The Sensor Optimization and Stealth Management Working Group

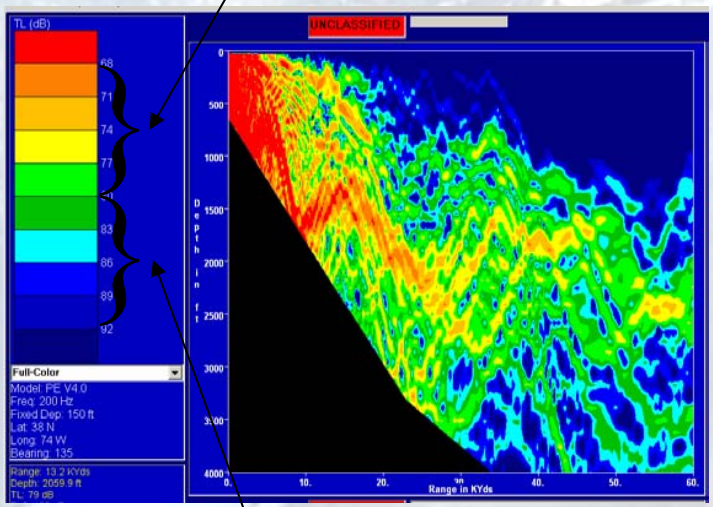
- SOWG Charter and Membership
- Uncertainty
  - SOWG Recommendation for APB-02
  - Future Refinements
  - Examples/Applications
- Signal Excess
  - Examples of current fleet use

SOWG Charter and Membership

- Charter (digest):
  - Recommend models, algorithms, databases for use in the Sonar Tactical Decision Aid (STDA)
- Membership
  - CAPT John Cooke and CAPT Ferd Diemer (N77)
  - Eleanor Holmes (NSWC)
  - John Pierse (APL/JHU)
  - Ruth Keenan (SAIC)
  - Carol Sheppard (ARL:UT)
  - Dave Heming (SUBDEVRON 12)
  - Dick Hodges (Sonalysts)
  - STSCM Bill Horsch (SUBDEVRON 12)
  - STSCS Jim Hess (SUBTRAFAC)

Managing Uncertainty
Current STDA Approach

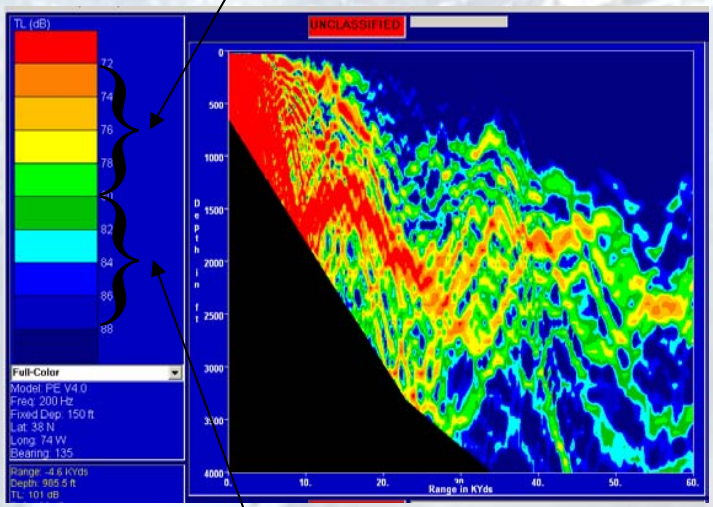
SE = 0 to SE = +12 dB: > 50% Probability of detection



SE = 0 to SE = -12 dB: <50% Probability of detection

Managing Uncertainty
Recommended APB-02 Approach

SE = 0 to SE = +x dB: > 50% Probability of detection



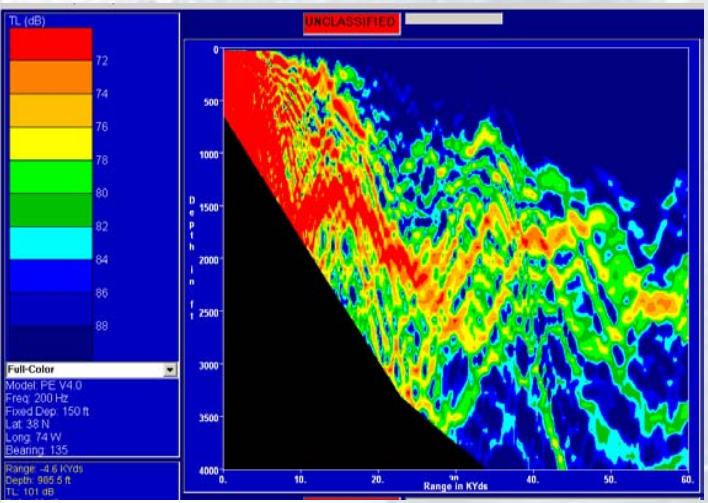
In this example, x = y = 8 dB

SE = 0 to SE = -y dB: <50% Probability of detection

Managing Uncertainty
Recommended APB-02 Approach

$$SE = LS - NW - LE - NRD$$

$$\Delta SE = \sqrt{\Delta LS^2 + \Delta NW^2 + \Delta LE^2 + \Delta NRD^2}$$



LS uncertainty:

ONI, User-defined

NW uncertainty:

TL difference charts

Validated (i.e., HEP) analyses

Otherwise, ± x dB (in classified report)

LE uncertainty:

Historical: ± 5 dB

Modeled: variability statistics

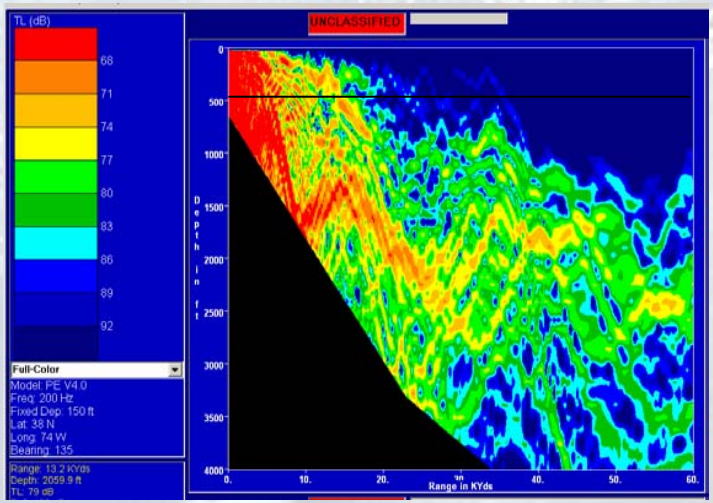
Measured: APB-01 measurement "error"

NRD uncertainty

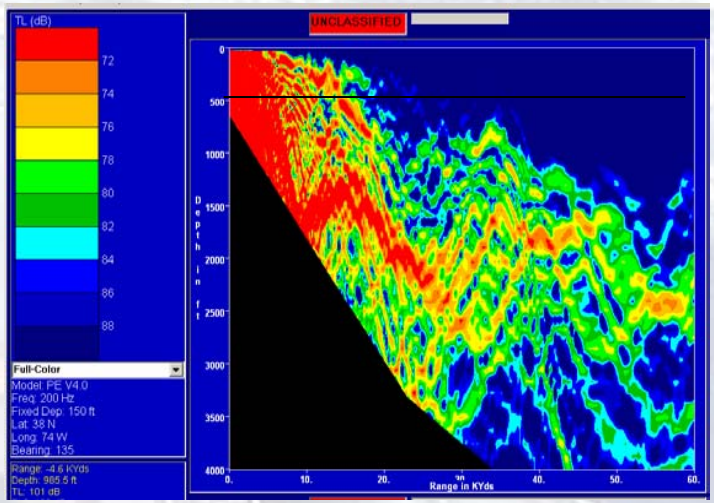
Unalerted vs. alerted vs. cued recommendations

Managing uncertainty – Example of Effect of Recommendation

±12 dB uncertainty



±8 dB uncertainty



Future Refinements to SOWG Uncertainty Recommendation

- Refinement of LS, LE, and NRD terms based on additional sea test data
- Refinement of NW terms based on analyses of OASES' (Phil Abbott) HEP and other measured transmission loss data sets
- Uncertainty FNC

