Surveillance Buoy

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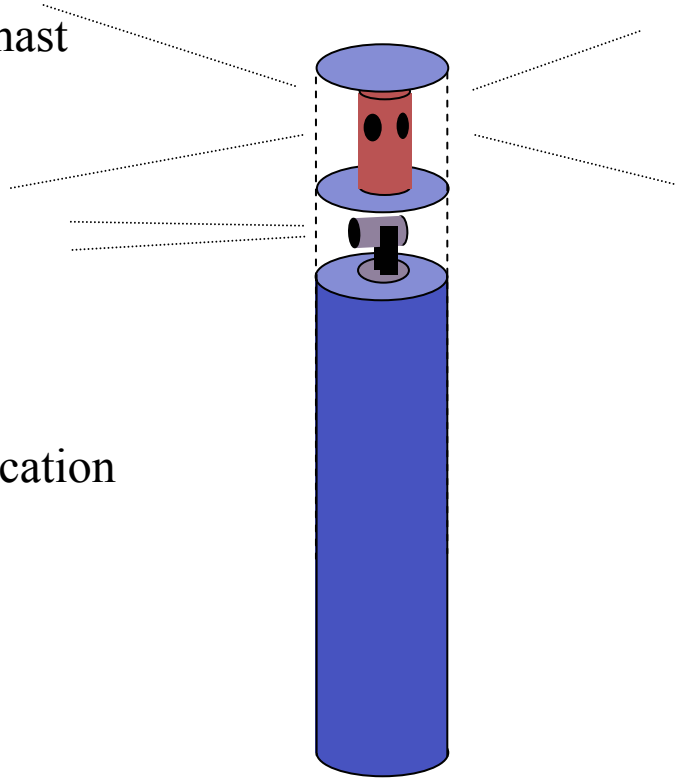
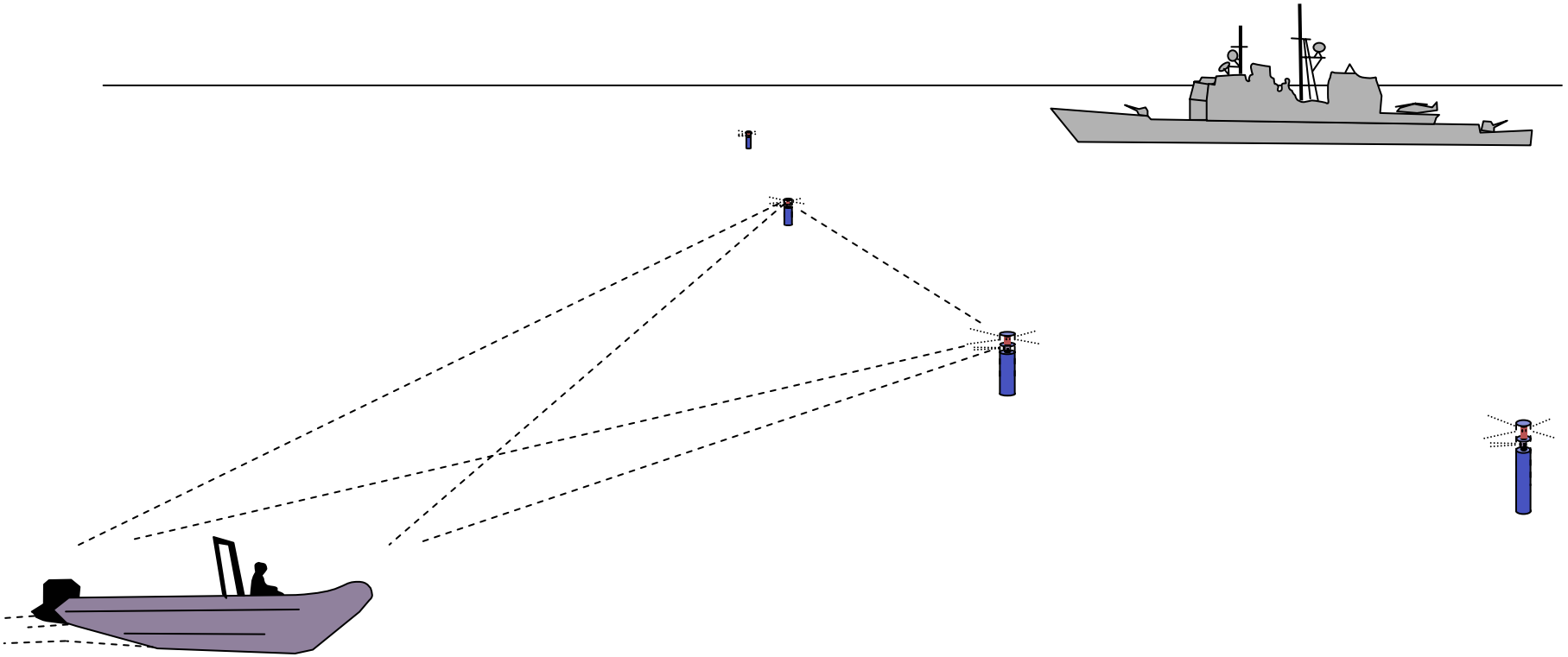
Surveillance Buoy Project

