

WIDE SECTOR ALS DATA DRIVEN NAVIGATION

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AHEAD LOOKING SONAR HIGH LEVEL DEFINITIONS

CAPABILITIES OVERVIEW

- **Object Detection & Avoidance Capabilities**

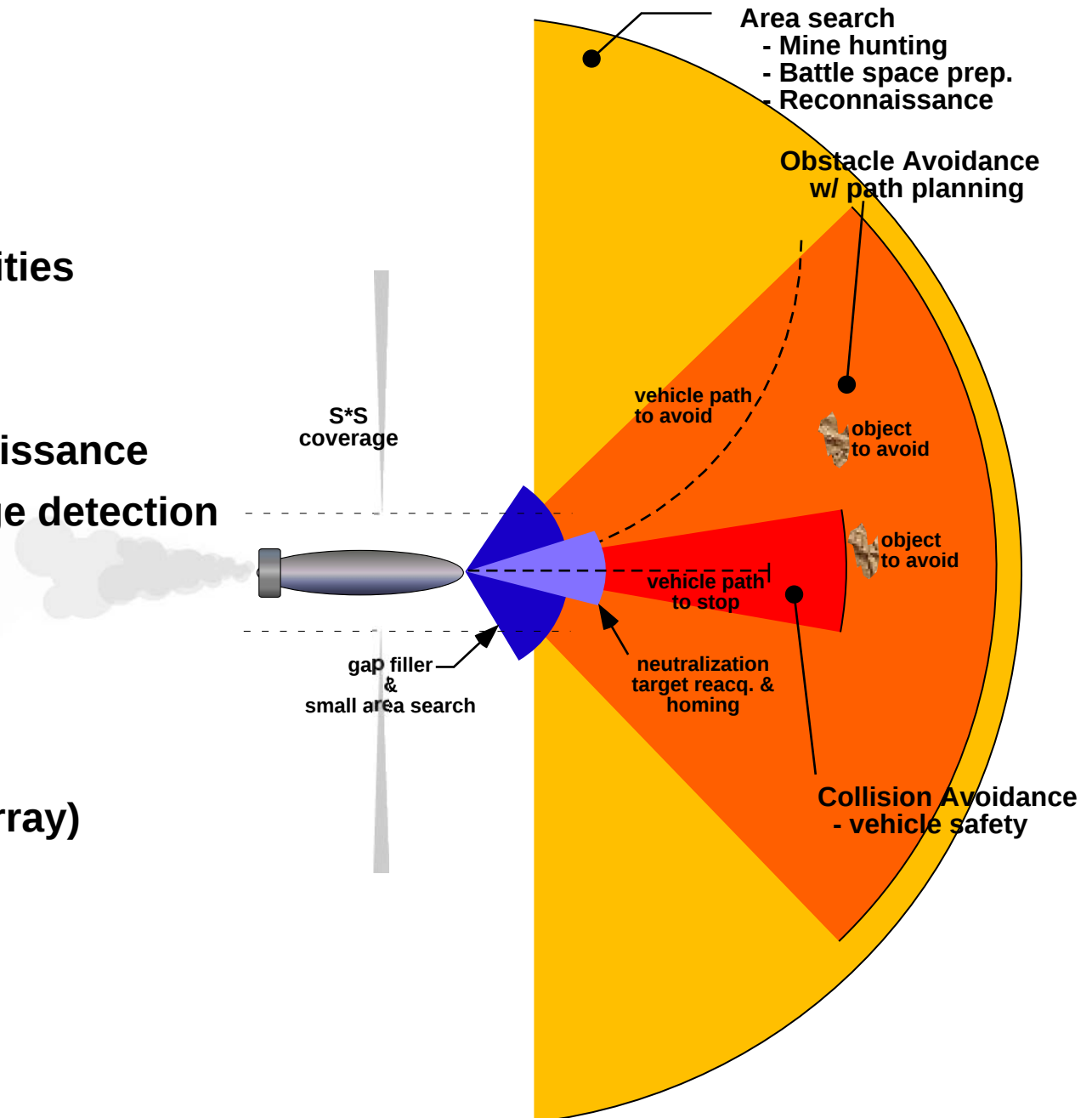
- collision avoidance
- obstacle avoidance
- gap filler
- neutralization

- **Area Search & Survey Capabilities**

- area search
- area mapping
- battle space prep & reconnaissance
- target reacquisition & change detection

- **Supporting Capabilities**

- navigation
 - real time aiding & re-nav
- acoustic comm (high gain array)
- environment estimation



