Changing the Game in Spectral:
A Spectral Detection Use Case – from Desktop to Enterprise

Dan Heinz, Greg Terrie, Thomas Bahr

L3Harris Geospatial

Dan.Heinz@L3Harris.com

Greg.Terrie@L3Harris.com

Thomas.Bahr@L3Harris.com

ENVIpalooza

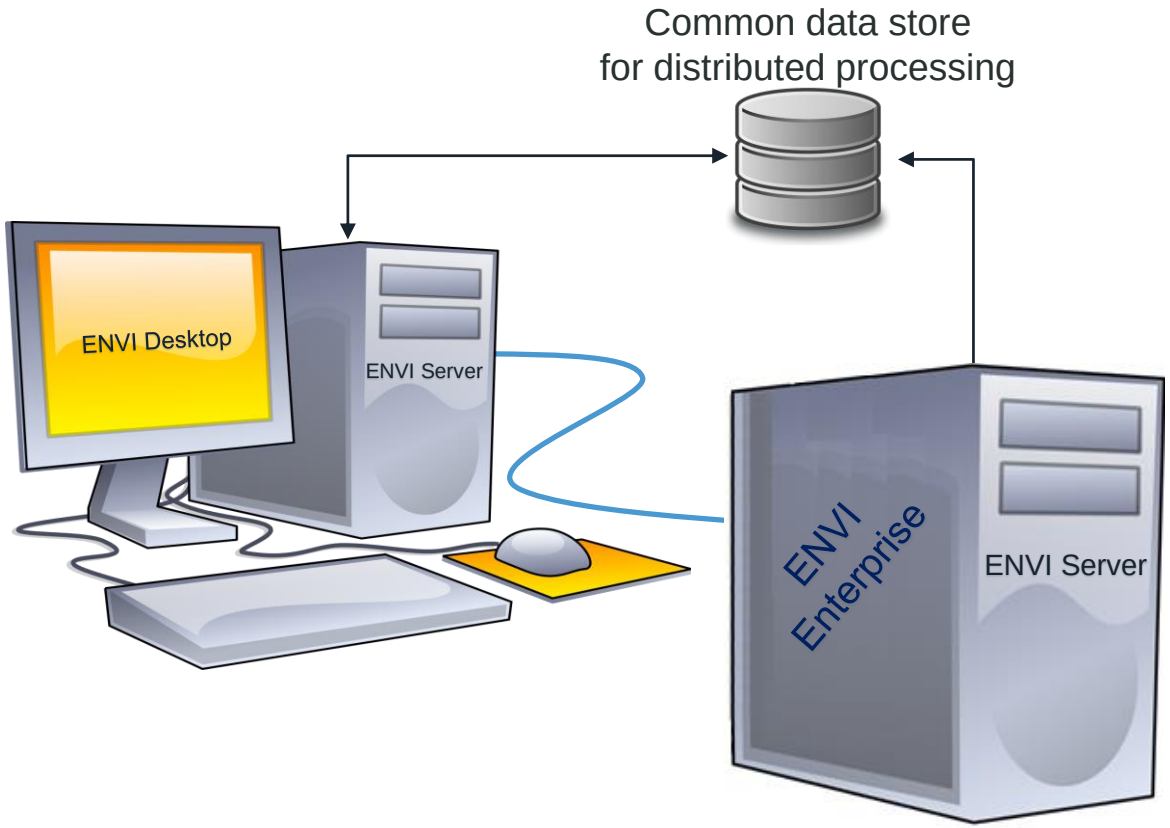
An Insider's Guide to GEOINT

Outline

- Creating workflows that work with
  - ENVI Desktop
  - ENVI Server
  - ENVI Enterprise
- Use Case: Using hyperspectral detection algorithms with multispectral data
  - Use Case Overview
  - ENVI Processing Steps
- As a Desktop Extension
- Running on an ENVI Server
- Running in the Enterprise
- Conclusions

Write Once -- Use Multiple Ways

- Leveraging the ENVI + IDL API enables users to **develop a processing algorithm once and use it in multiple ways** within the ENVI/IDL ecosystem
- ENVI Desktop
  - Custom extension
  - ENVI Modeler
- Run on an ENVI Server
  - Can be initiated from ENVI Desktop if Desktop and Server have shared storage
- Deploy as a service via ENVI Enterprise
  - Usually accessed via a web client