Algorithms for buoy-based maritime surveillance

- ONR technology development on an inexpensive platform
  - Apply developments to a surfaced UUV with an EO mast
  - Secondary interest in a standalone surveillance buoy
- Full 360 degree ship and watercraft detection
  - Horizon / shoreline in all directions for stabilization
  - Multi-hypothesis ship segmentation
- Cued pan-tilt-zoom analysis
  - Close-in view to confirm detection and enable classification
- Watercraft trajectory estimation
  - Track watercraft and build trajectory model over time
- Watercraft classification
  - Collect large database of images to train classifier
  - Enable multi-class discrimination
- Install and test on buoy



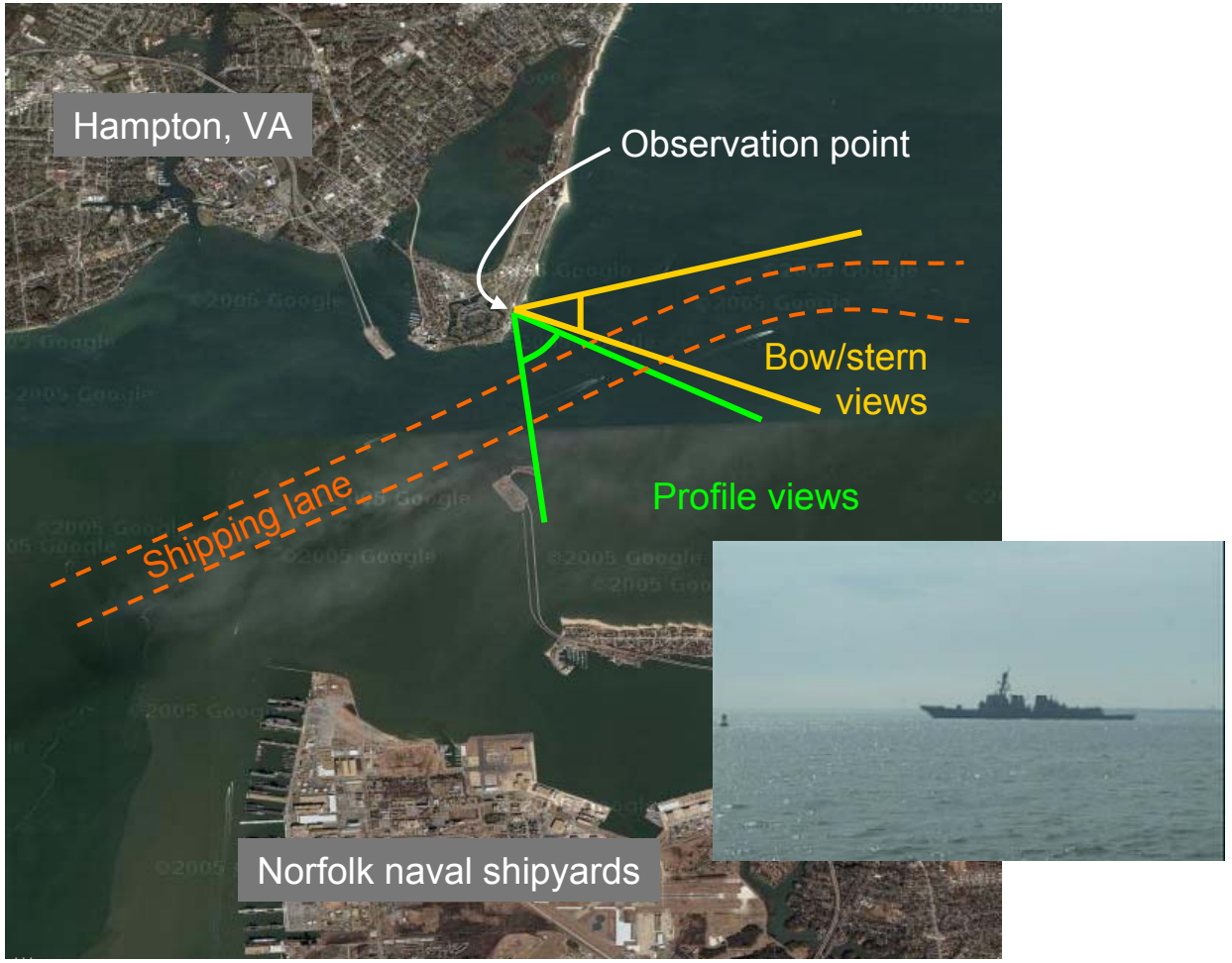
Concept: Buoy Array



Current Achievements

- Data collection (ongoing)
  - Over 2 months of imagery of commercial and military shipping passing Norfolk VA shipping lane
  - Automatic detection of ships in images
- Classification
  - Developed feature sets
  - Manually classified ships in imagery (ground truth)
  - Preliminary training of classifier
- Test and Evaluation
  - Response Operator Curve (ROC) for a variety of classes