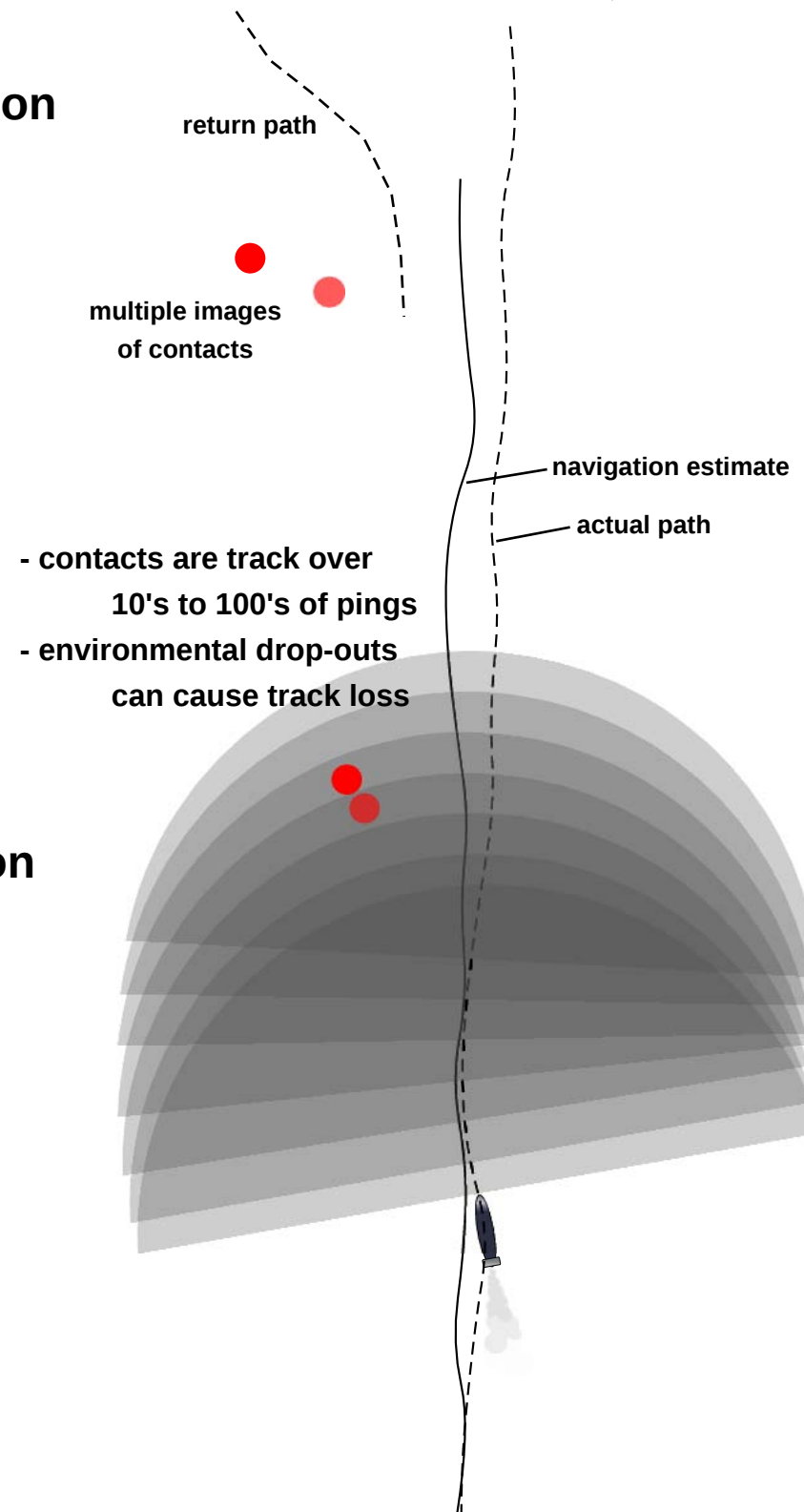
CONTACT TRACKING & NAVIGATION

- **Wide-Sector Multi-Beam Sonar Data Based Navigation**

- ping-to-ping correlations
 - very accurate within beam direction
 - short-term navigation estimate
 - sensitive to numerous factors
- multi-ping contact tracking
 - multiple contact tracking
 - longer term navigation estimate
 - more robust to environmental factors
- track-to-track contact tracking/locking
 - “position reacquisition” or mission re-navigation
 - multiple contact tracking/locking
 - long term navigation estimate

- **Issues**

- contact track & re-acquisition loss
 - environment effects (within a track)
 - large long term navigation errors (track-track)
- contact reacquisition
 - too low or high density
 - aspect changes

