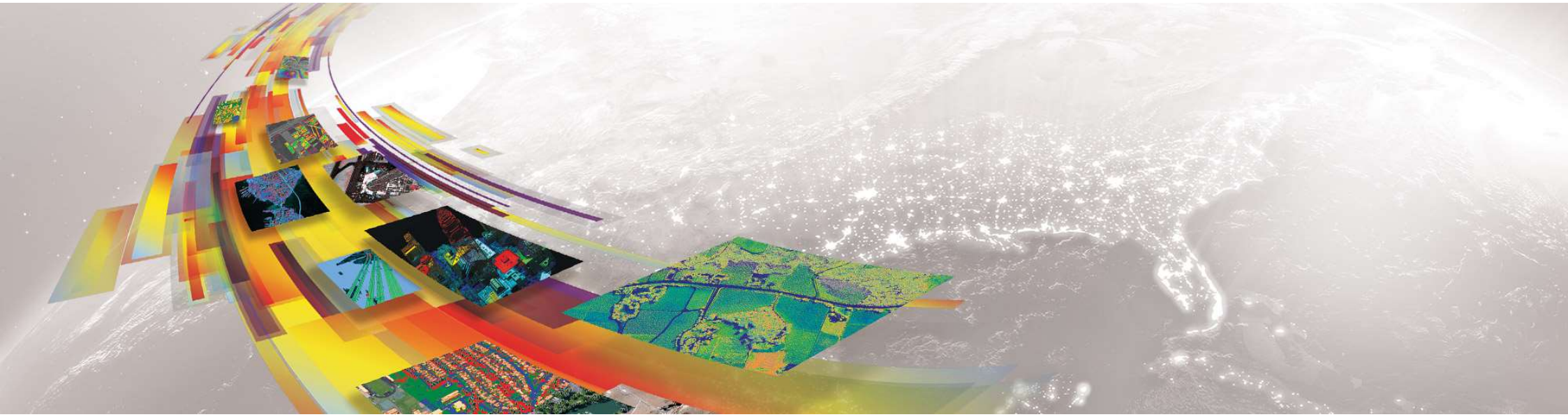




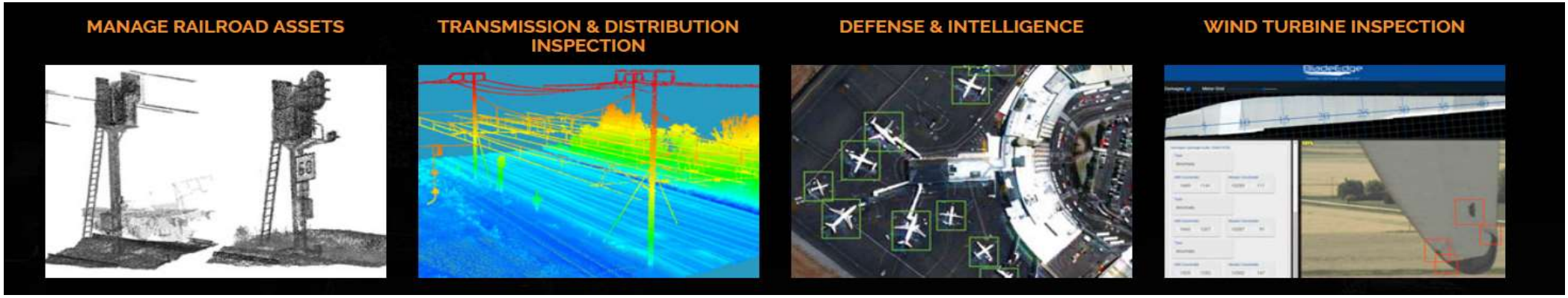
GSF Example


GSF Dashboard
Not secure
192.168.1.19:3000
HARRIS GSF Dashboard
Task List
Task
Jobs
ChangeThresholdClassification
ENVI
Description
ISODATAClassification
ENVI
Description
SARscapeFloodChangeDetection
ENVI
Description
SpectralIndex
ENVI
Description
WinnerTakesAll
ENVI
Description
Enter a place to go...

GSF Demo



HARRIS MACHINE LEARNING - MEGA



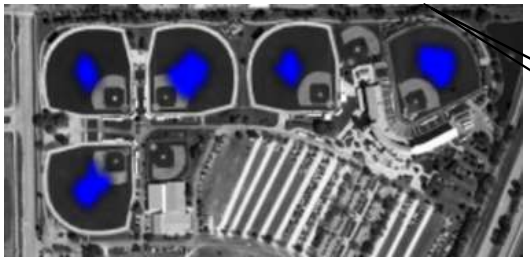
Pilot Programs

Automatic Target Recognition in Pan / MSI

- Near ceiling performance in Pan and RGB
- Robust against occlusions, orientation, image quality

Sampling of Successful ATRs Tested

- Airplanes
- Storage tanks
- Sports Stadiums
- Athletic Fields
- Smokestacks
- Cooling Towers
- Clouds
- Swimming Pools
- Buildings
- Paved Roads
- Overpasses
- Tollbooths

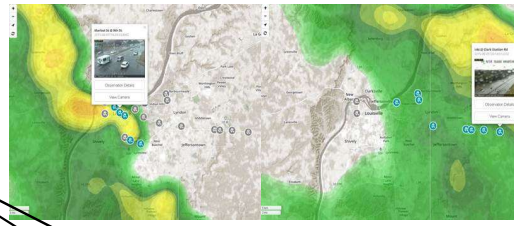


HELIOS

Traffic Cam – Scene Detection

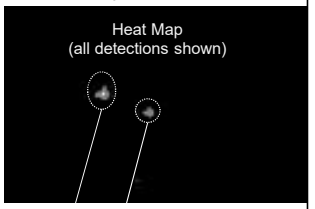
- Real-time ground weather intelligence system
- Data from traffic-cam videos
- Learn state of the world, instead of finding targets
  - *Is it raining? Are the roads wet? Is snow present?*
- Dramatic performance improvement
- Fewer frames needed = substantial cost savings
- ***In use today*** in operational commercial product