Data Collection Site

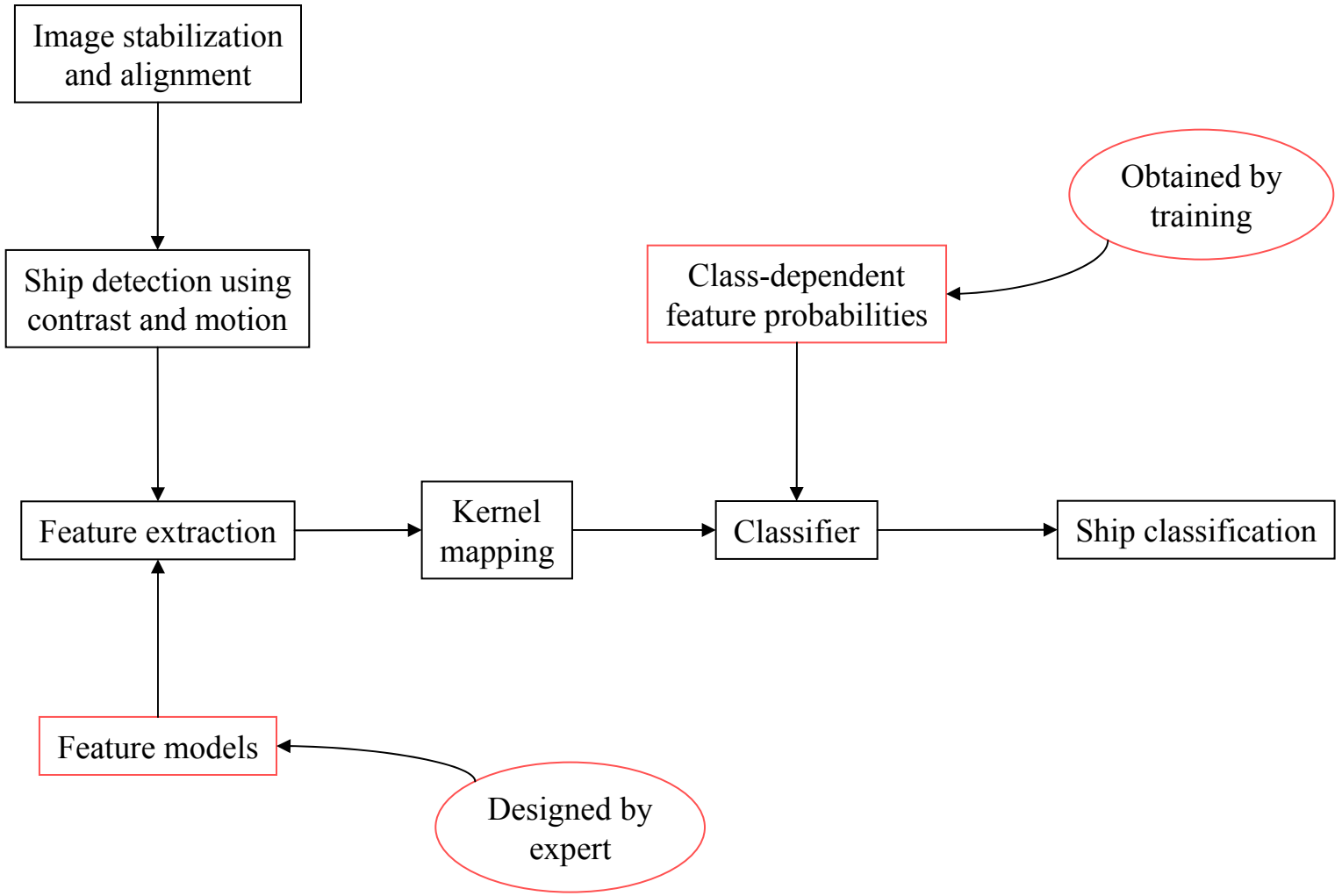


Copyright Google Maps

Data Collection Hardware

- Sony camcorder 3CCD
- Time-delay recording:
  - 0.5 sec video every 30 sec
  - 1 DV tape lasts 3.5 days
- Over 2 months of images so far

Classification Flow Chart



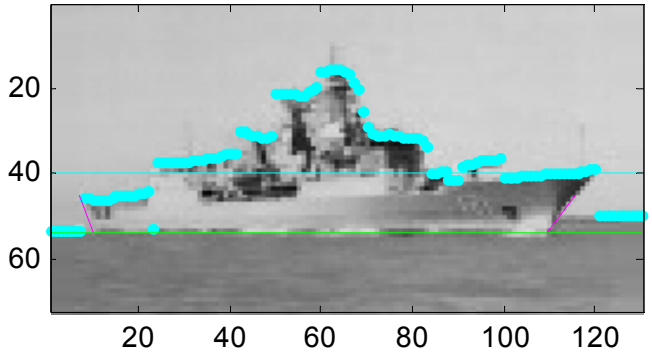
Automatic Ship Detection

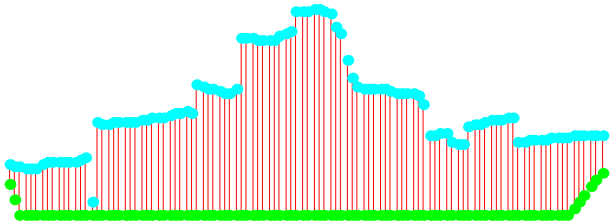
1. Collect images
2. Stabilize
3. Use contrast and change detection to locate ships in video