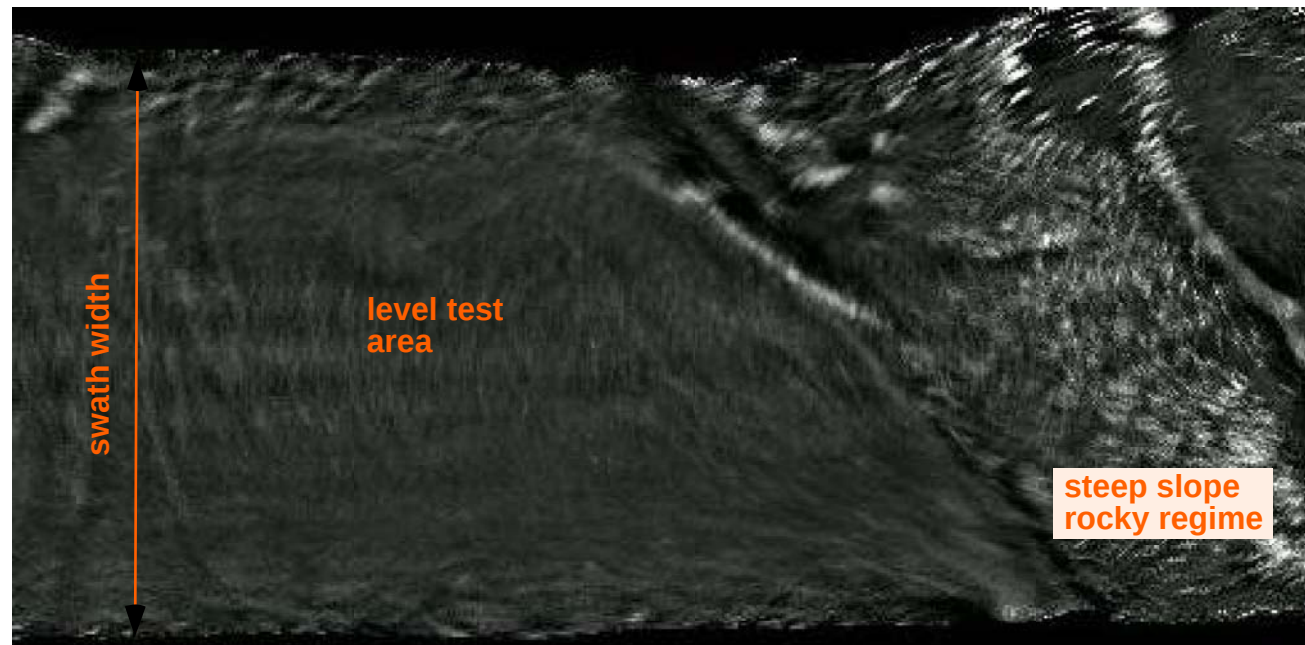


WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- **Historical Data Set**
 - a few passes over the same test area
 - relatively flat test area w/ steep rocky ridge to side
 - calibrated test targets for basic sensor evaluation
 - 3 overlapping passes in test field
 - primary nav: platform INU
- **In-lab post-processing tools**
 - feature tracker
 - feature based navigation estimation
 - post-INU Kalman filter
 - multi-ping scene merger
- **Ping-2-ping nav/tracking errors**
 - targets appear as clusters of contact
- **Pass-2-pass nav errors**
 - target and clusters diverge
- **w/o data-driven re-nav**
 - terrain features: visible
 - discrete targets: hidden

3 Pass Merged Image

- wide swath ALS data
- intensity merger

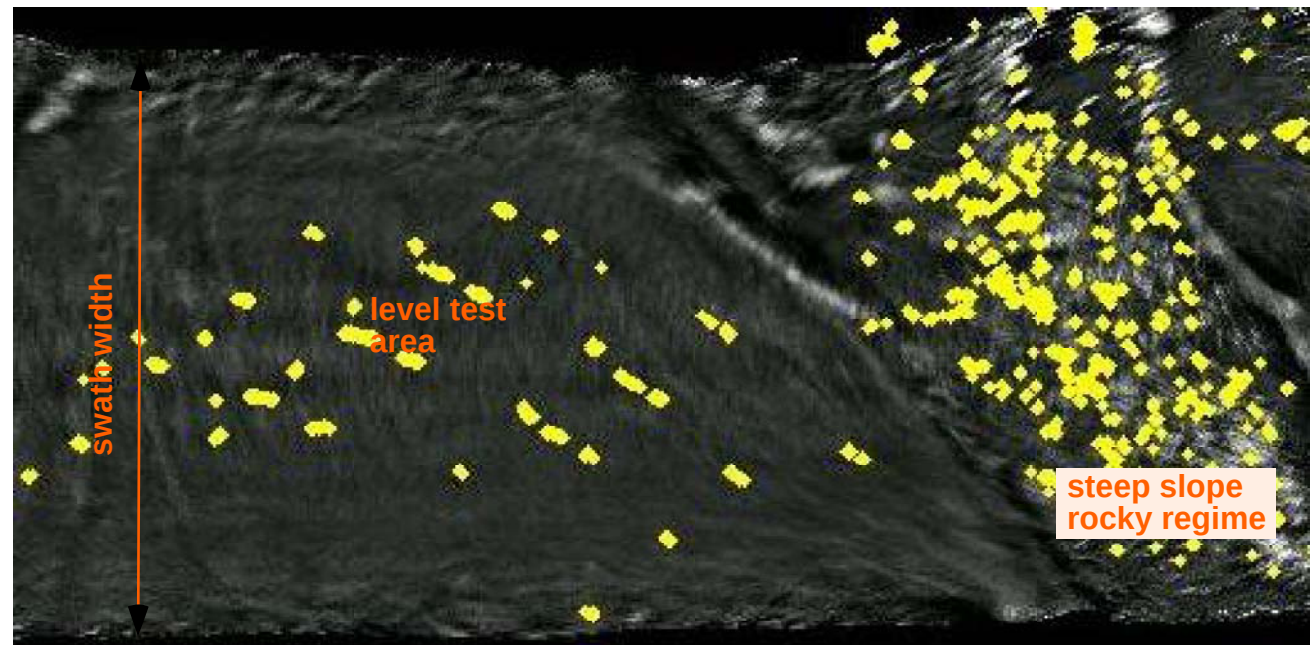


WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- Post-processing contact tracker
- 3 passes
- Individual objects appear multiple time
 - track-to-track
 - some within track splits
- Rocky slope
 - highly cluttered
- Test area appears marginally cluttered