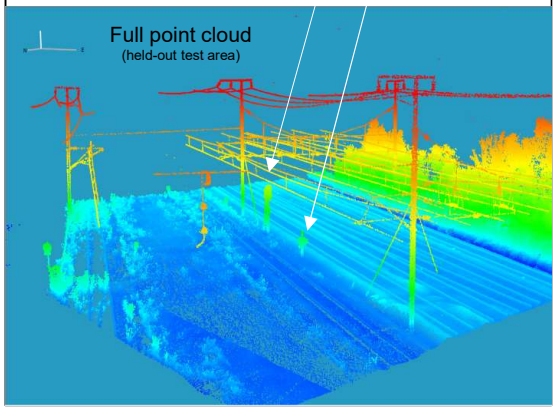
https://exelishelios.com/



Object Detection in LiDAR Point Clouds

- European National Railroad asset inventory project
- Extension of 2D ConvNet to 3D data source
- Preliminary results are very encouraging
- Finds variety of 3D objects (signals, crossings, boxes, poles)





Computational Requirements

Machine Learning techniques are highly computationally intensive

- 2-step process: (1) Train Classifiers (2) Apply Classifiers
- Both steps are computationally intensive

Methods are very well suited for Massively Parallel Processing

- Use of GPUs to speed processing is commonplace and very effective
  - CUDA-enabled GPU cards are especially effective
- Cluster Computing
  - Exelis VIS currently developing infrastructure to move processing to Cluster
  - Tools are system-agnostic
    - ❖ One machine with many CPUs or GPUs
    - ❖ Many machines with 1 or multiple processors
  - Distributed processing model could support 3rd-party or private clusters

❖ Amazon Cloud

❖ IBM SoftLayer

❖ Digital Globe's GBDx

Machine Learning Algorithms

Allows for extracting training data and combining data from multiple files.

Two new machine learning algorithms:

- **C45 Decision Tree**
- **Occam's Genetic Algorithm**

Wraps existing tools with same, easy-to-use interface:

- **Softmax**
- **SVM (Support Vector Machine)**

Algorithm Comparison: 8.2 million pixels, 4 classes

HARRIS

C45 Decision Tree

Generation Time: 82 sec, 90% data
Accuracy: 97.93
Classification Time: ~4 min

Occam's Genetic Algorithm

Generation Time: ~30 min , 100% data
Accuracy: 97.54
Classification Time: ~30 seconds

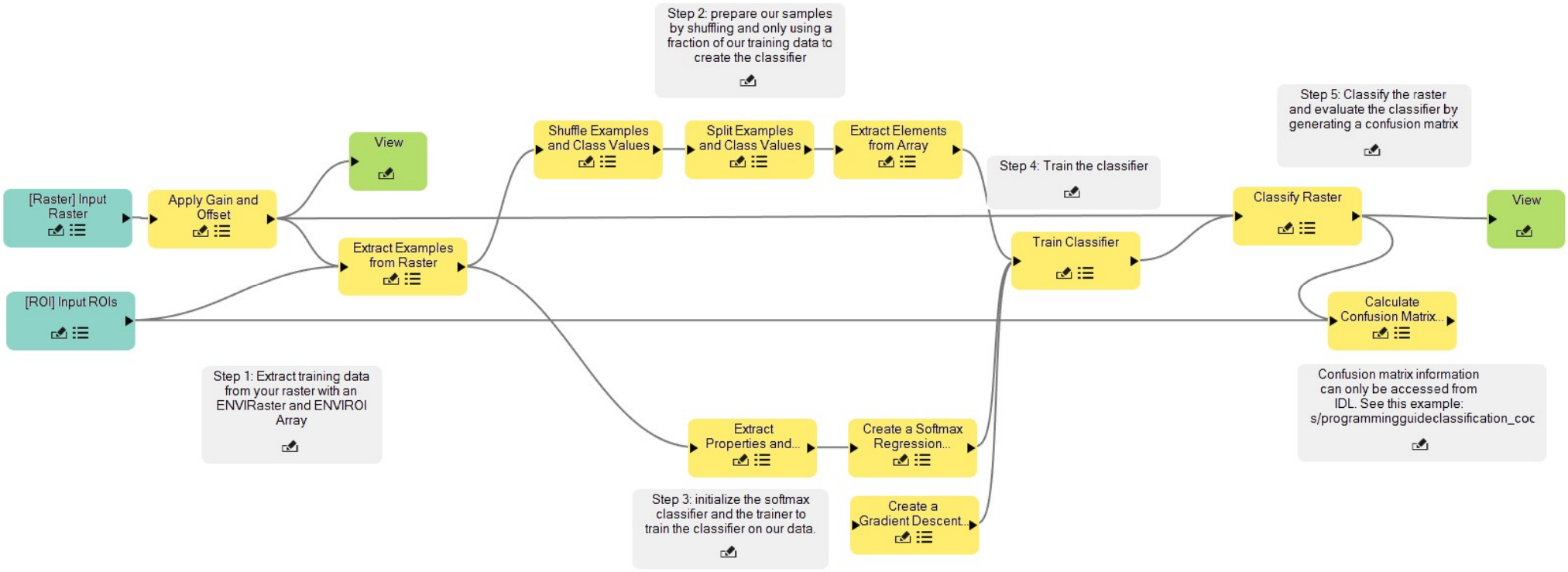
SVM: N/A

Generation Time: >10 minutes/iteration
Accuracy: N/A
Results: N/A

Softmax

Generation Time: ~20 min, 30% data
Accuracy: 96.86%
Classification Time: ~1.5 minutes