Planning with Uncertainty

Two examples of using uncertainty information to assist with search planning

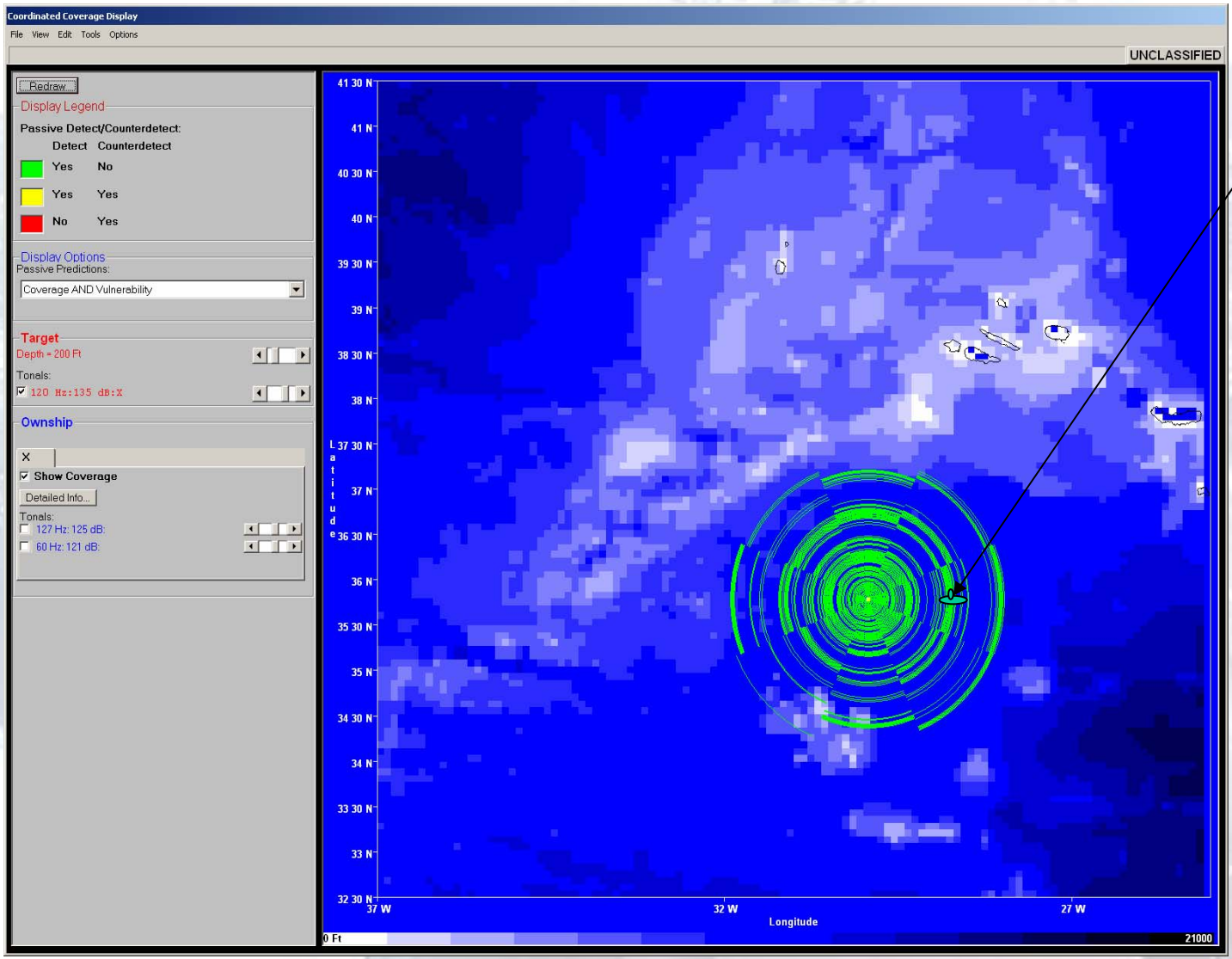
1. Atlantic example where uncertainty leads to change in ownship plans
2. Pacific example, where knowing uncertainty increases confidence in original plan

Atlantic Example

Conditions:

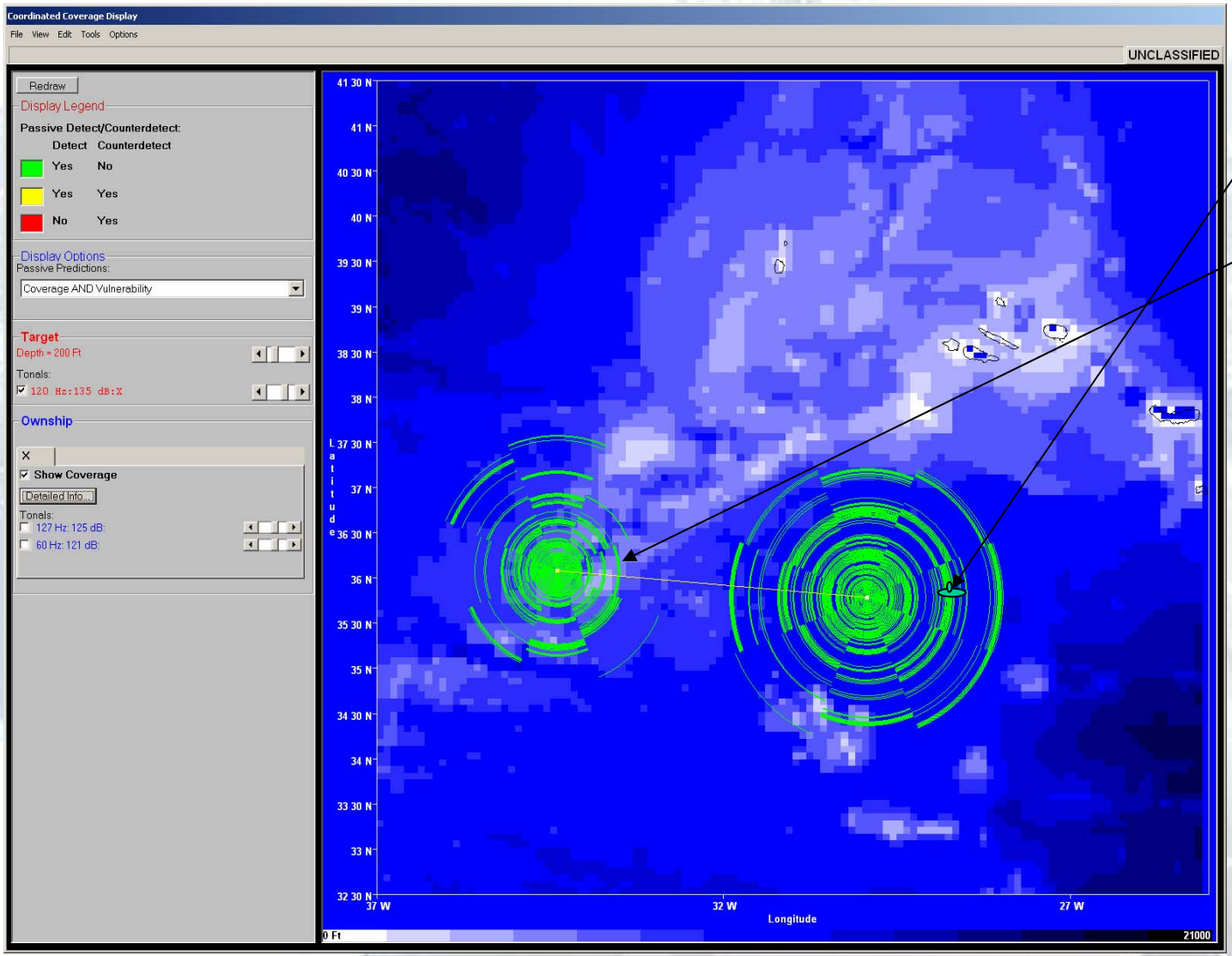
- Well-Known Parameters
  - Threat radiated levels
  - Environment
- Parameters with large uncertainty
  - Threat sensor characteristics (NRD, NDI)
  - Ownship Radiated Noise