Classes

- Military
  - Aircraft, helicopter carriers
  - Frigate, destroyer, cruiser, transport
  - Gunboat, cutter
  - Submarine
  - RHIB
- Commercial
  - Barge
  - Cargo freighter
  - Dredger, Sailboat
  - Motorboat
  - Tugboat
- Other
  - Other
  - Partial
  - Not a ship

Features

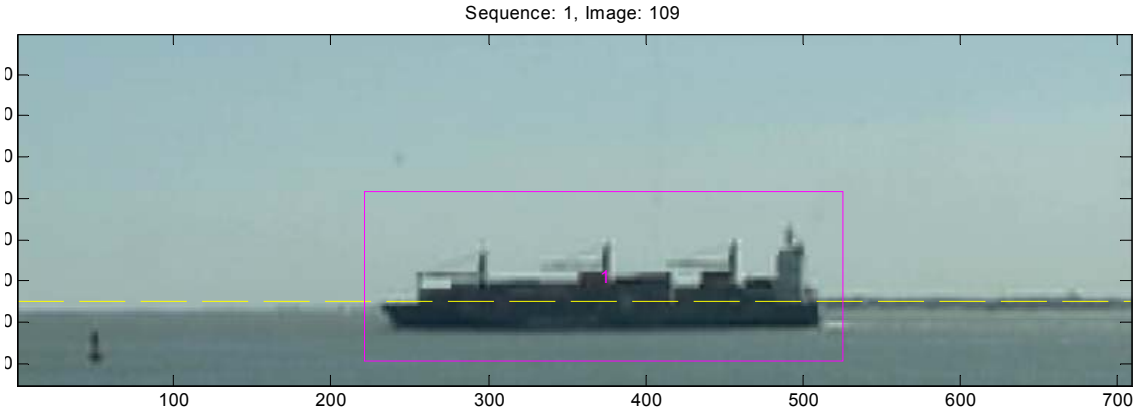




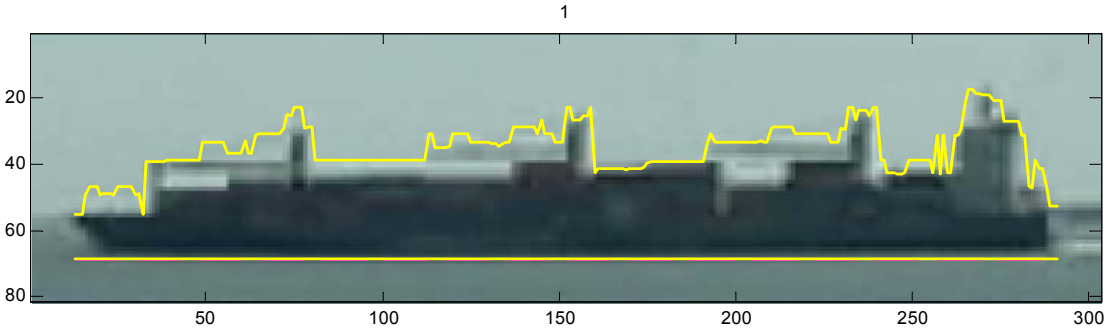
- Candidate Features:
  - Moments
  - Profile heights
  - Gradient ratios for each column: $g_x/(g_x+g_y)$

Feature Extraction

Auto detection:

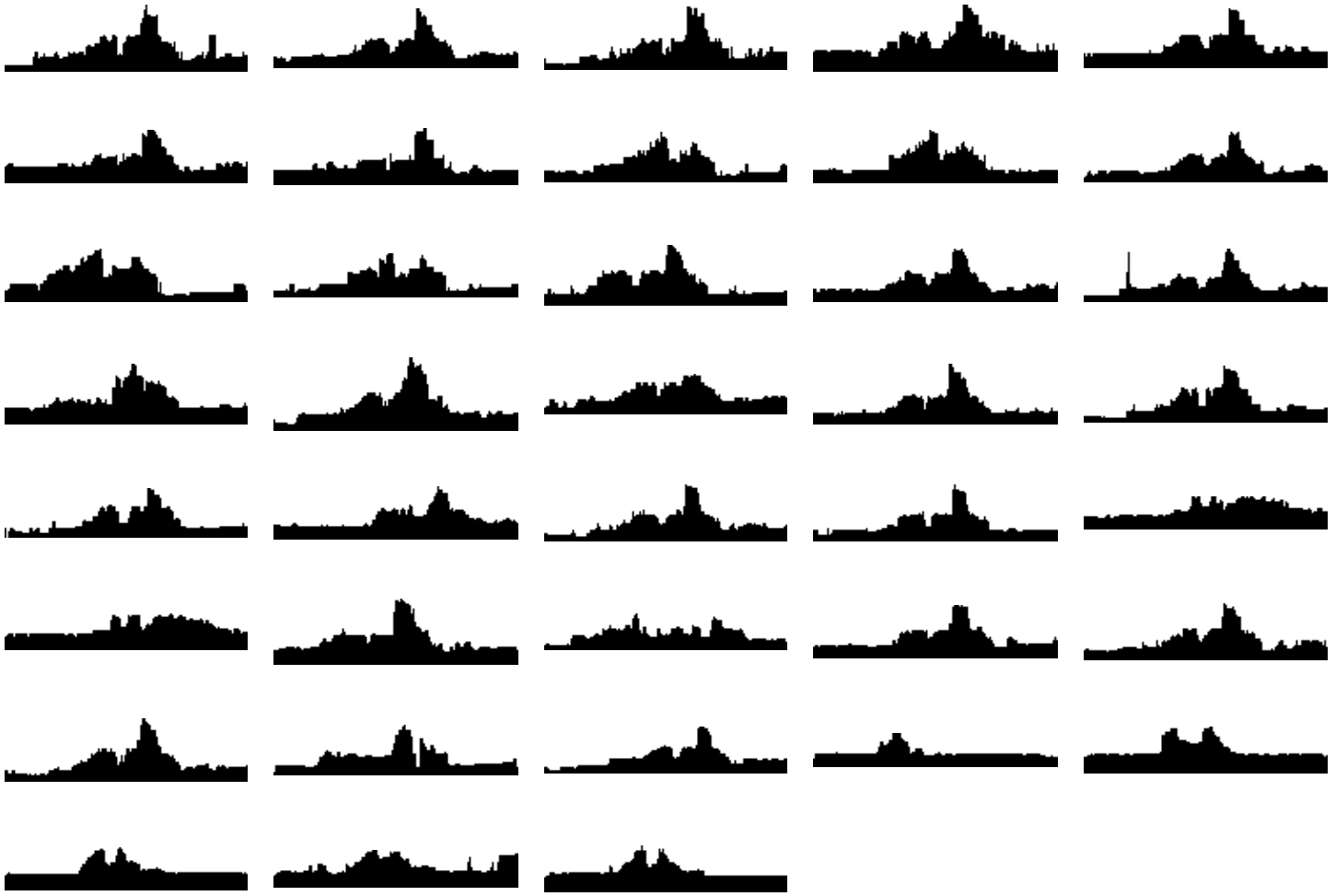


Auto profile estimation:

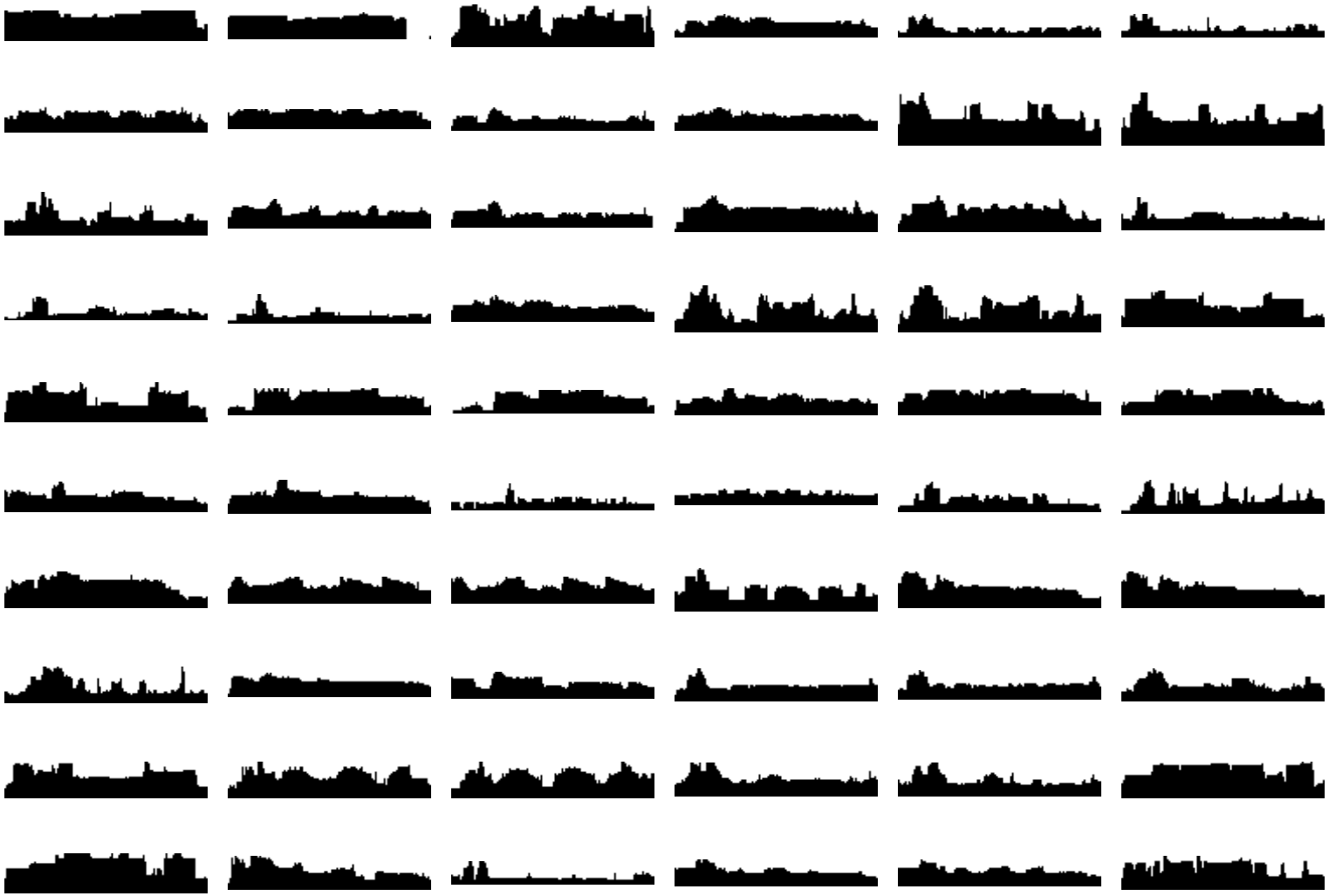


NORTHROP GRUMMAN
Electronic Systems

38 Fighters & Carriers

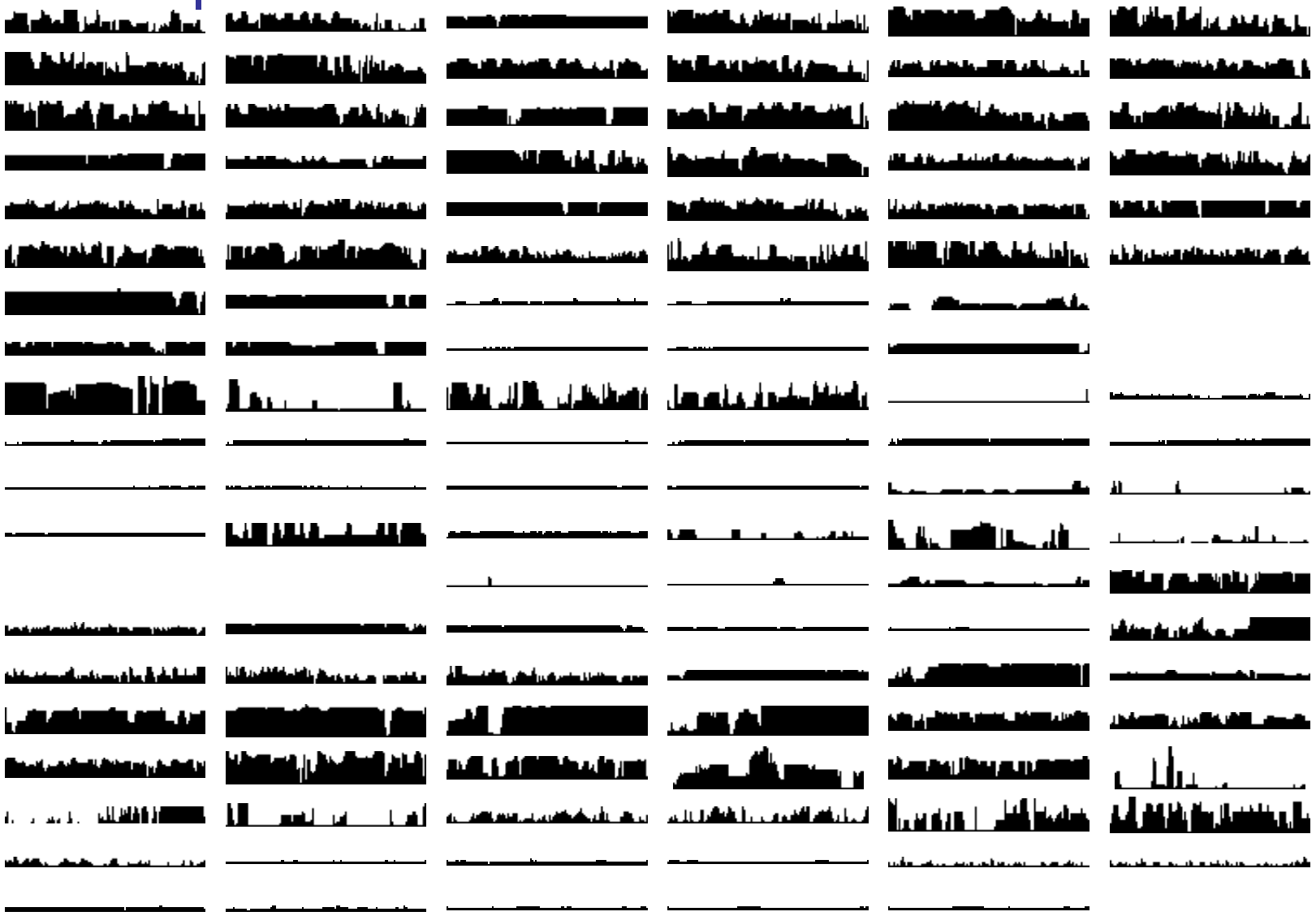


116 Freighters



128 Barges

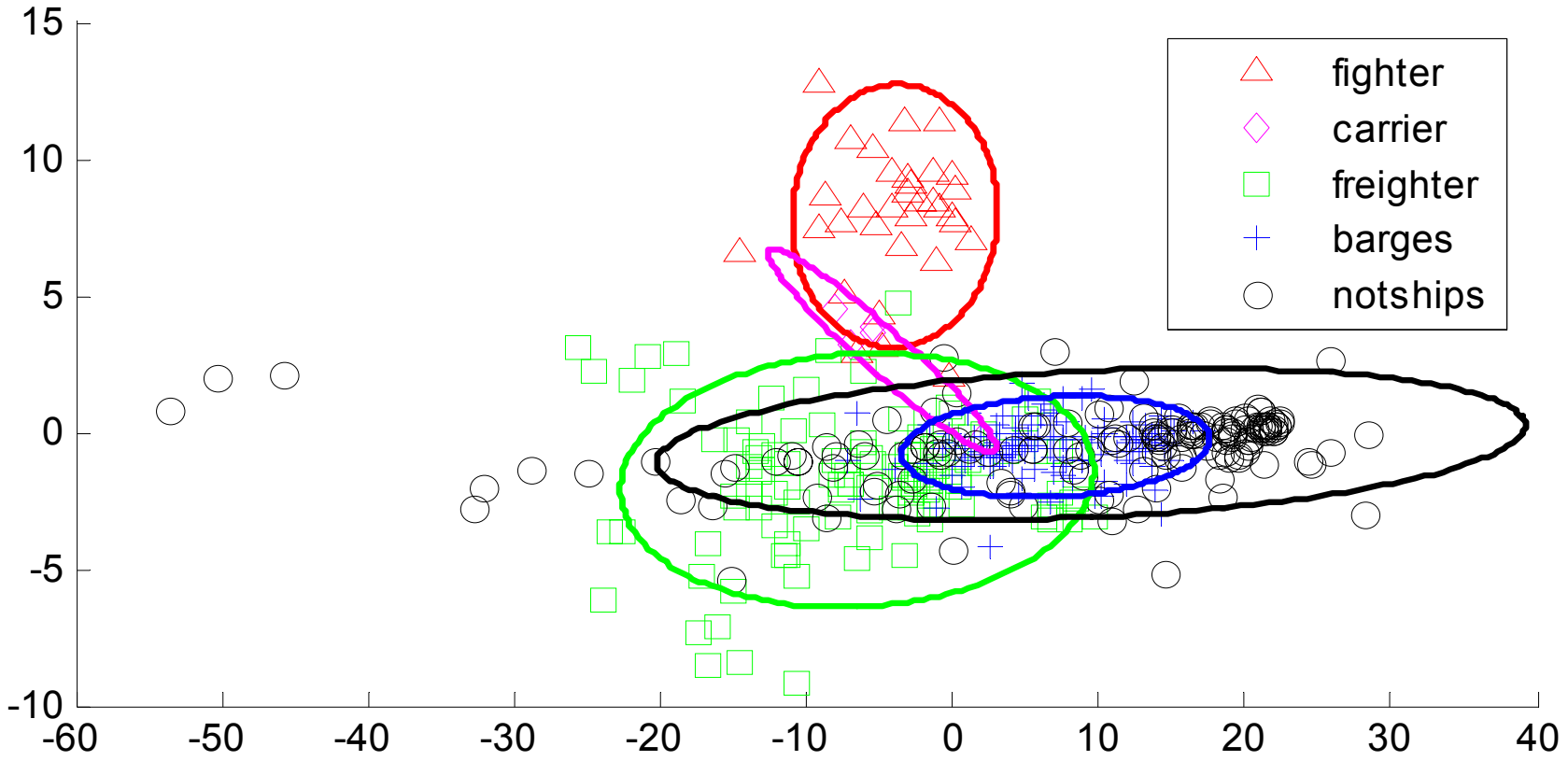
Not Ships



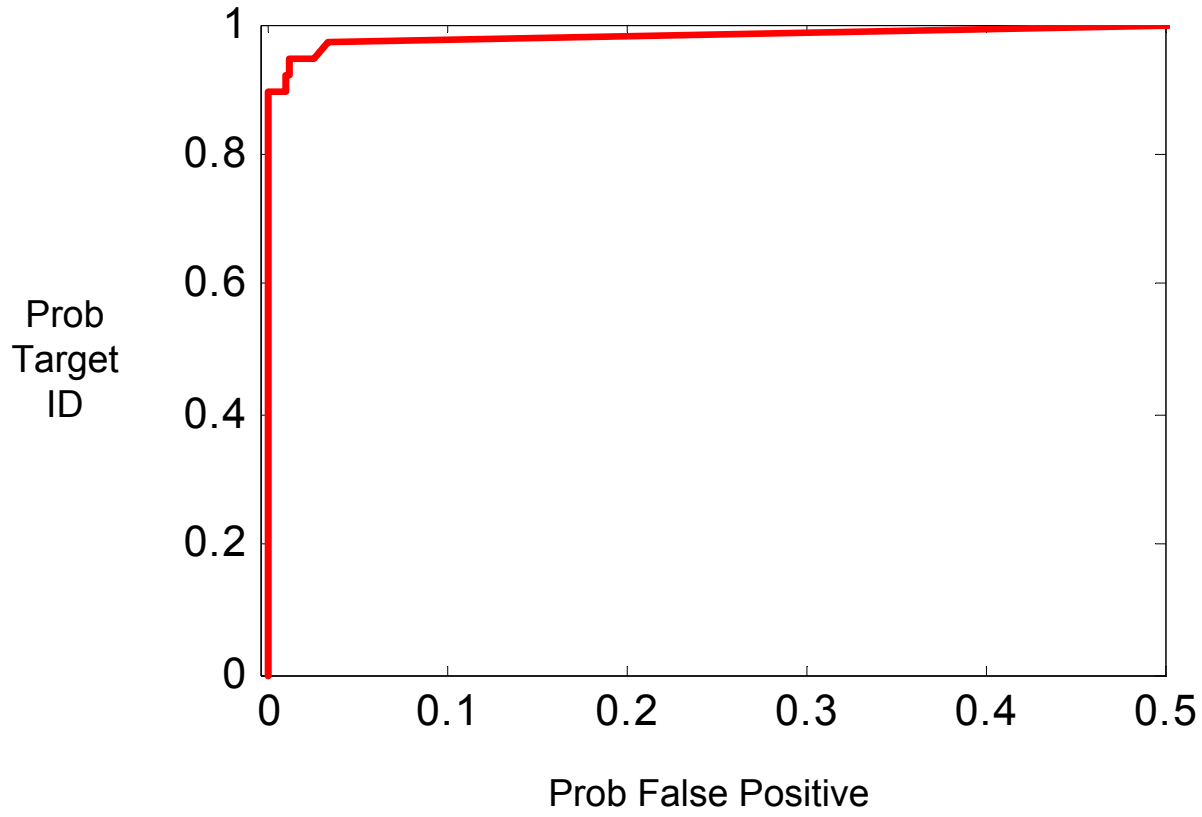
Classifier