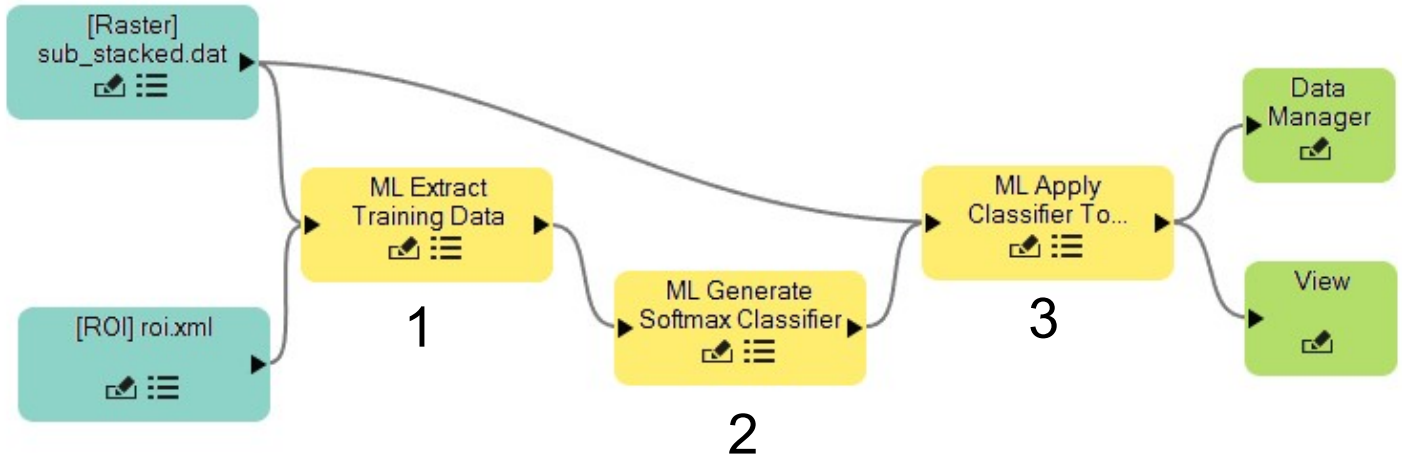
Softmax Before



After

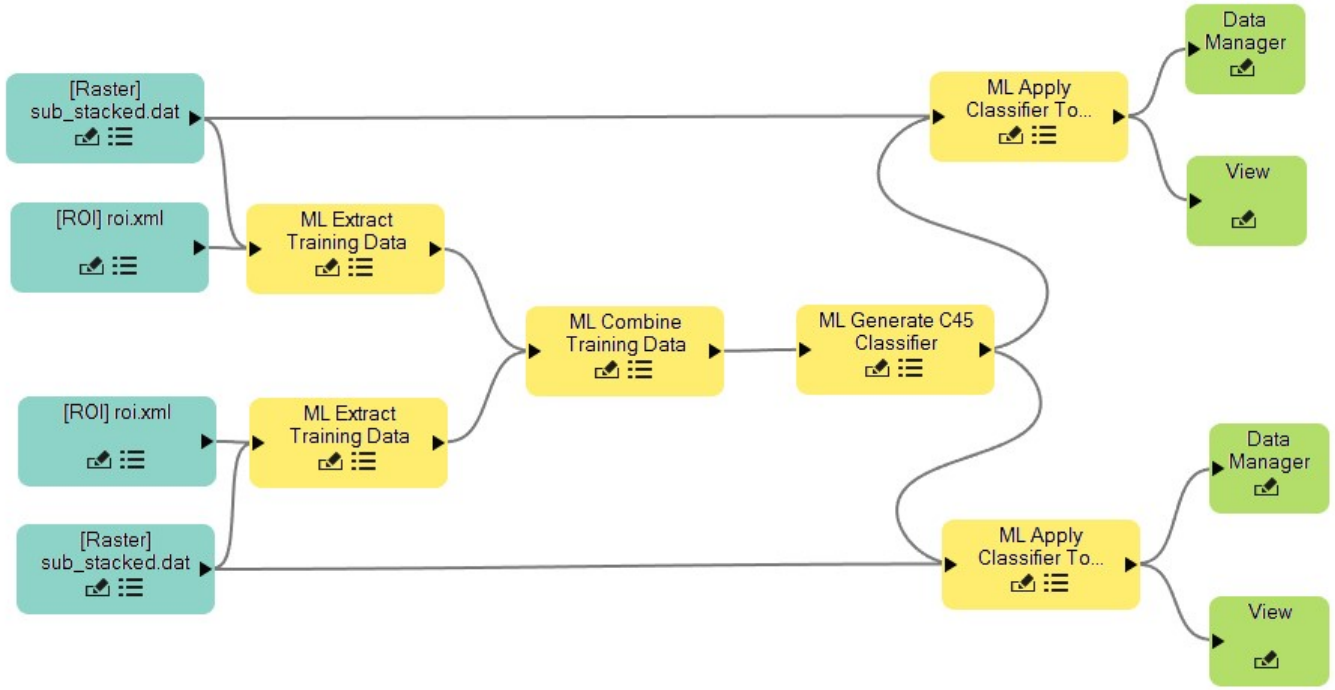
Each algorithm has three, simple steps:

1. **Extract training data**
2. **Train classifier**
3. **Apply classifier to raster**