Ownship Current Coverage Only



1) SSN Tracking target from range of 58 nm.

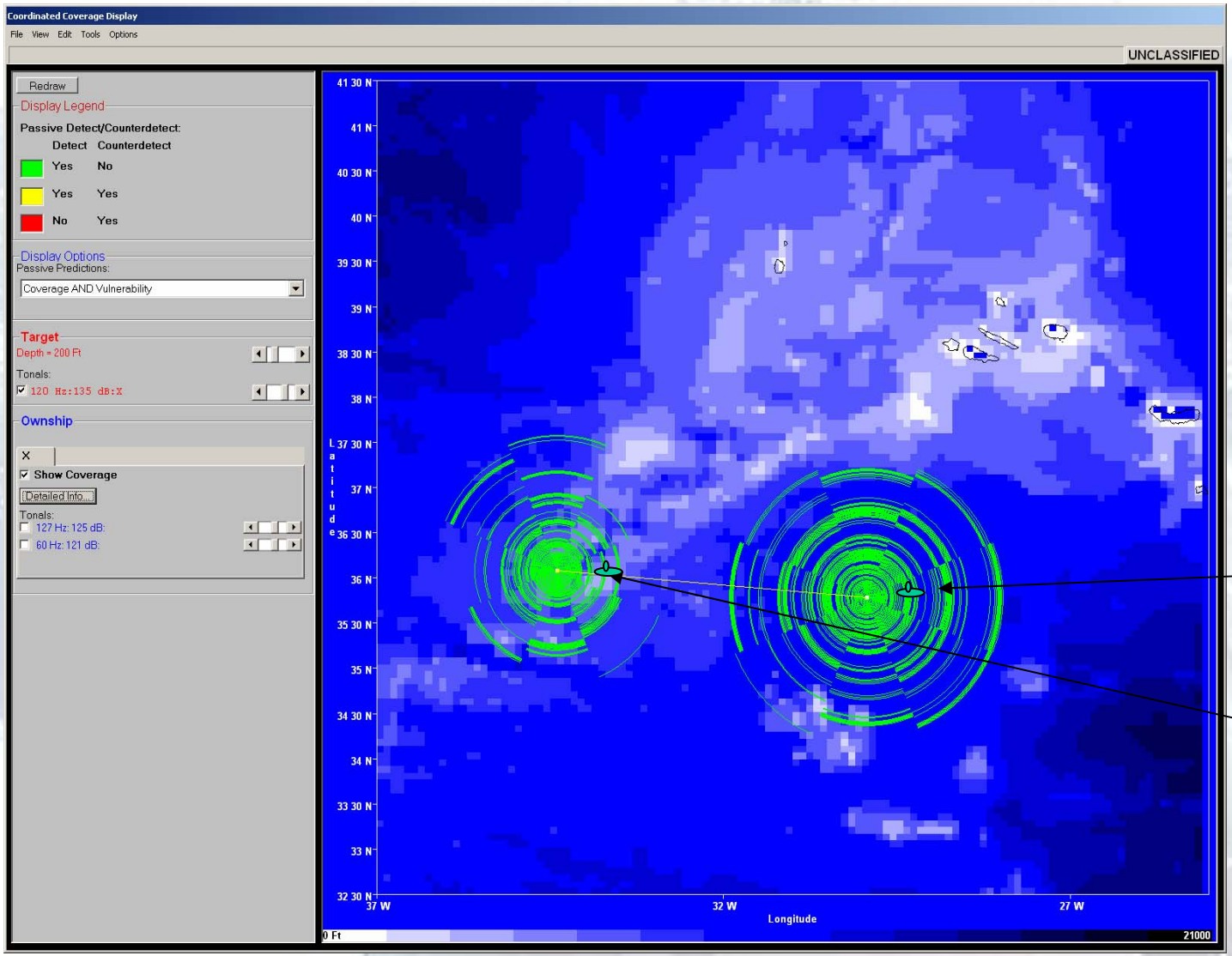
Current and Anticipated Coverage



1) SSN Tracking target from range of 58 nm.

2) Coverage against projected threat location indicates anticipated shortened max detection ranges (<43 nm).