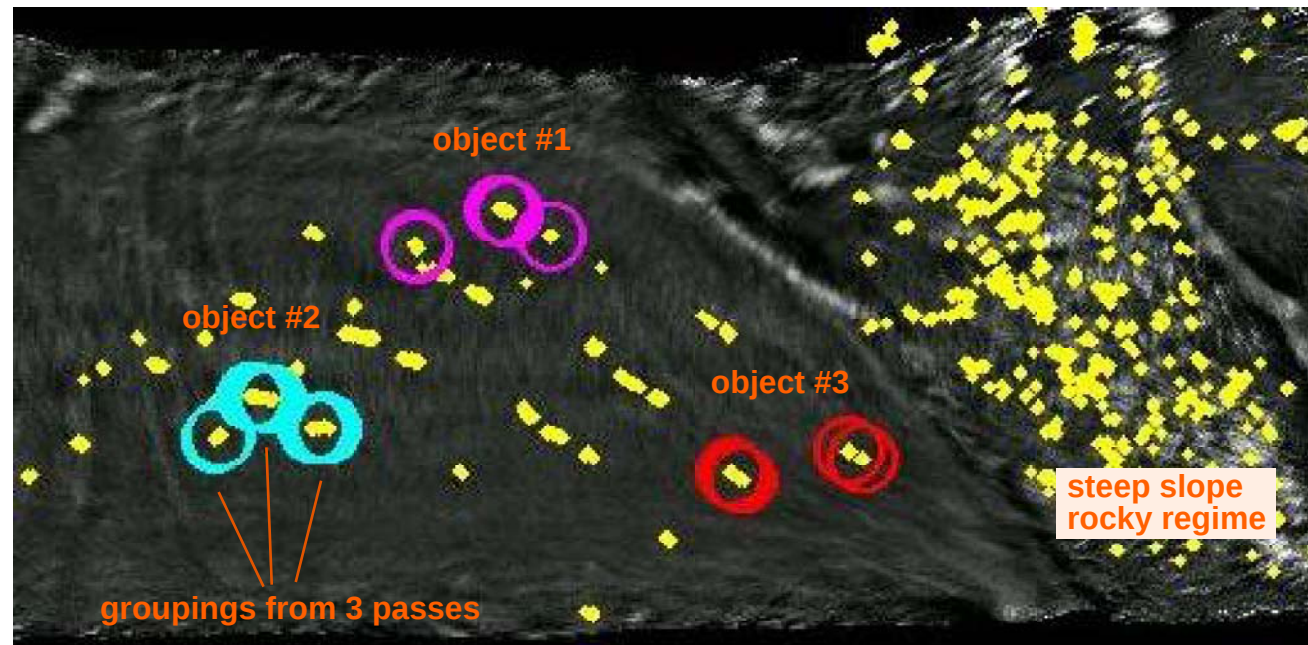
3 Pass Merged Image

- wide swath ALS data
- intensity merger



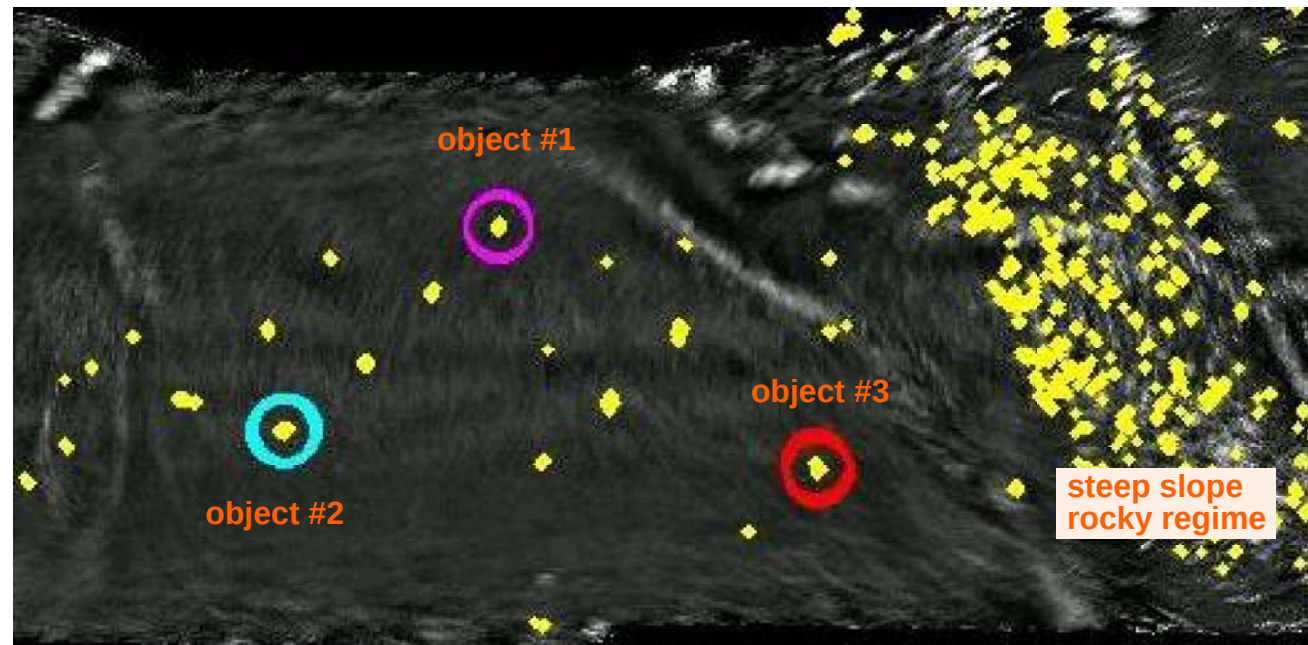
WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- 3 objects ID's from intra-run patterns
- individual objects appear multiple times
 - track-to-track
 - some within track splits
- clusters are re-nav anchor points
 - Kalman smoother