Other Features

Can easily extract data from two rasters and combine for classification



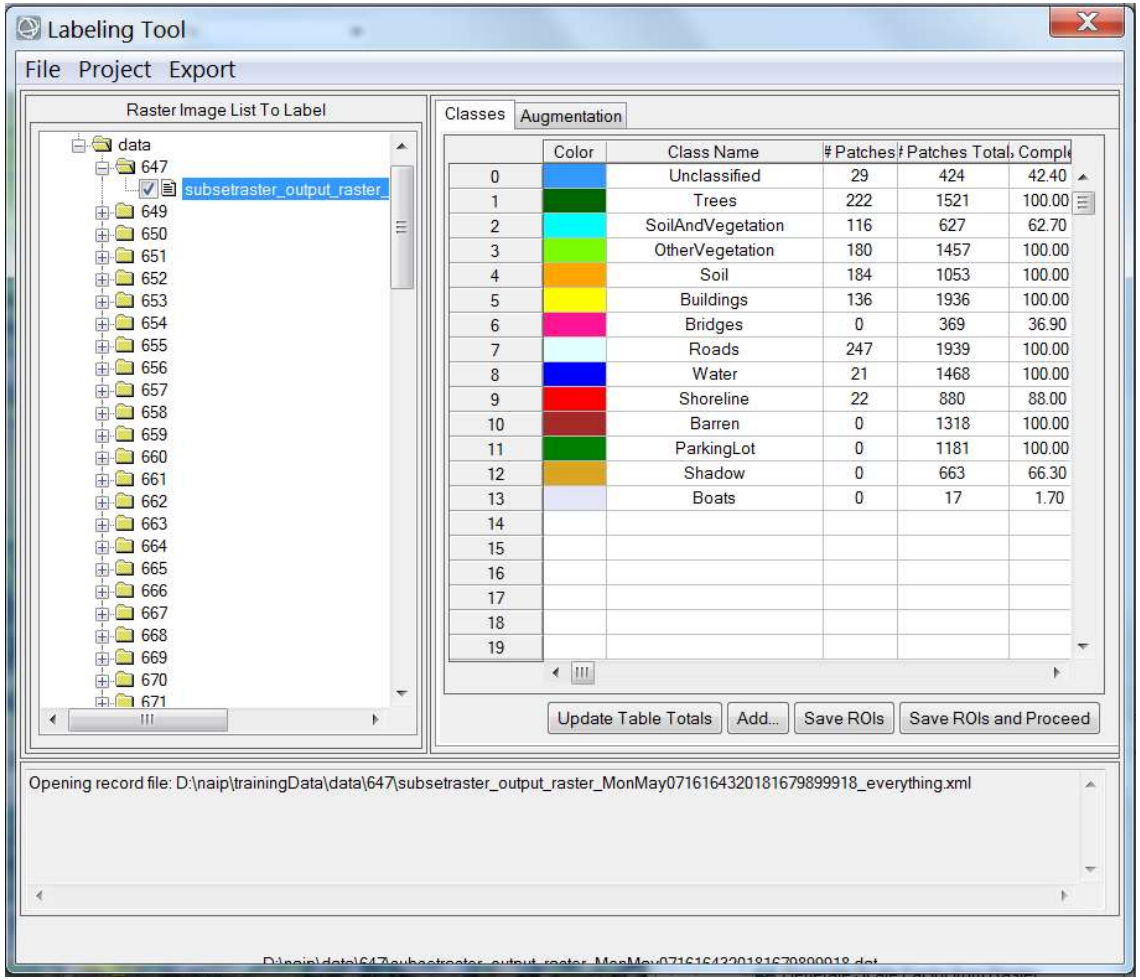
Classifier File (JSON)