Plan without Vulnerability *or* Uncertainty



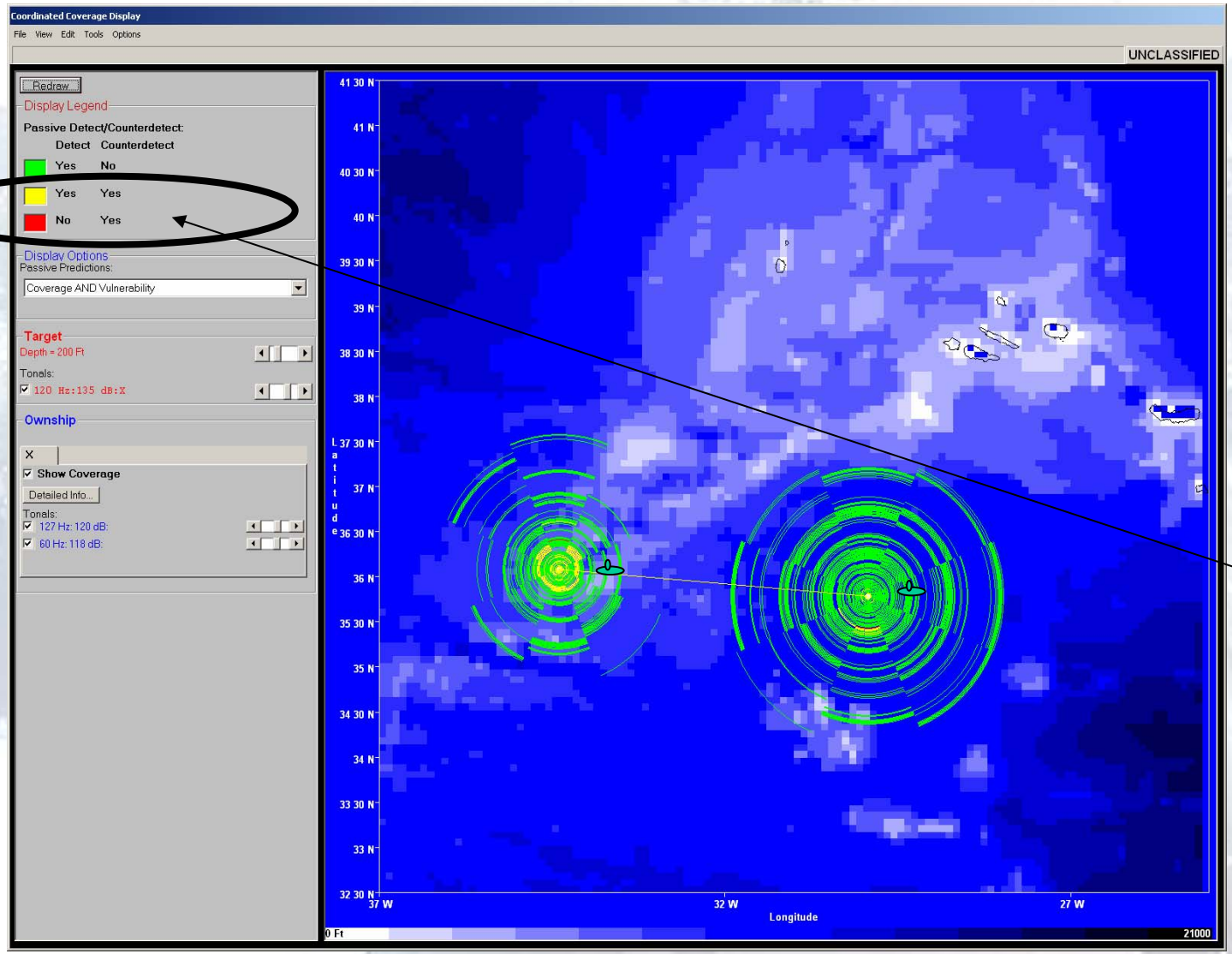
1) SSN Tracking target from range of 58 nm.

2) Coverage against projected threat location indicates anticipated shortened max detection ranges (<43 nm).

3) Close range now to <30 nm

4) Remain close enough to maintain contact beyond ridge

Vulnerability Check – still no Uncertainty



1) SSN Tracking target from range of 58 nm.