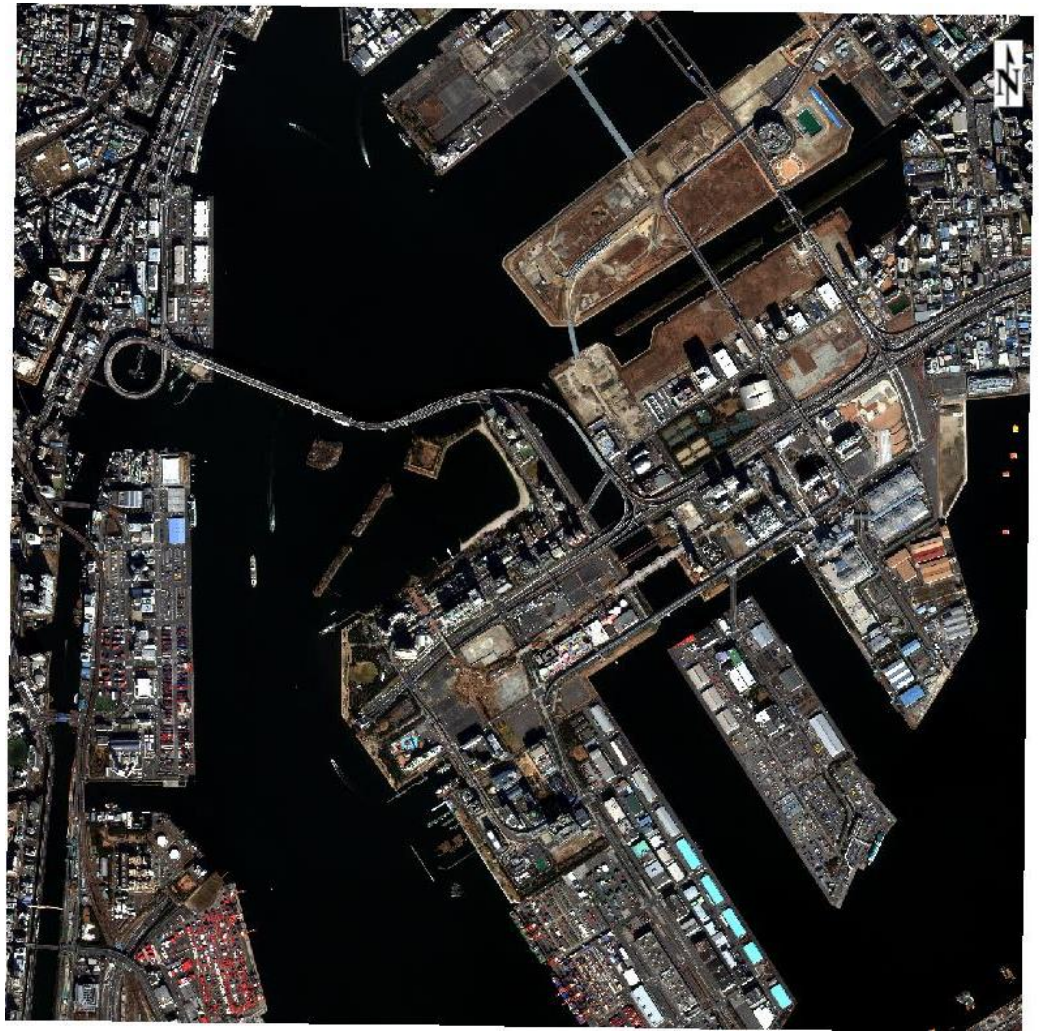


ENVI is a client for ENVI Server, meaning we can connect to machines used for dedicated processing

Situation: Have 4-Band Data with Many Endmembers >> 10

Some endmembers:

- Shadow
- Trees
- Vegetation
- Bare Earth
- Parking / Roads
- Purple / Pink Buildings
- Bright Buildings
- Blue Shipping Containers
- Red Shipping Containers
- White Shipping Containers
- Green Shipping Containers
- Water
- Etc.



WorldView-2 true-color RGB composite of Port of Tokyo

Problem: Similar to the Pigeonhole Principle Problem

Pigeons in holes.

- Here there are n = 10 pigeons in m = 9 holes
- Since 10 is greater than 9,
  the pigeonhole principle says
  that at least one hole has more than one pigeon

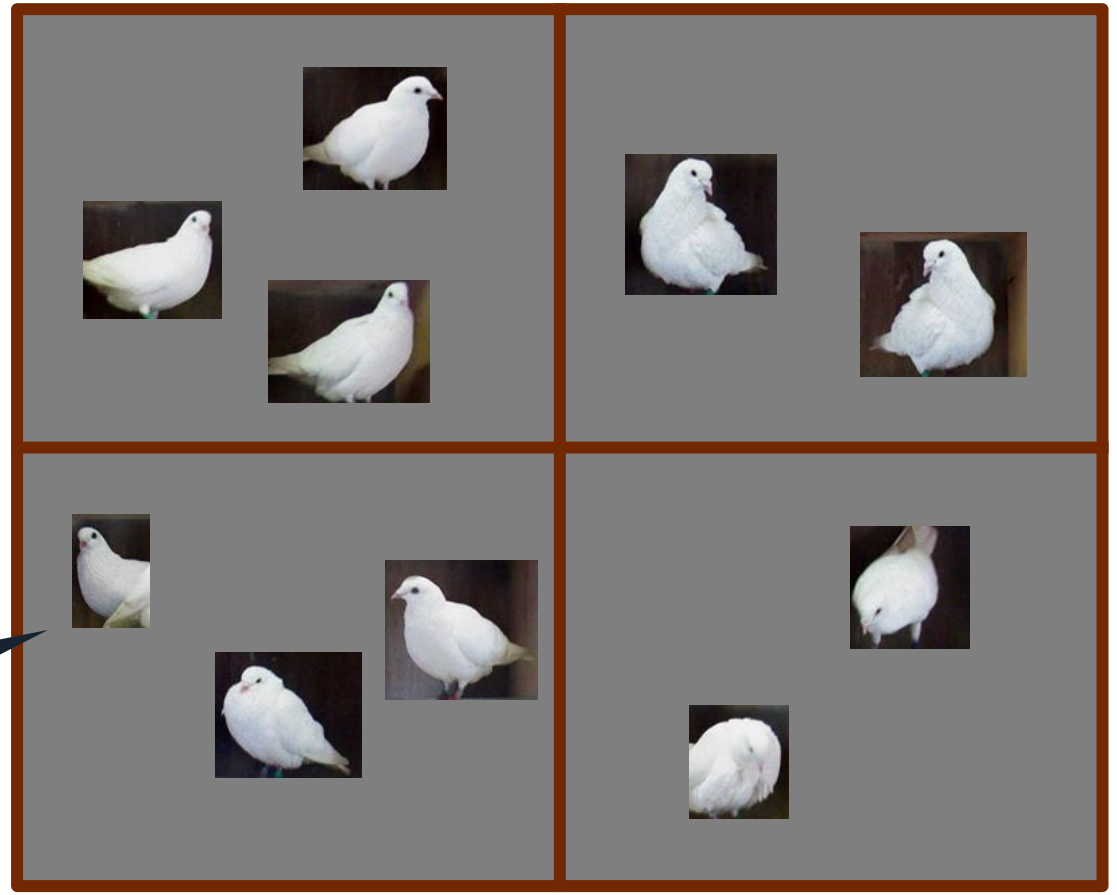
We can equate

- pigeons to endmembers and
- holes to bands

By Pigeons-in-holes.jpg by en:User:BenFrantzDale; this image by en:User:McKay – Transferred from en.wikipedia to Commons.;
Original text : Edited from Image:Pigeons-in-holes.jpg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=4658682

Problem: So Our Problem Becomes …

… We have more than 10 endmembers (pigeons) and only four bands (holes)



Pigeons with similar features in same hole

Solution: Increase the Number of Bands (Holes)

- Simple mathematical trick – **Dimensionality Expansion (DE)**
- New bands can be added by conducting Nonlinear transforms on the original bands
- First-order band:
  - $\{\boldsymbol{B_i}\}_{\boldsymbol{i=1}}^{\boldsymbol{l}}$ → set of original bands
- Second-order correlated bands:
  - (i) $\left\{\boldsymbol{B_i^2}\right\}_{\boldsymbol{i=1}}^{\boldsymbol{l}}$ → set of auto-correlated bands
  - (ii) $\left\{\boldsymbol{B_i B_j}\right\}_{\boldsymbol{i,j=1,i\neq j,j>i}}^{\boldsymbol{l}}$ → set of cross-correlated bands
- Other nonlinear correlated bands:
  - (i) $\left\{\sqrt{\boldsymbol{B_i}}\right\}_{\boldsymbol{i=1}}^{\boldsymbol{l}}$ → set of square-rooted bands
  - (ii) $\{\boldsymbol{\log B_i}\}_{\boldsymbol{i=1}}^{\boldsymbol{l}}$ → set of logarithmic functions