Human readable and contains accuracy information in the confusion matrix

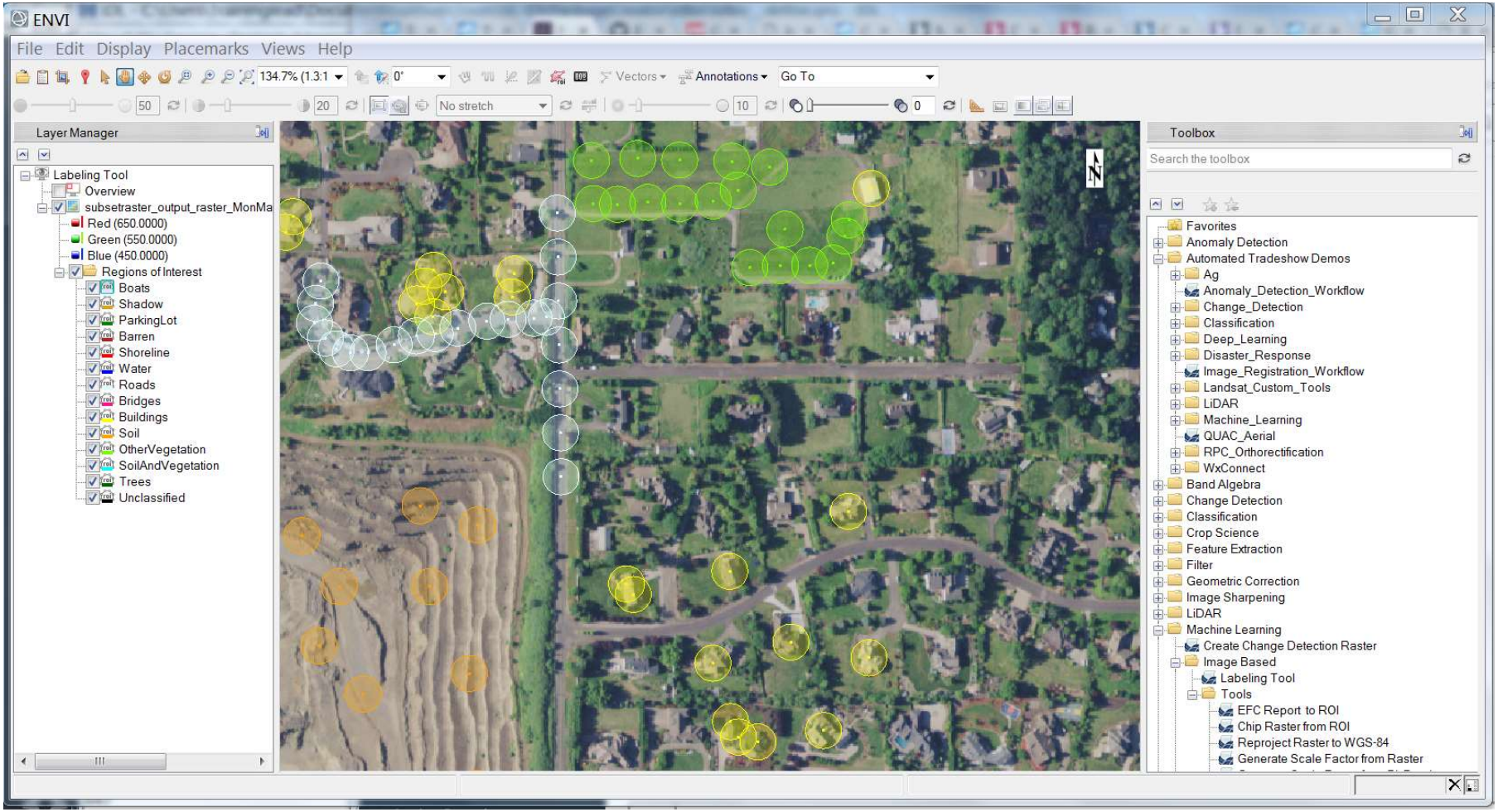

```
{
    "classifierType": "occams",
    "sourceInfo": {
        "nBands": 4
    },
    "classInfo": {
        "nClasses": 4,
        "names": ["cloud", "water", "snow", "unclassified"],
        "colors": [[255, 0, 0], [0, 128, 0], [0, 0, 255], [0, 128, 0]]
    },
    "classifierInfo": {
        "confusionMatrixInfo": {
            "accuracy": 0.97538930,
            "producer_accuracy": [0.95994365, 1.0000000, 0.99442291, 0.97340232, 0.0013596193],
            "expected_class_totals": [519094.00, 0.00000000, 1382624.0, 6324878.0, 5884.0000],
            "predicted_class_totals": [672163.00, 5930.0000, 1388488.0, 6164935.0, 964.00000],
            "predicted_over_expected": [1.2948772, 0.00000000, 1.0042412, 0.97471207, 0.16383412],
            "user_accuracy": [0.74133950, 0.00000000, 0.99022317, 0.99865627, 0.0082987556],
            "kappa_coefficient": 0.93708795,
            "error_of_comission": [0.25866050, 1.0000000, 0.0097768307, 0.0013437271, 0.99170125],
            "error_of_omission": [0.040056348, 0.00000000, 0.0055770874, 0.026597679, 0.99864036],
            "f1_value": [0.83659697, 0.00000000, 0.99231863, 0.98586768, 0.0023364488],
            "recall": [0.95994365, 1.0000000, 0.99442291, 0.97340232, 0.0013596193],
            "column_and_row_names": ["ML: No Classification", "ML: Multiple Classification", "Cloud", "Water", "Snow"],
            "confusion_matrix": [[498301, 0, 6592, 167270, 0], [51, 0, 0, 3, 5876], [13567, 0, 1374913, 8, 0], [7165, 0, 1119, 6156651, 0], [10, 0, 0, 946, 8]]
        },
        "lossProfile": {
            "cloud": [0.015576899, 0.015424907, 0.014553249, 0.013246417, 0.013218582, 0.013162673, 0.013162673, 0.013162673, 0.013162673, 0.013076544, 0.012679577, 0.012
            "water": [0.097240746, 0.097240746, 0.064705908, 0.062154770, 0.062153280, 0.062153280, 0.047351241, 0.047351241, 0.047351241, 0.047351241, 0.047351241, 0.047
            "snow": [0.052075744, 0.052075744, 0.0041419268, 0.0040163994, 0.0036335588, 0.0030117631, 0.0028212667, 0.0028212667, 0.0028212667, 0.0028212667, 0.00282126
        },
        "classifier": {
            "cloud": "((((*dat[0]) - (*dat[2]))/((*dat[0]) + (*dat[2]))) lt 0.876570)  AND  ((((*dat[0]) - (*dat[1]))/((*dat[0]) + (*dat[1]))) lt 0.219841)  AND  (((*dat
            "water": "((((*dat[0]) - (*dat[1]))/((*dat[0]) + (*dat[1]))) gt 0.0760150)  AND  ((*dat[1]) lt 0.865953)  AND  ((((*dat[0]) - (*dat[2]))/((*dat[0]) + (*dat[2
            "snow": "(((*dat[0]) / (*dat[1])^2) lt 137.875)  AND  ((1.0/(*dat[0]) - 1.0/(*dat[1])) gt -0.568730)  AND  ((((*dat[3])^2 - (*dat[2]))/((*dat[3])^2 + (*dat[2
        }
    }
}
```

Capabilities: Labeler

- Organizes input data
- Tracks class counts
- Allows for exporting training data as image chips or projects
- Imports most files in project folder
- Uses IDL's object graphics
- Handles +10k points
- Create polygons and auto-fill with points