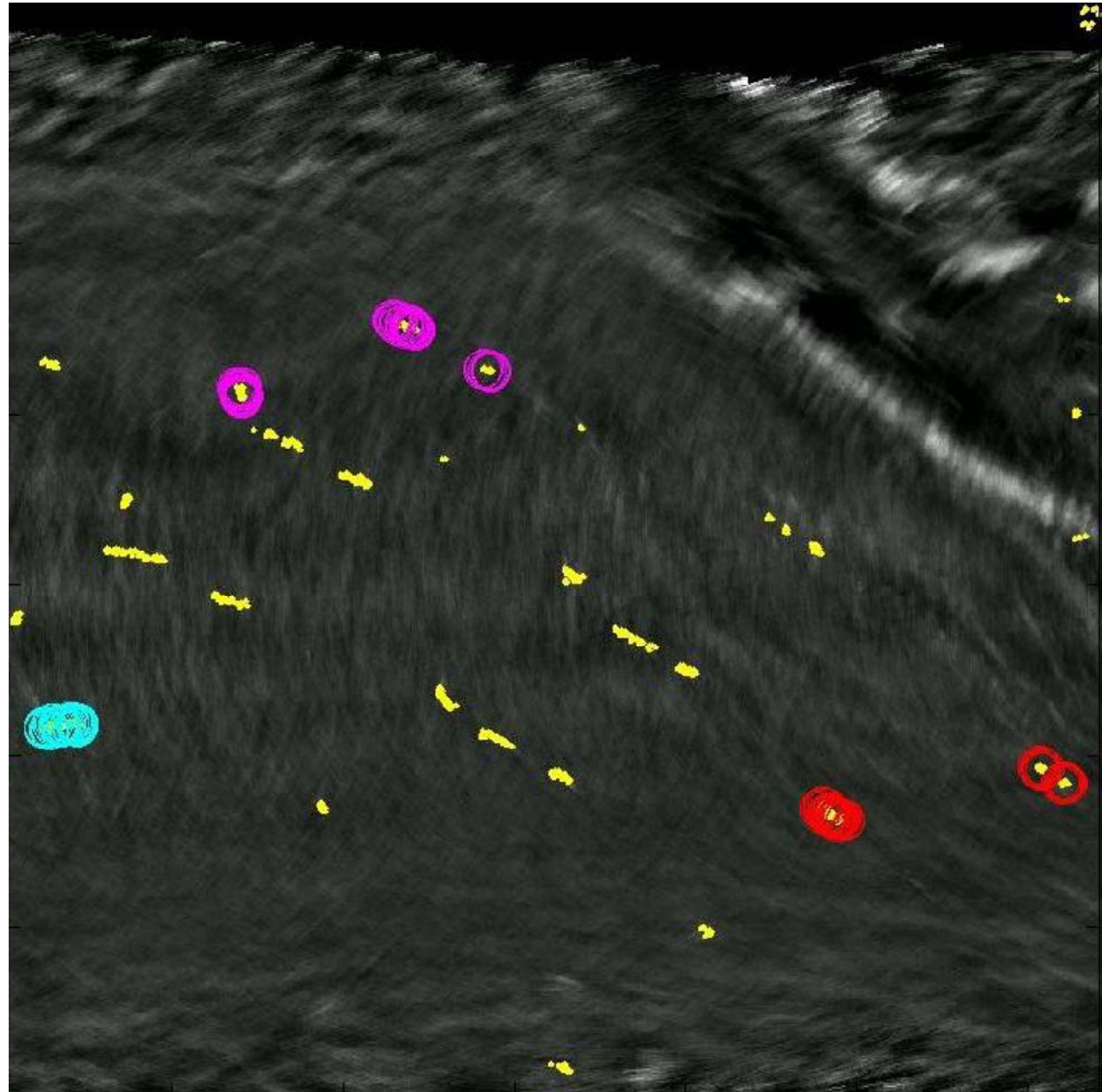
WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- Identified discrete objects used for locking navigation points
- Re-Nav w/ Kalman smoother over full multi-pass run
- Individual objects cluster
 - track-to-track & intra-track splits are removed



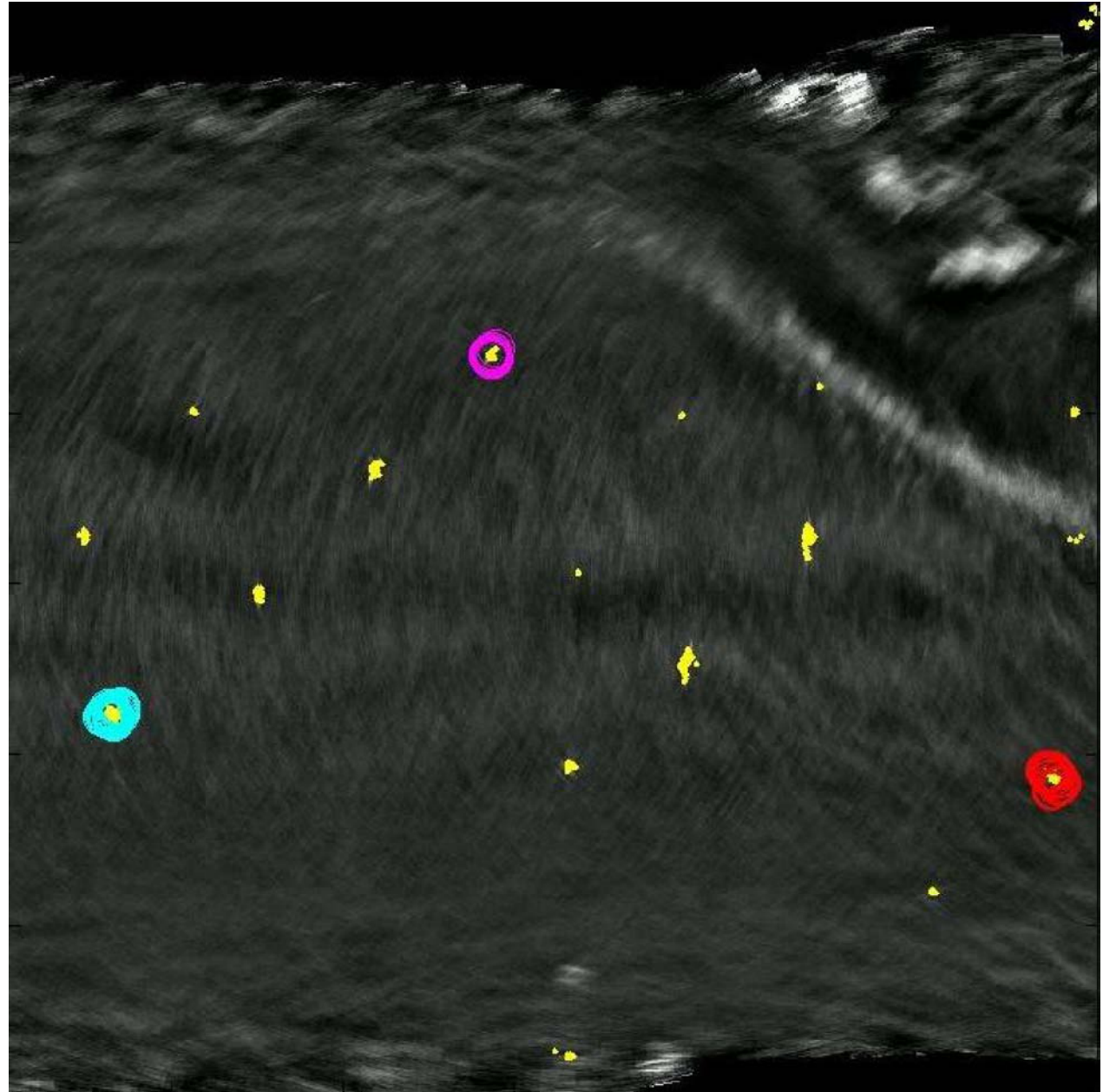
WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- contacts before Re-Nav
i.e. INU only navigation
- individual contact tracks
 - ping-2-ping spreading
 - loss within tracks



WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- contacts after Re-Nav



WIDE SECTOR ALS DATA DRIVEN NAVIGATION

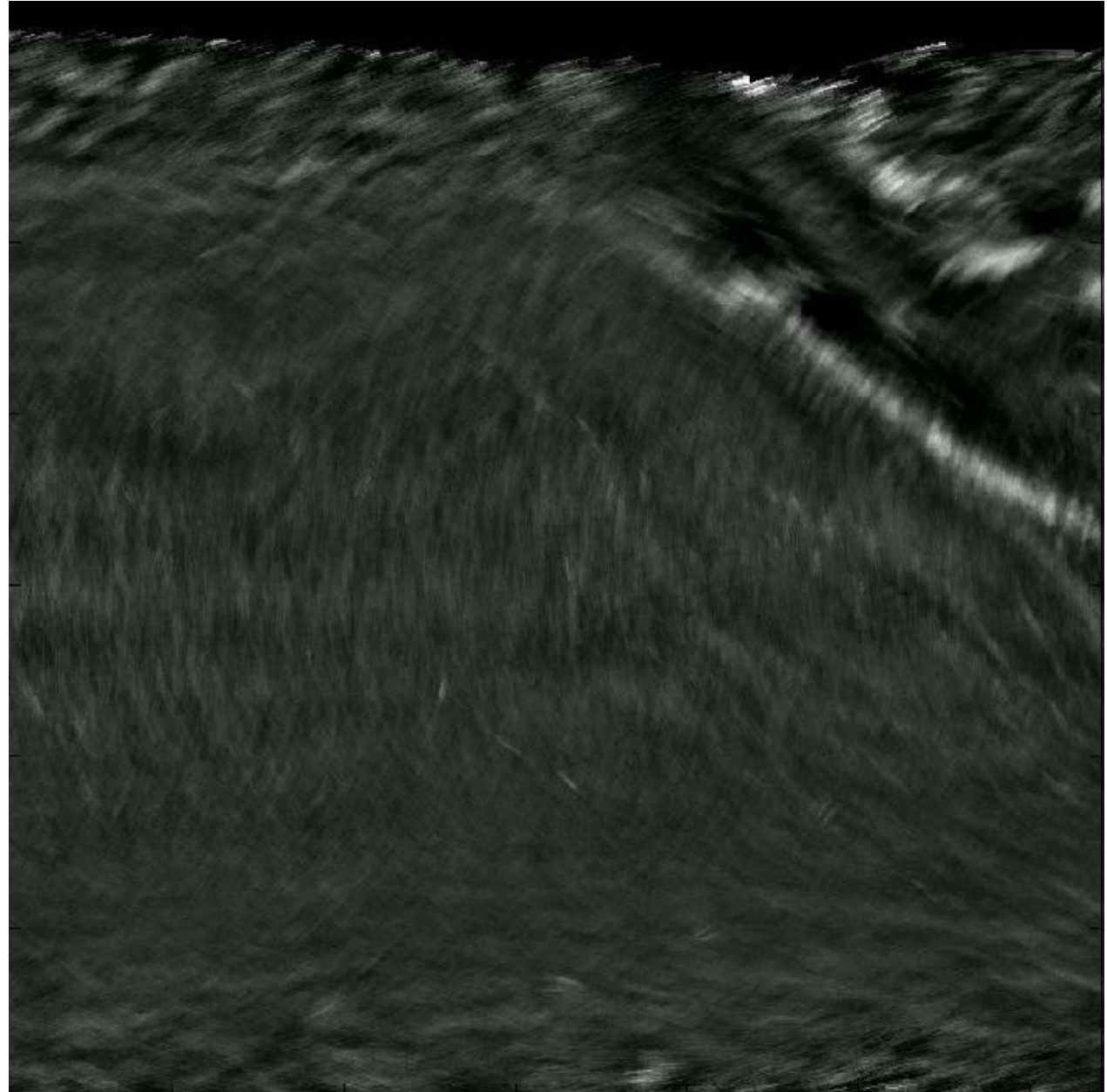
LOCALIZATION IMPROVEMENT

	Avg. Error (scaled)	Error Std. Dev. (scaled)
Pre-ReNav	100	34
1 Object Lock	10	3.3
3 Object Lock	9.0	5.3
10 Object Lock	2.0	1.1

- statistics computed for 10 discrete objects
- statistics scaled to a standard dist of "100"