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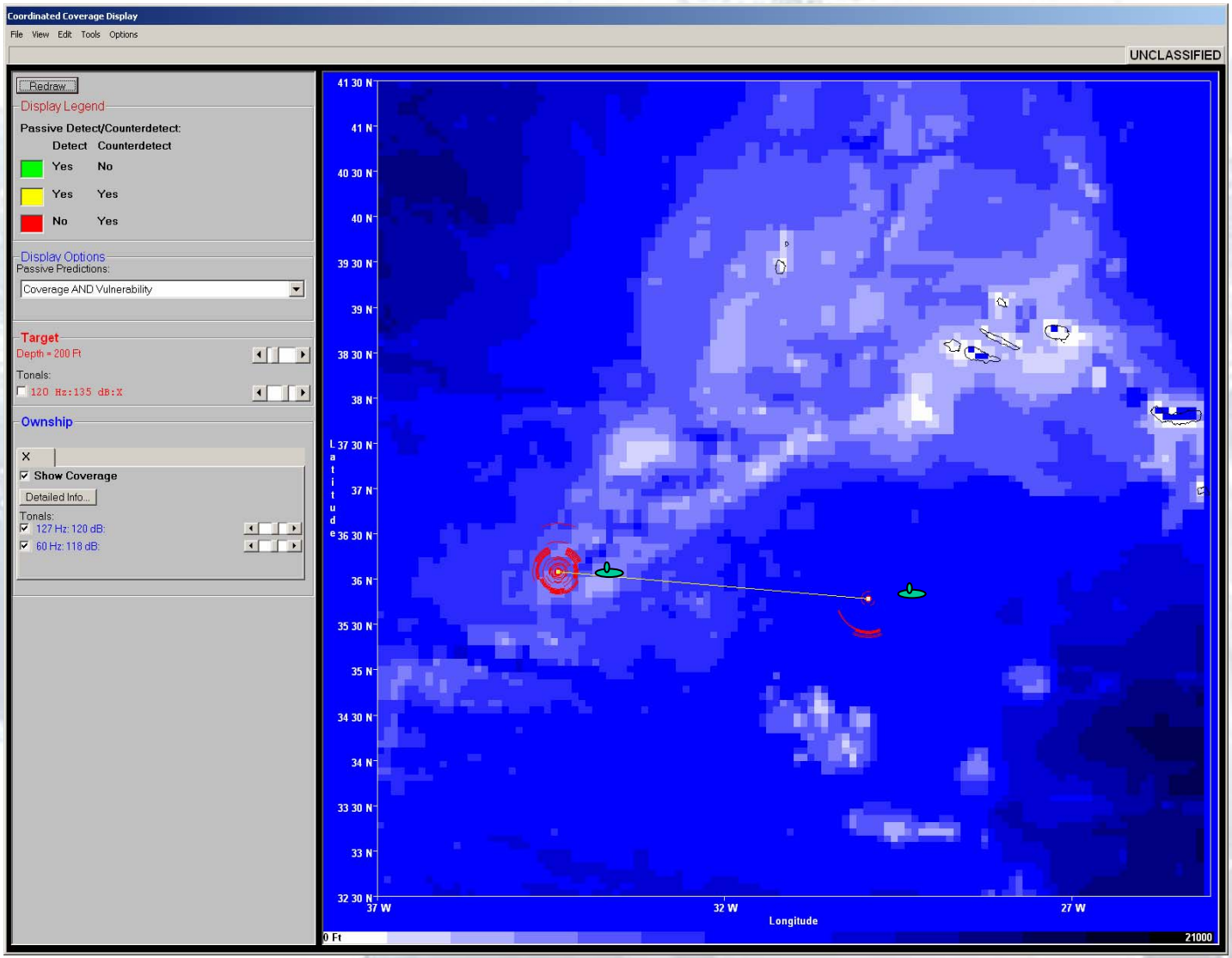
3) Close range now to <30 nm

4) Remain close enough to maintain contact beyond ridge

5) Check that plan does not expose ownship to counterdetection

Vulnerability Double check – Vulnerability only, still no Uncertainty



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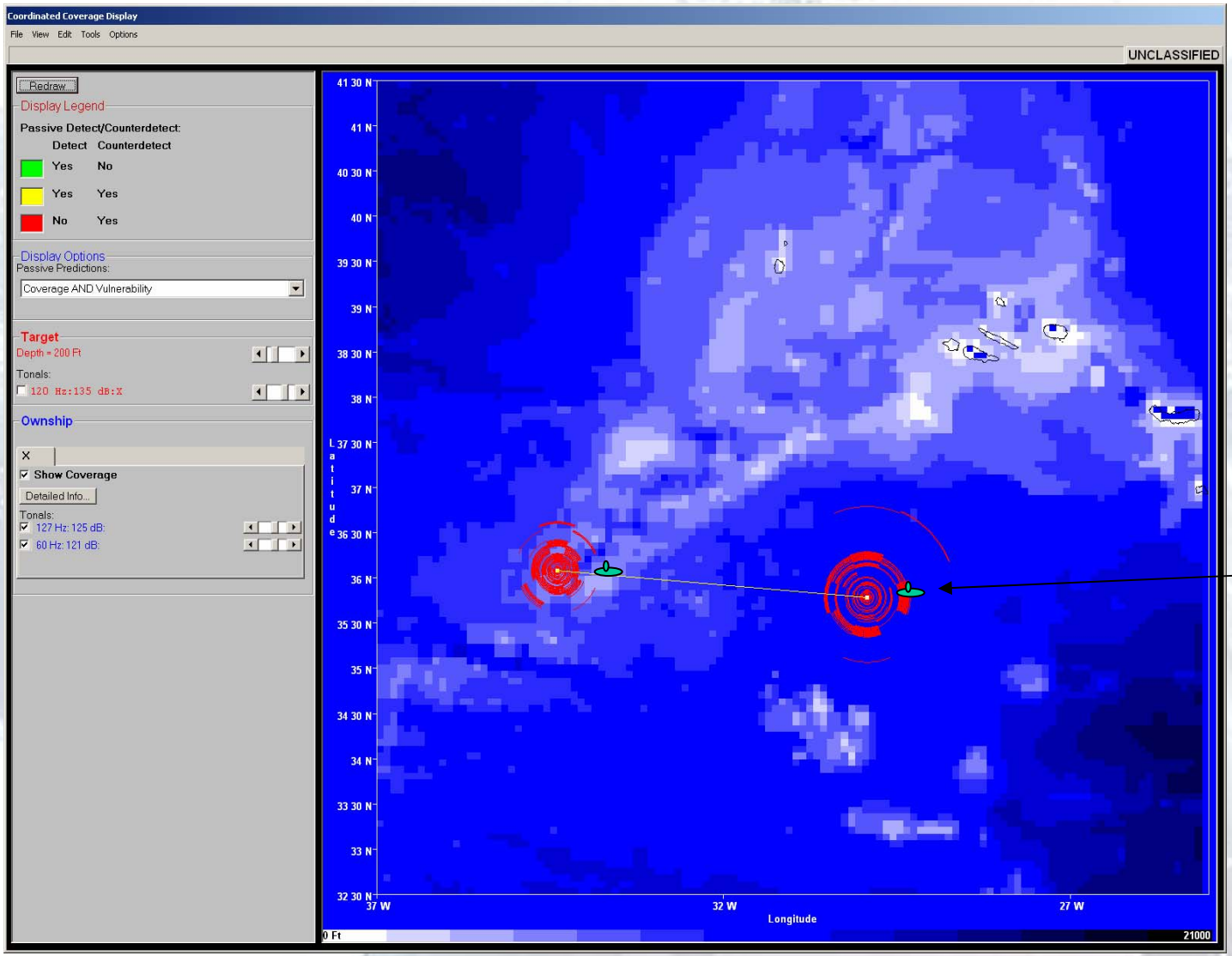
Vulnerability Check – Including Uncertainty