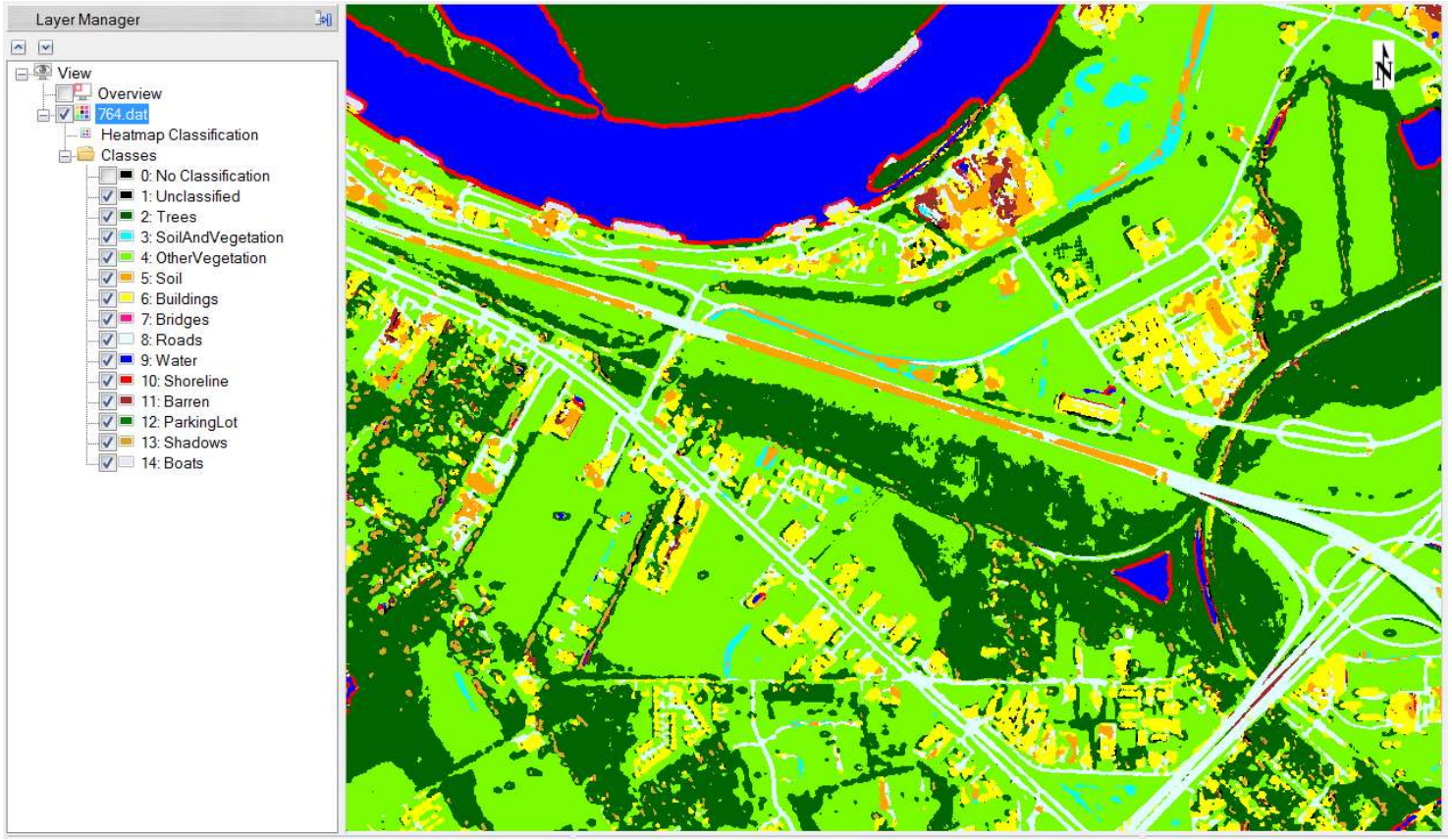


Capabilities: Labeler Contd.