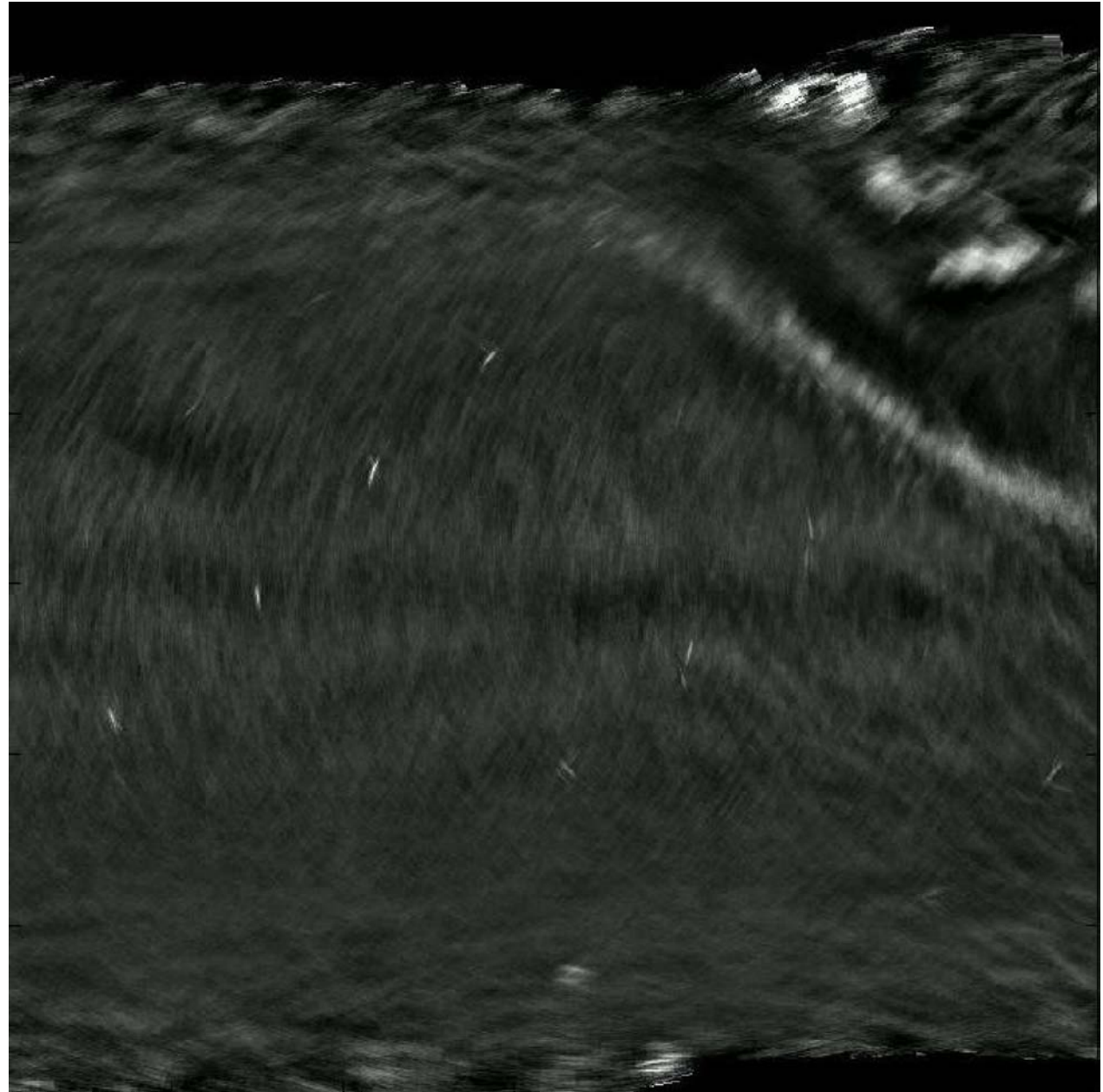
WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- image before Re-Nav



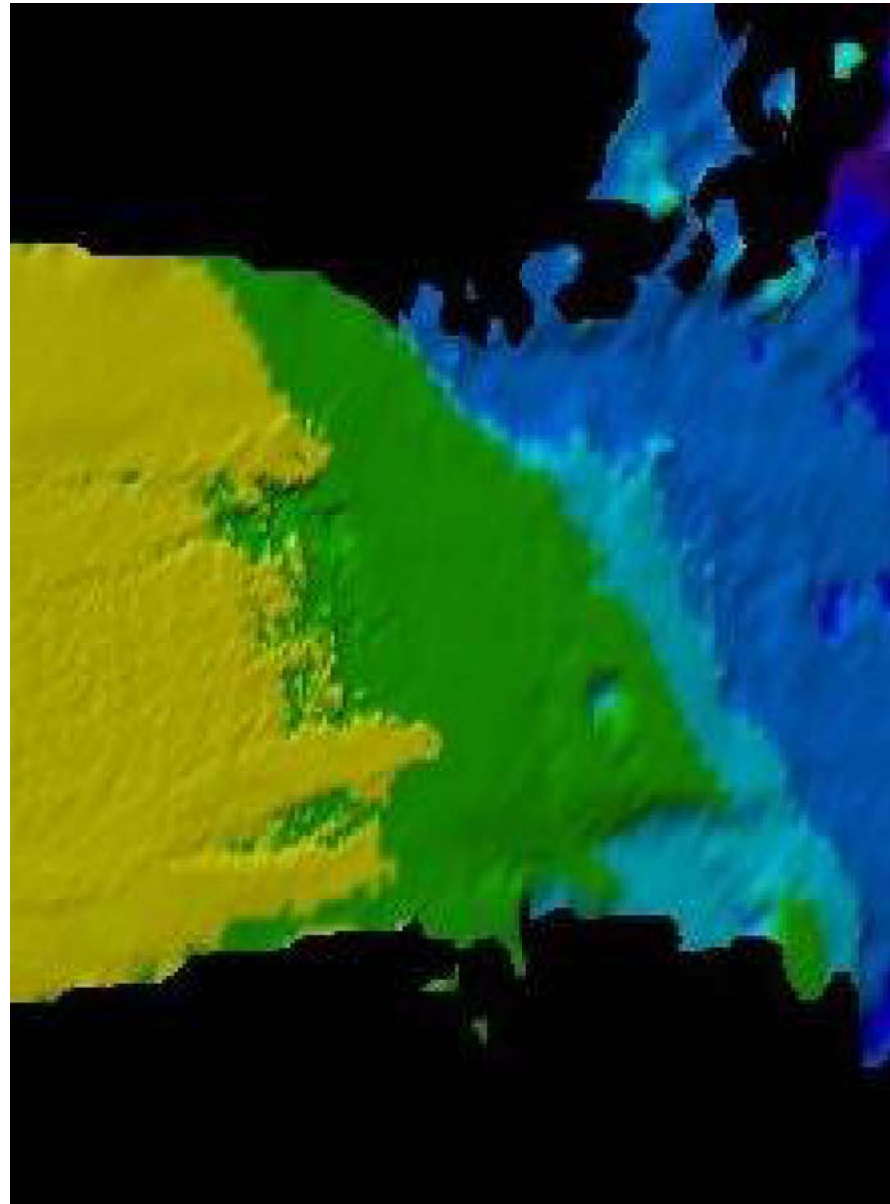
WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- image after Re-Nav