1) SSN Tracking target from range of 58 nm.

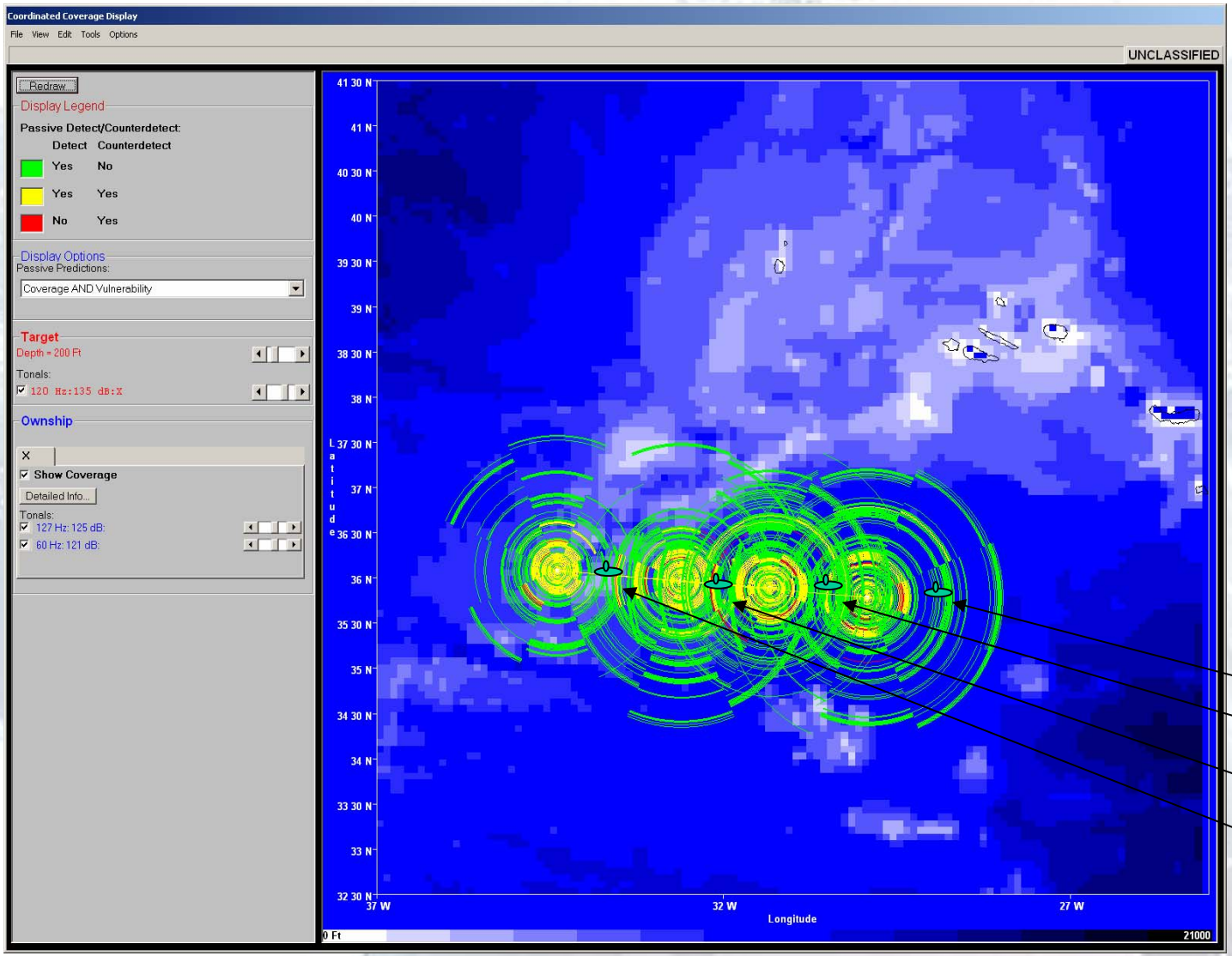
2) Coverage against projected threat location indicates anticipated shortened max detection ranges (<43 nm).