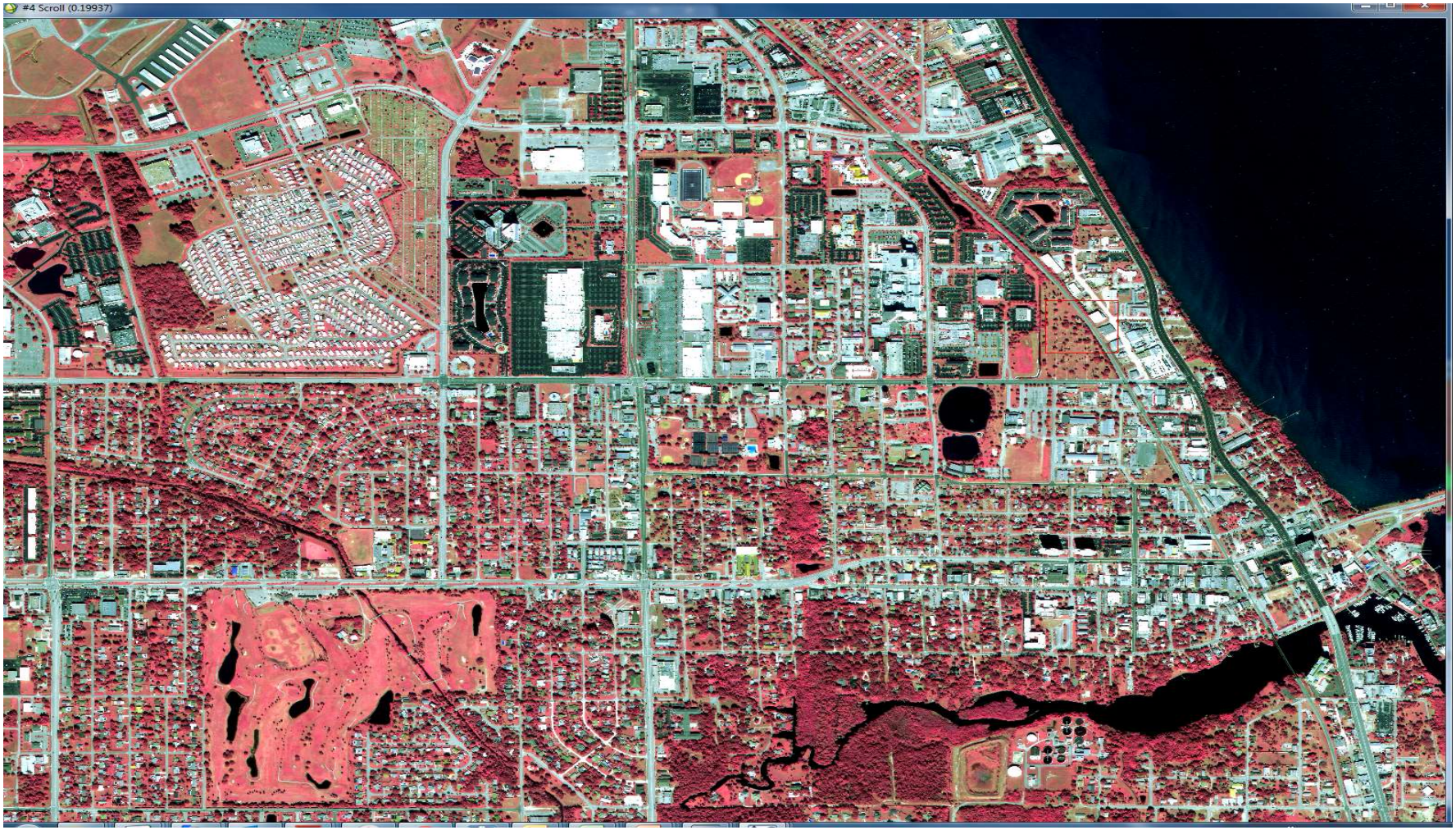
Capabilities: Heatmap Processing

Easily generate classification images from complex classifiers

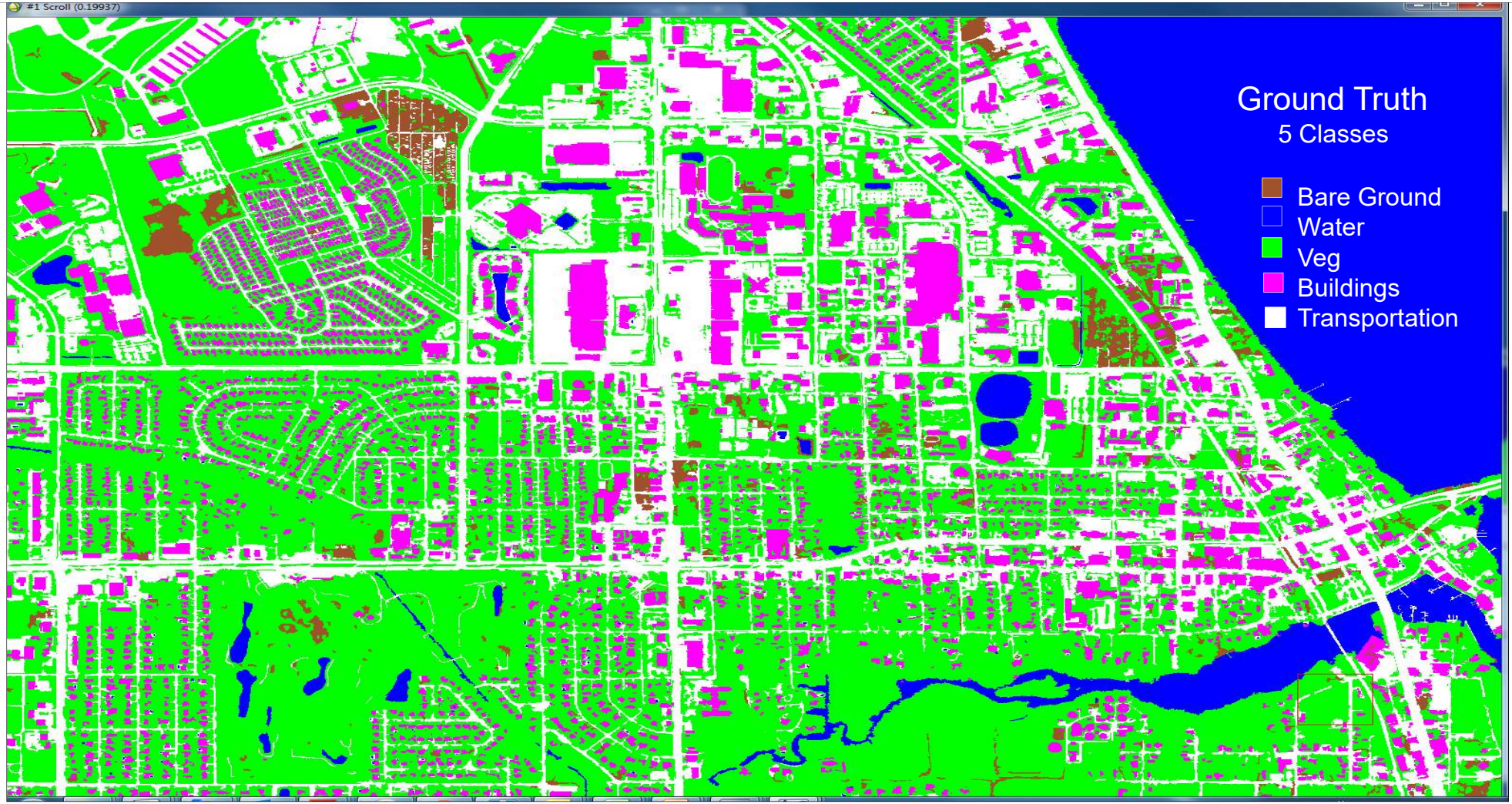


This classifier has 14 classes and the direct output from MEGA would otherwise be hard to interpret.

Can Deep Learning be used for full scene classifications?