Any *Nonlinear* transform will work

Data Experiments: ENVI DE Tool Generated Bands

After DE we have 22 Bands

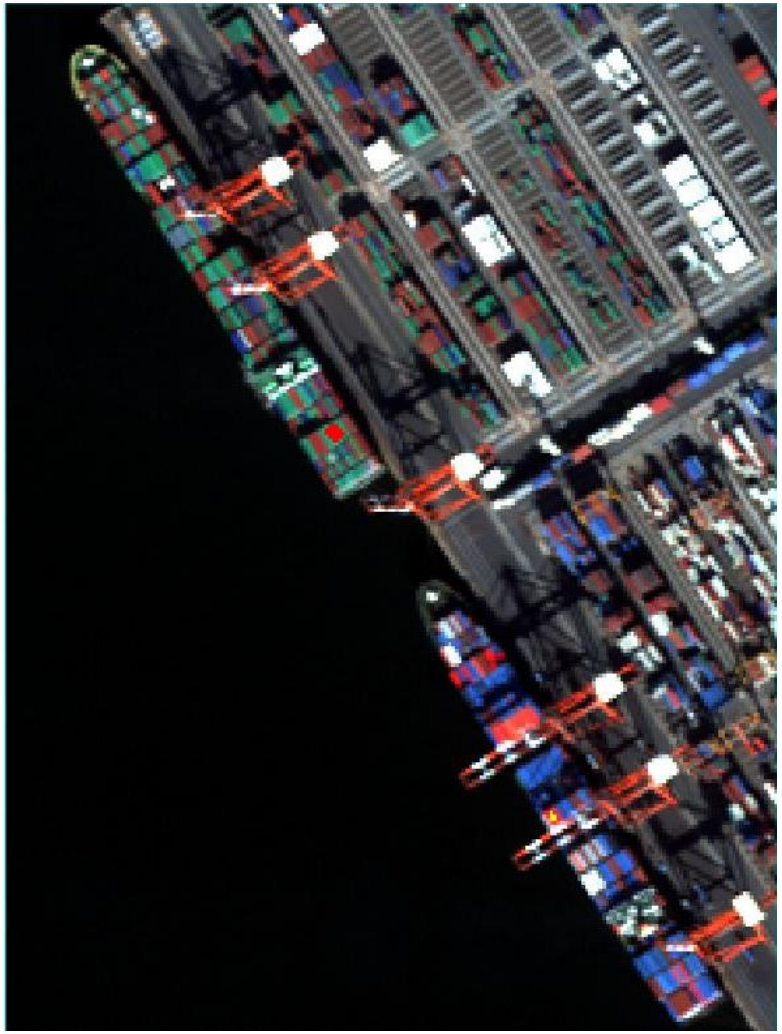
Band #	Bandname	Wavelength [nm]	FWHM [nm]
B1	Coastal Blue	477.9	60.8
B2	Green	546.2	69.8
B3	Red	658.8	59.3
B4	NIR1	832.5	117.8
B5 – B8	Sqrt(B1, B2, B3, B4)		
B9 – B12	Alog(B1, B2, B3, B4)		
B13 – B16	$(B1, B2, B3, B4)^2$		
B17 – B22	B1*B2, B1*B3, B1*B4 B2*B3, B2*B4, B3*B4		

Data Experiments: ENVI Processing Steps

1. Selection of a subset of data for processing
2. Scaled the original data values from 1 to 11
3. Applying the DE tool
4. Using the ROI tool to select two target endmembers from the image scene: Bright Red Container and Green Container
5. Selecting compute statistics from ROI tool and using the mean target spectra as the target for the ACE classification tool
6. Using the ACE classification tool

Data Experiments: ENVI ROI Tool Used to Subset Data

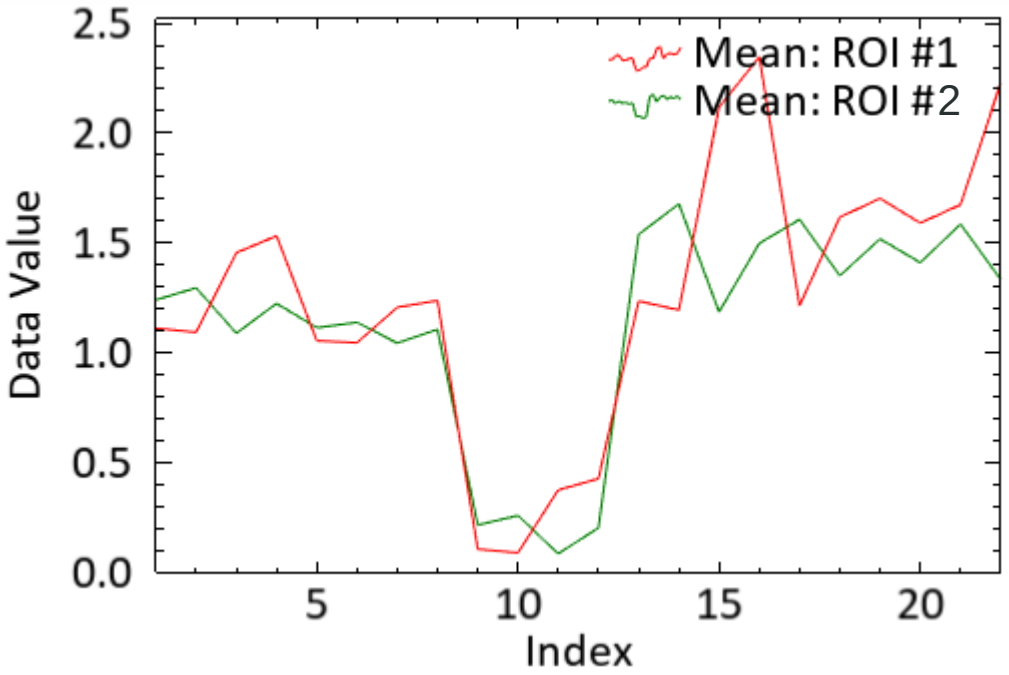
- Want to determine location of different colored shipping containers
- Shipping containers make for a good target when ground truth data is unavailable