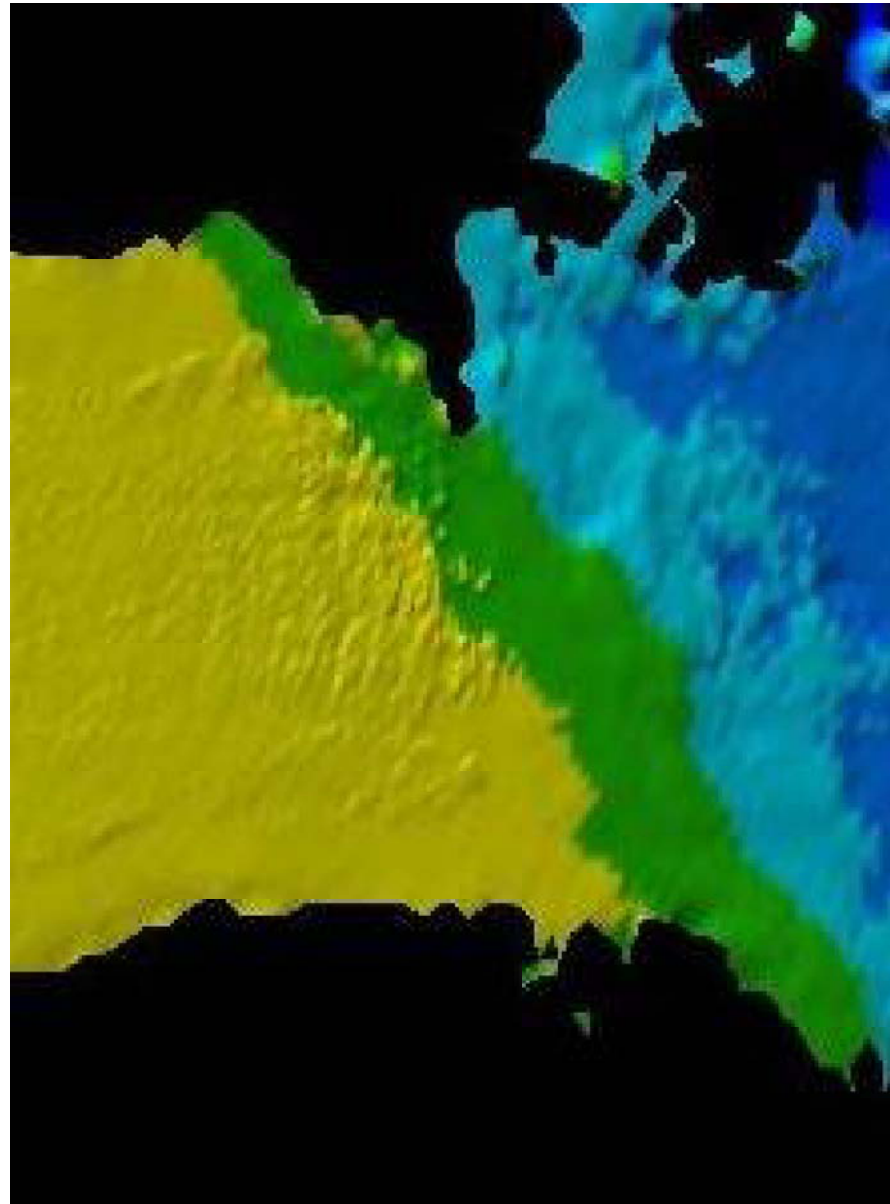
WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- bathymetry before Re-Nav
- bathymetry sensor on host platform
- multi-merger
 - quality screening & processing
 - improve terrain estimates



WIDE SECTOR ALS MULTI-PING MERGED IMAGE

- bathymetry after Re-Nav
- discrete target based reNav used to align bathymetry merger
- contours clearly defined



WIDE SECTOR ALS DATA DRIVEN NAVIGATION

SUMMARY

- **A variety of vehicle navigation estimates**
 - ping-to-ping correlations
 - ping-to-ping contact tracking
 - track-to-track reacquisition
- **Aid to other on-board navigation systems**
- **Follow-on navigation filter**
- **Stand-alone estimate**
- **post-run re-navigation**
- **Can provide an order of magnitude improvement of inertial navigation solutions**
- **Issues**
 - environmental conditions can cause track splitting
 - significant initial position errors challenge “contact locking”
 - extremes of contact density limit capability to lock