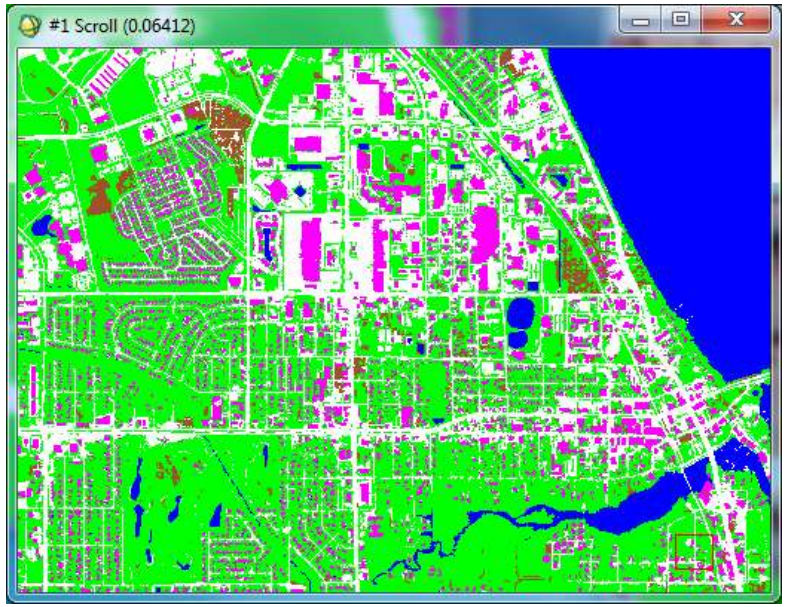
YES! – Full Scene Classification



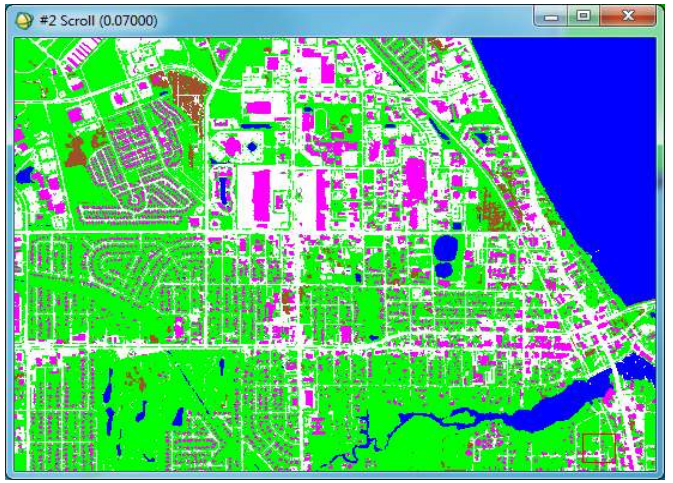
Full Scene

HARRIS

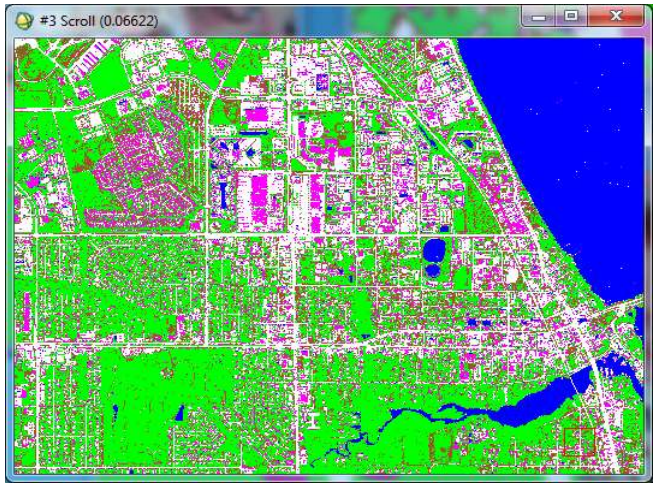
Ground Truth



Deep Learning

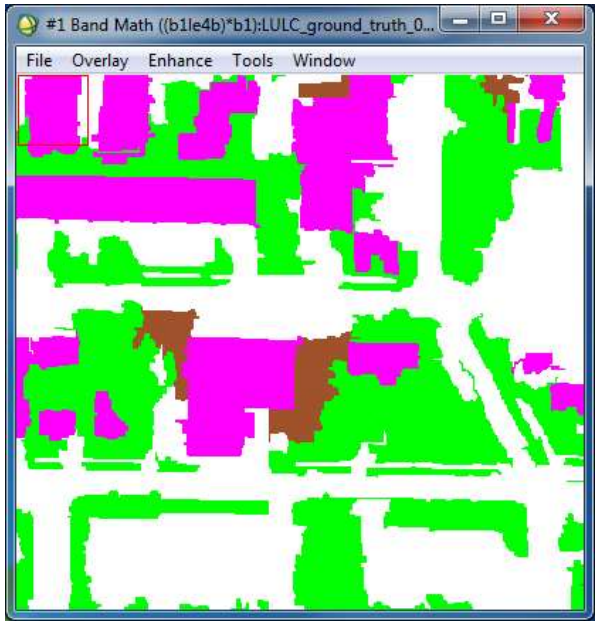


SAM
(GS-Sharp > QUAC)

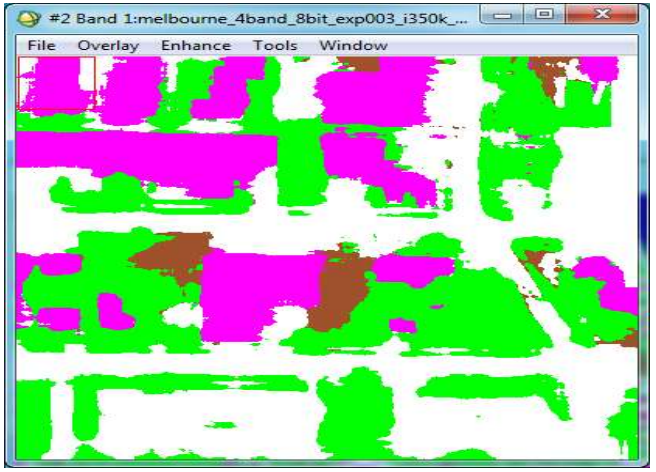


Detail

Ground Truth

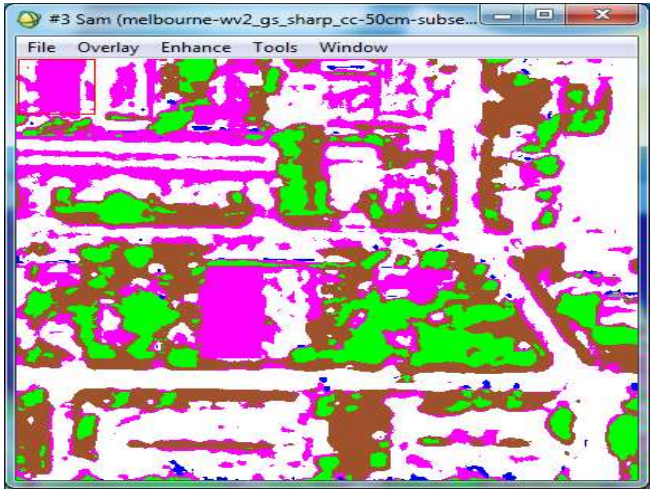


Deep Learning



SAM

(Bldg , Trans, Bare Ground confusion)



Questions?

Connor McKissick
Solutions Engineer
jmckissi@harris.com

Harris Corporation
www.harrisgeospatial.com
geospatialinfo@harris.com
303-786-9900