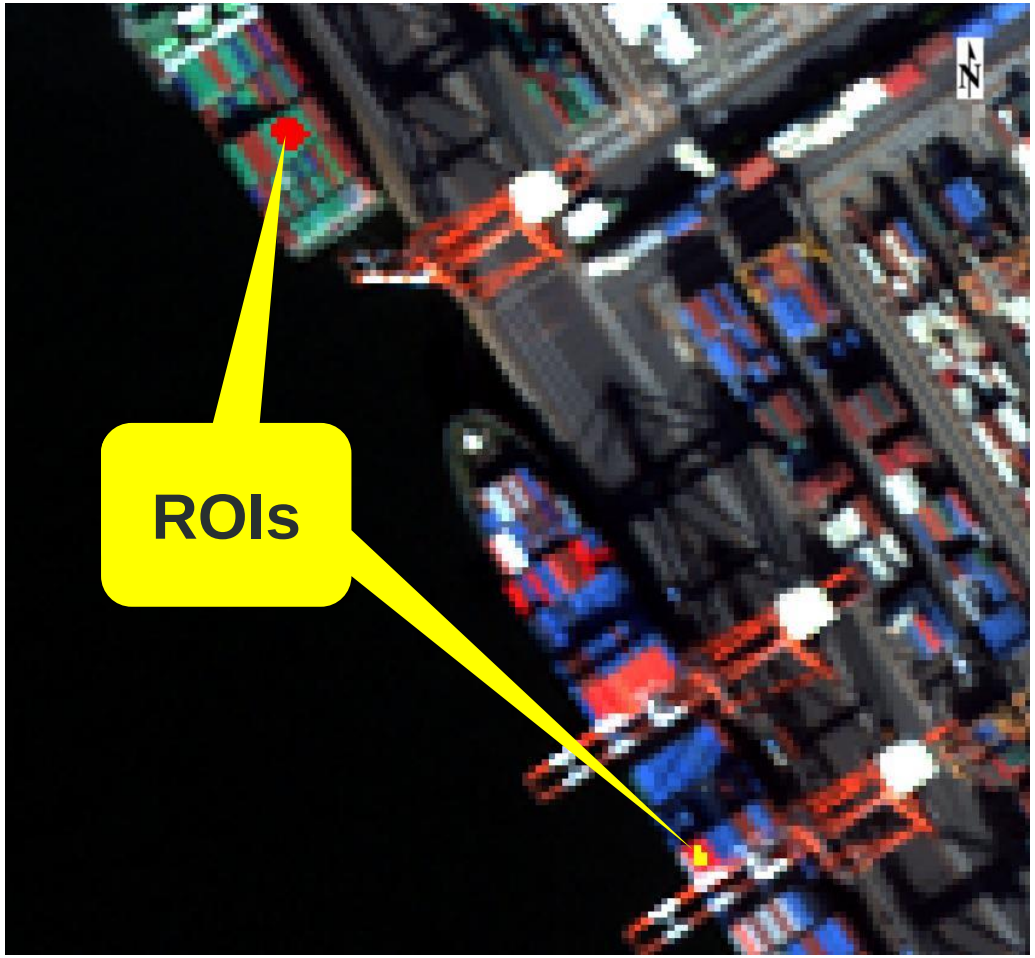
ENVIpalooza
An Insider's Guide to GEOINT

Data Experiments: ENVI ROI Tool

DE spectra used by ACE



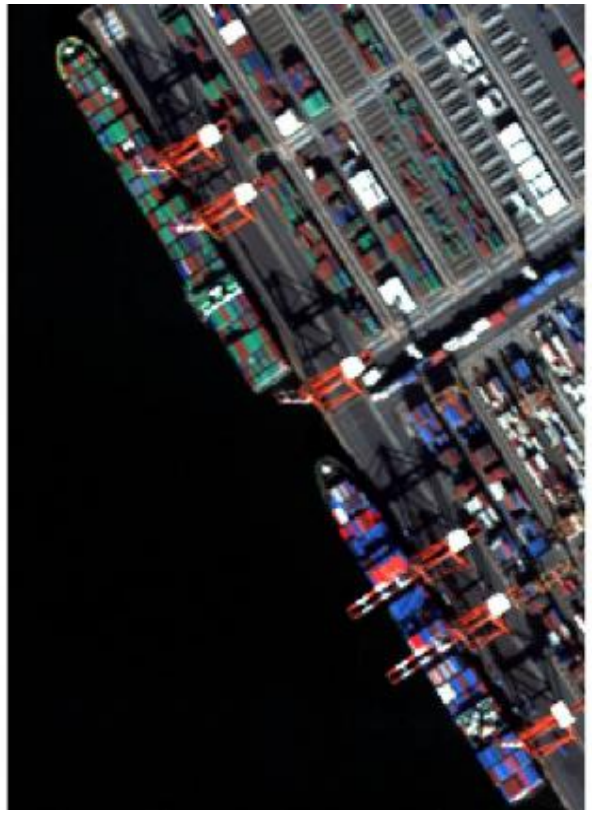
Bright Red Container and Green Container DE Spectra



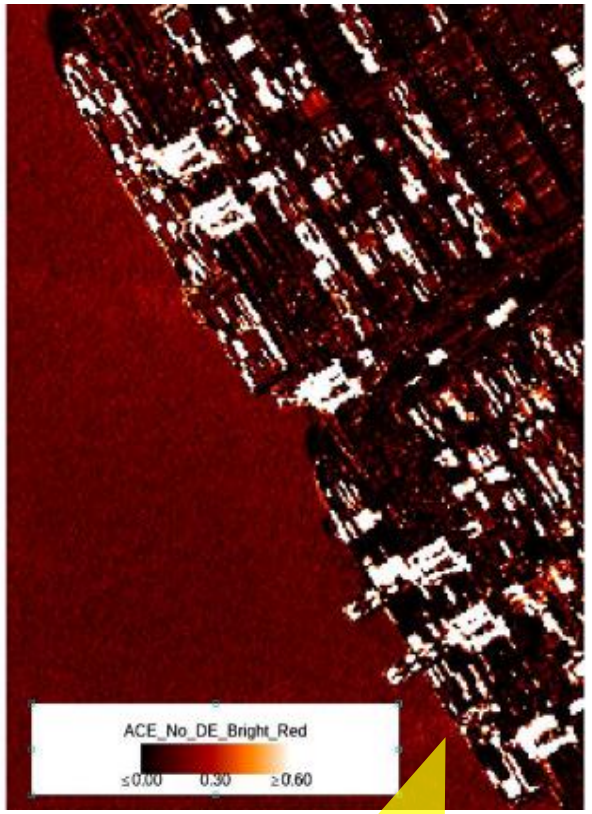
ENVIpalooza
An Insider's Guide to GEOINT