- Bayesian classifier with Gaussian density models
- Reduced parameter space using Principal Component Analysis (PCA)
  - 128 dimensions to 4 dimensions
- Manually classified image clips for training
  - Ground truth
- Evaluated using leave-one-out technique

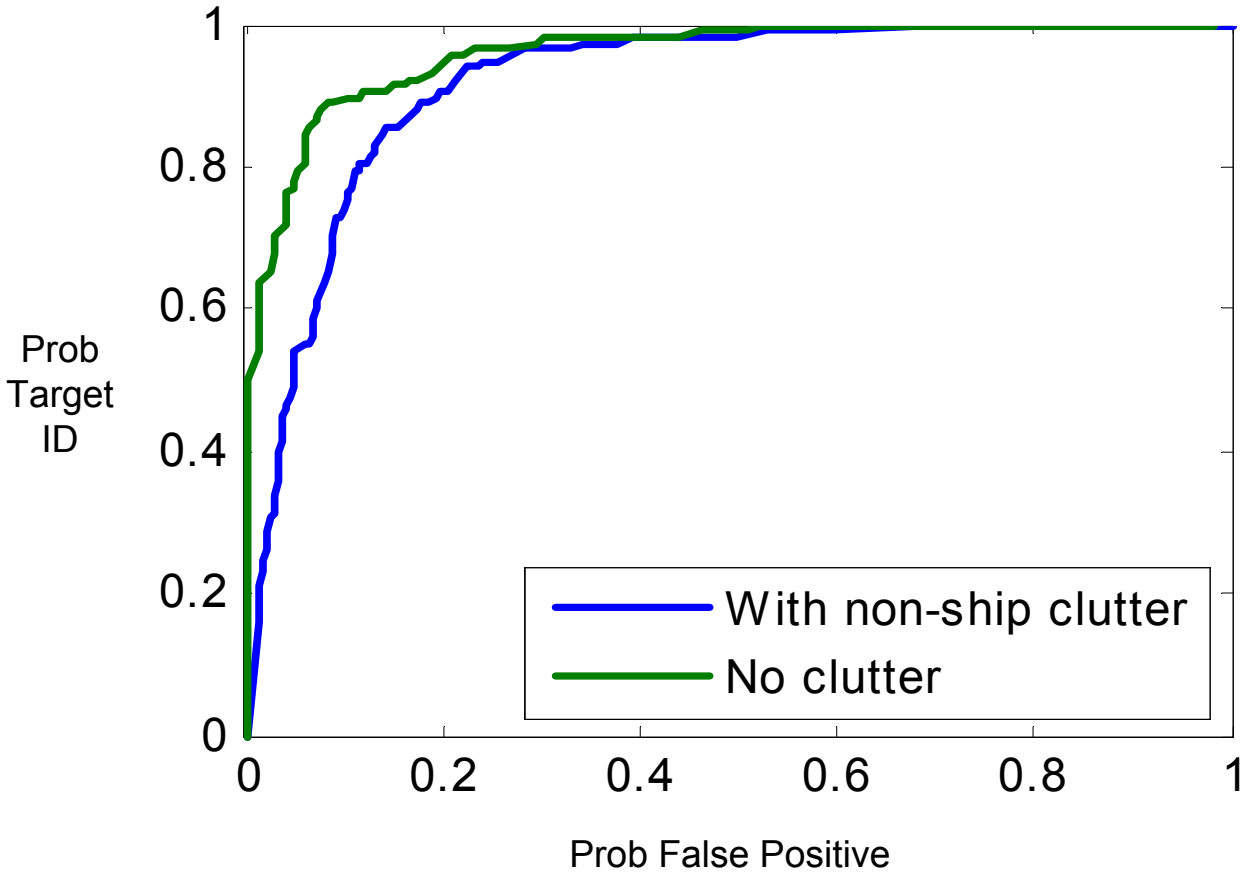
Top 2 Profile Dimensions with PCA



Fighter + Carrier ROC



Freighter ROC



Ongoing work

- Developing new features
  - Enable classification of smaller craft
- Gathering more data
- Gathering multiple viewing angles
- Use motion (tracking) to mitigate false alarms