WorldView-2 Data Experiments: Bright Red Container Results

RGB Composite Image

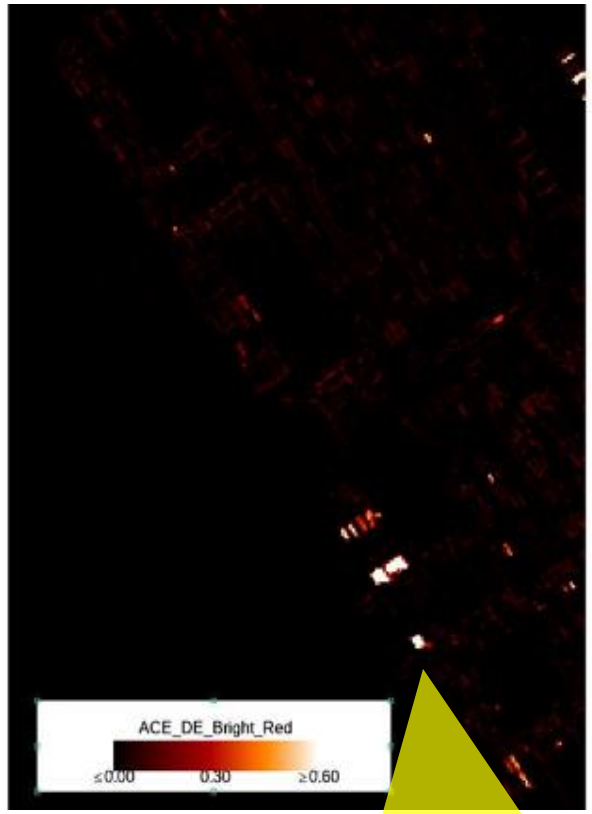


ACE without DE



Detects all red objects

ACE with DE

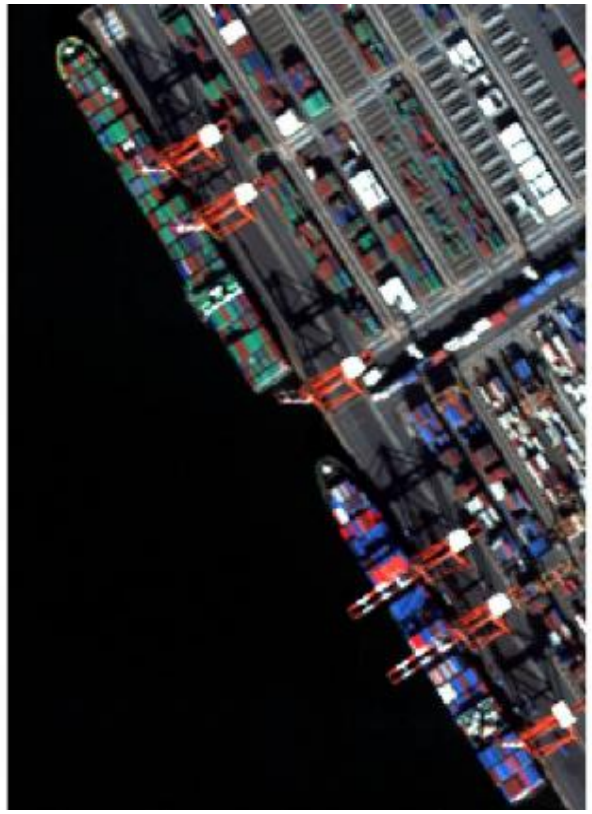


Detects only bright red containers

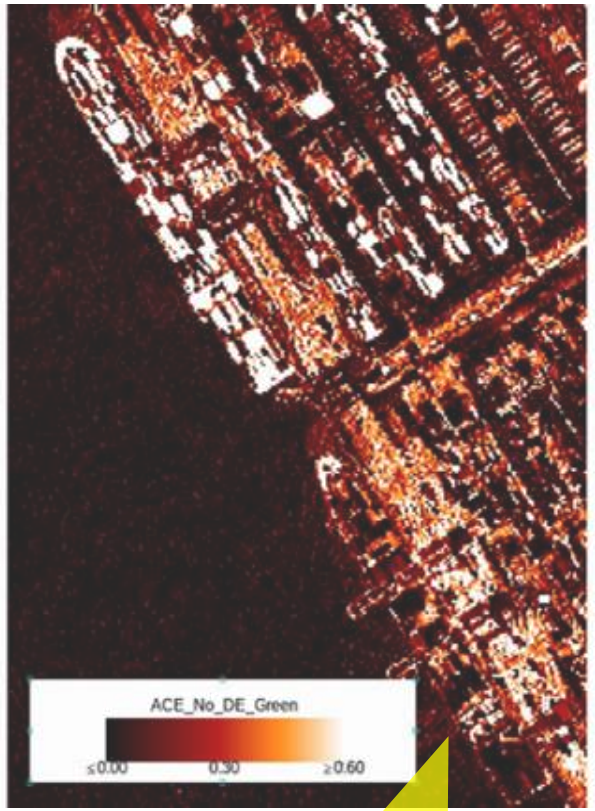
ENVIpalooza
An Insider's Guide to GEOINT

WorldView-2 Data Experiments: Green Container Results

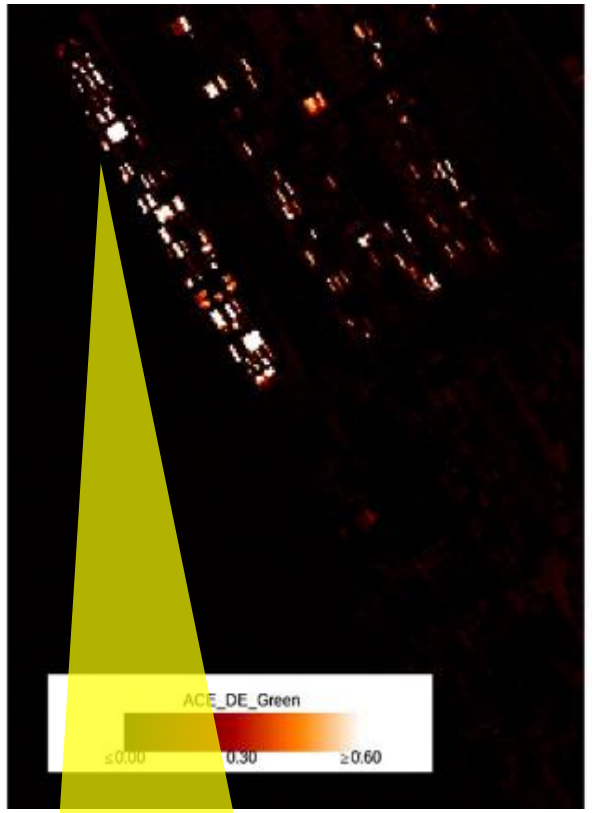
RGB Composite Image



ACE without DE



ACE with DE

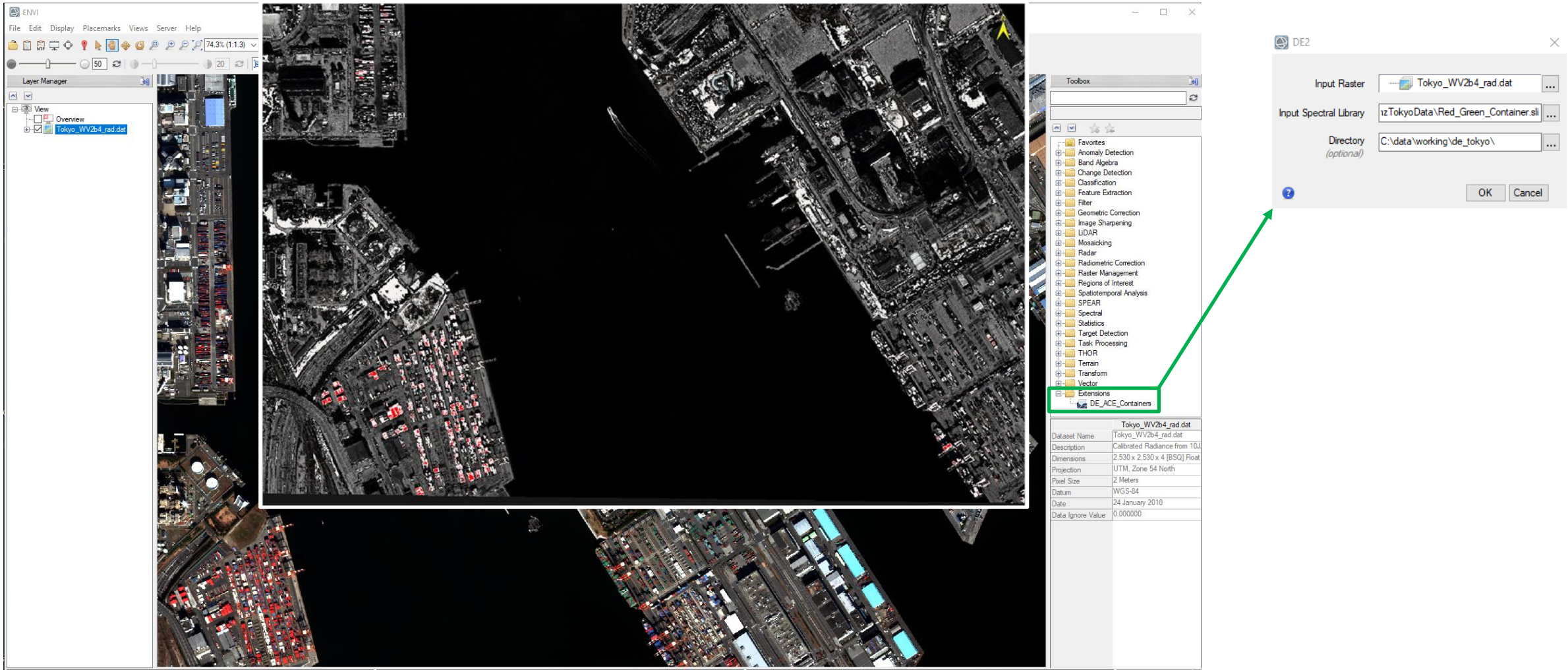


Detects many objects

Detects only green containers

ENVIpalooza
An Insider's Guide to GEOINT

Run as an ENVI Extension



ENVI Modeler

A visual programming tool to create custom task-based workflows in ENVI

Combines the power of the ENVI API with a simple and intuitive user interface

- Build workflows without any knowledge of ENVI programming

Batch-process data

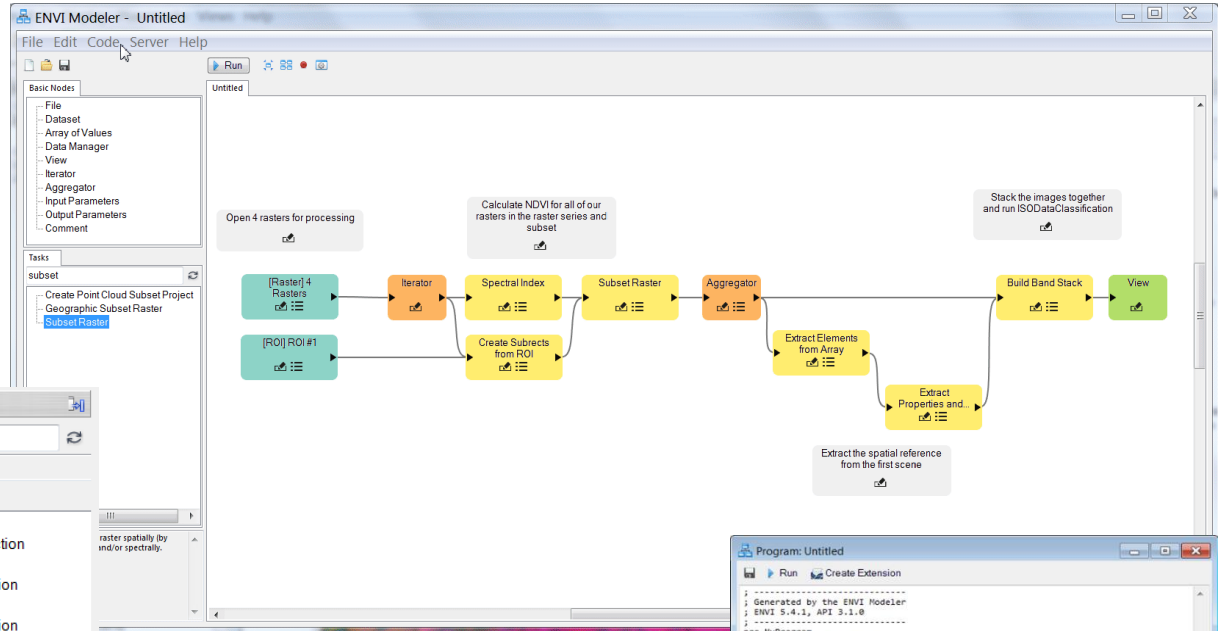
Run tasks remotely on an ENVI Server

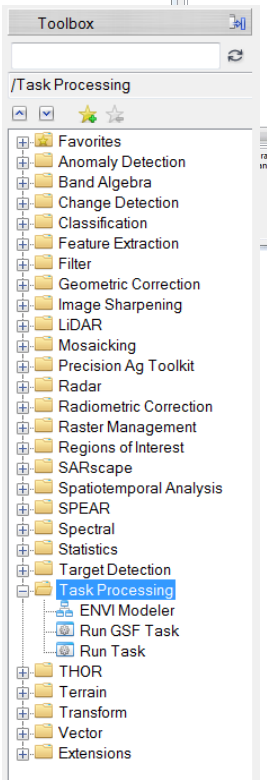
Generate IDL and Python programs from models

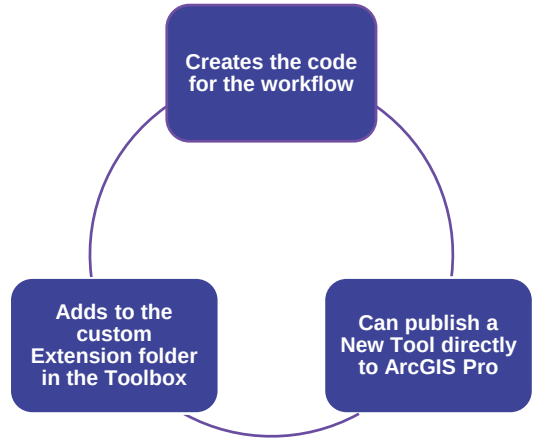
ENVI Tasks

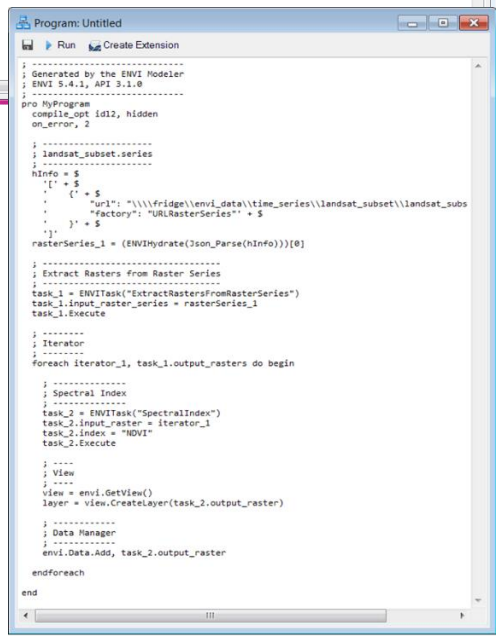
ENVIpalooza

An Insider's Guide to GEOINT

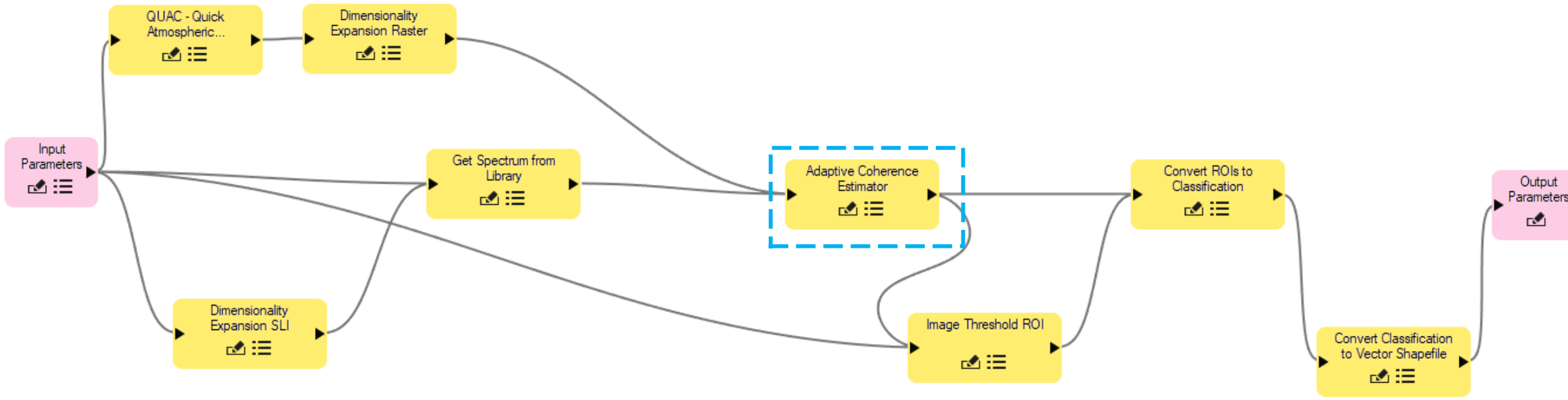








ENVI Processing Steps in Modeler

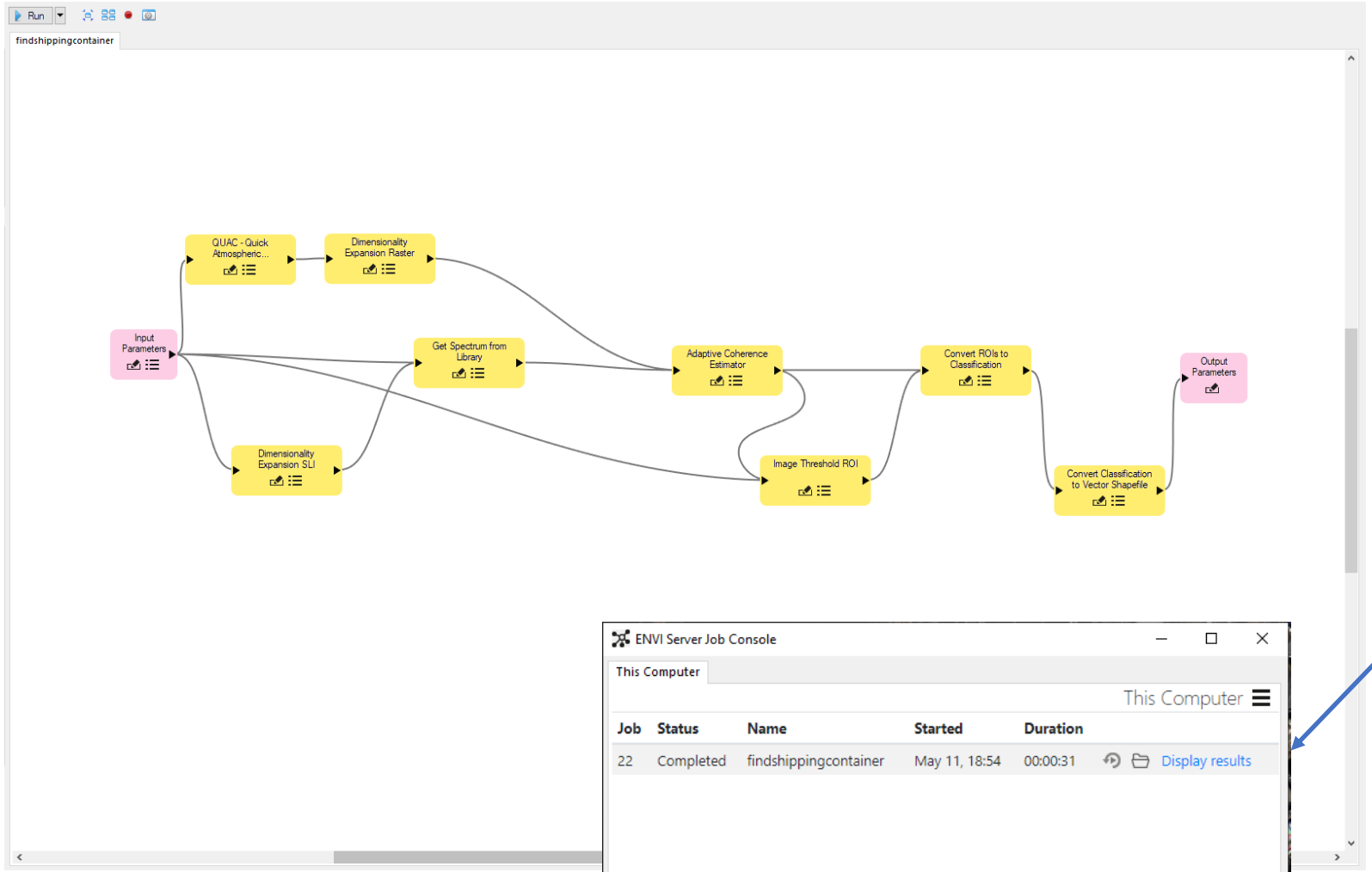


Can be other target detection algorithms

Each represents an ENVI Task

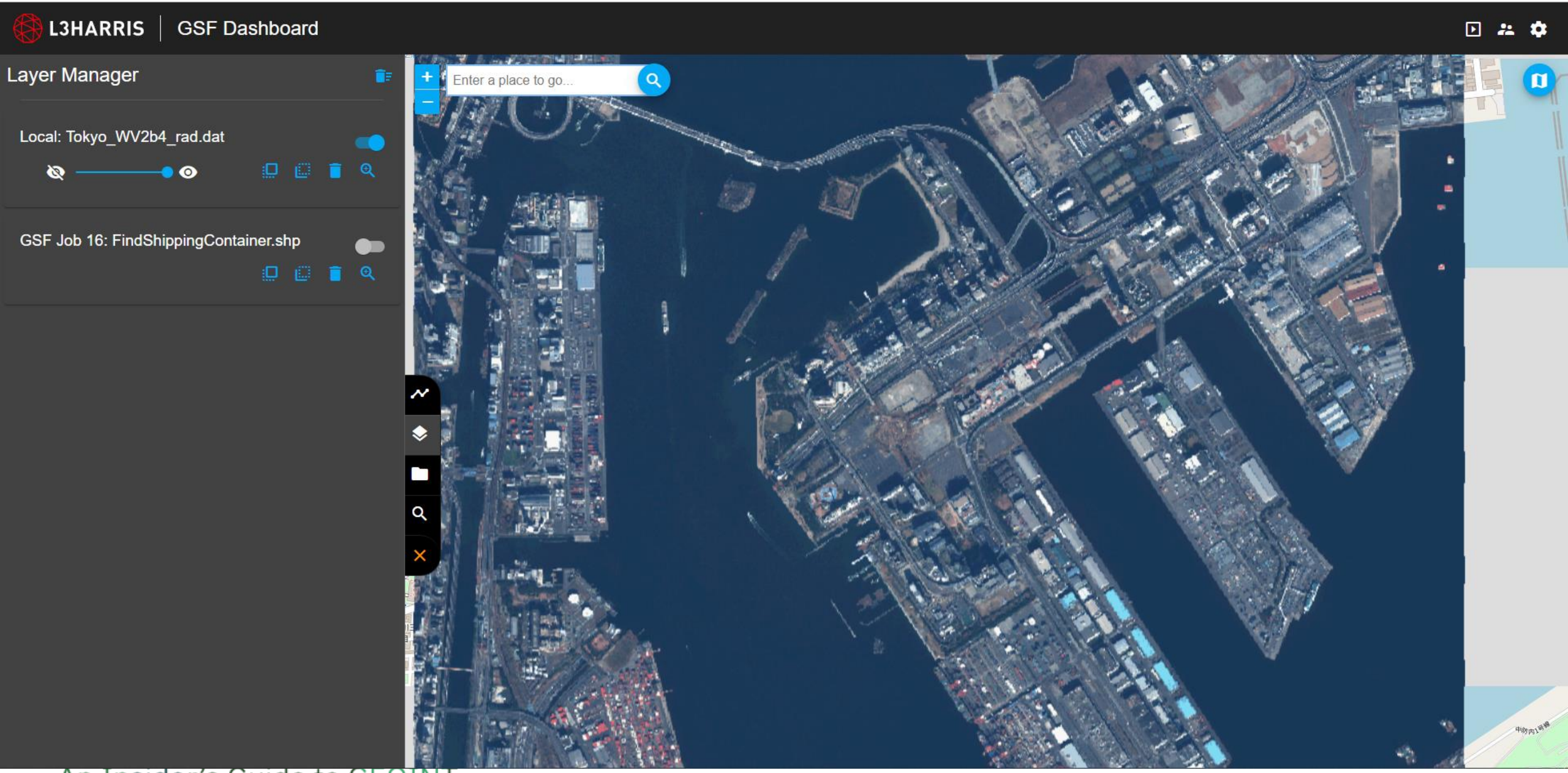
ENVIpalooza
An Insider's Guide to GEOINT

Run on ENVI Server



- Can initiate the spectral processing from the Modeler to run on a separate Server
- For this example, we will use the same machine to act as the ENVI Server
- Note that the results can be displayed in Desktop ENVI provided that the Desktop and ENVI Server share the output directory

Run in a Web Client



Conclusions

- ENVI / IDL Technologies allow for development of spectral analysis processing tools/workflows that can be utilized from Desktop to Enterprise including allowing for pushing processing to external Servers: **Write Once – Use Multiple Ways**
- Multispectral images usually do not have sufficient dimensionality to accommodate all targets to be classified, a DE process is used to alleviate this dilemma.
- This presentation demonstrates how this DE allows the ACE hyperspectral classifier to be utilized for effective classification of targets in an urban environment using WorldView-2 multispectral imagery.
- The use of models made the process of testing the classifier and comparing the results much more efficient, compared to writing API code or invoking tools through a user interface.

DE solves the Pigeon Hole problem and allow hyperspectral detectors/classifiers to work well with multispectral imagery

Dan.Heinz@L3Harris.com

Greg.Terrie@L3Harris.com

Thomas.Bahr@L3Harris.com