3) Close range now to <30 nm

4) Remain close enough to maintain contact beyond ridge

5) Include Uncertainty in vulnerability estimate – use "high end" of FOM. Recommendation: delay closing target.

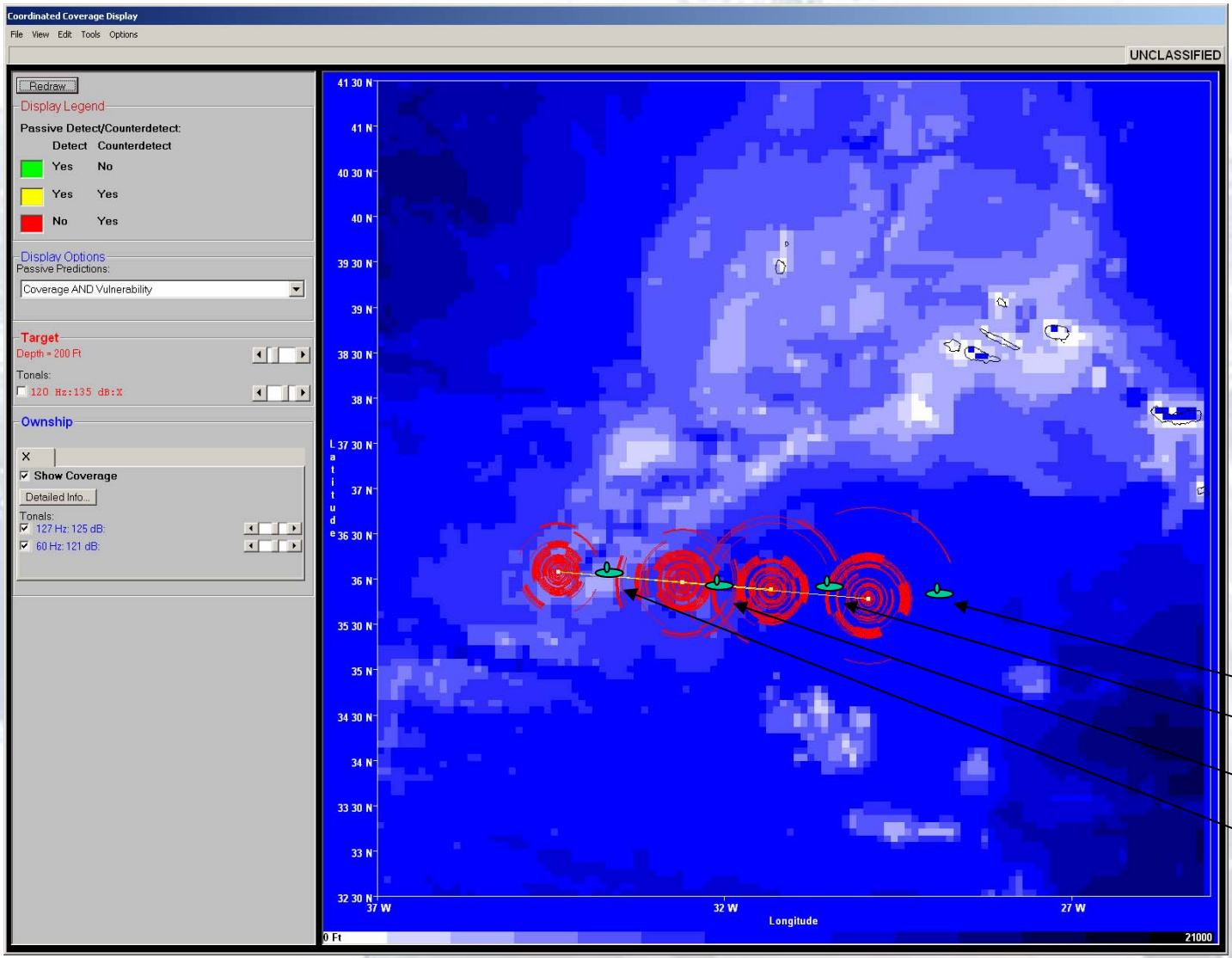
Plan for closing range



Using nominal coverage estimates and pessimistic vulnerability estimates, plan to maintain contact with little chance of counter-detection

Pt 1: 33-70 nm
Pt 2: 30-70 nm
Pt 3: 30-50 nm
Pt 4: 20-45 nm

Plan for closing range
Double-check vulnerability separately



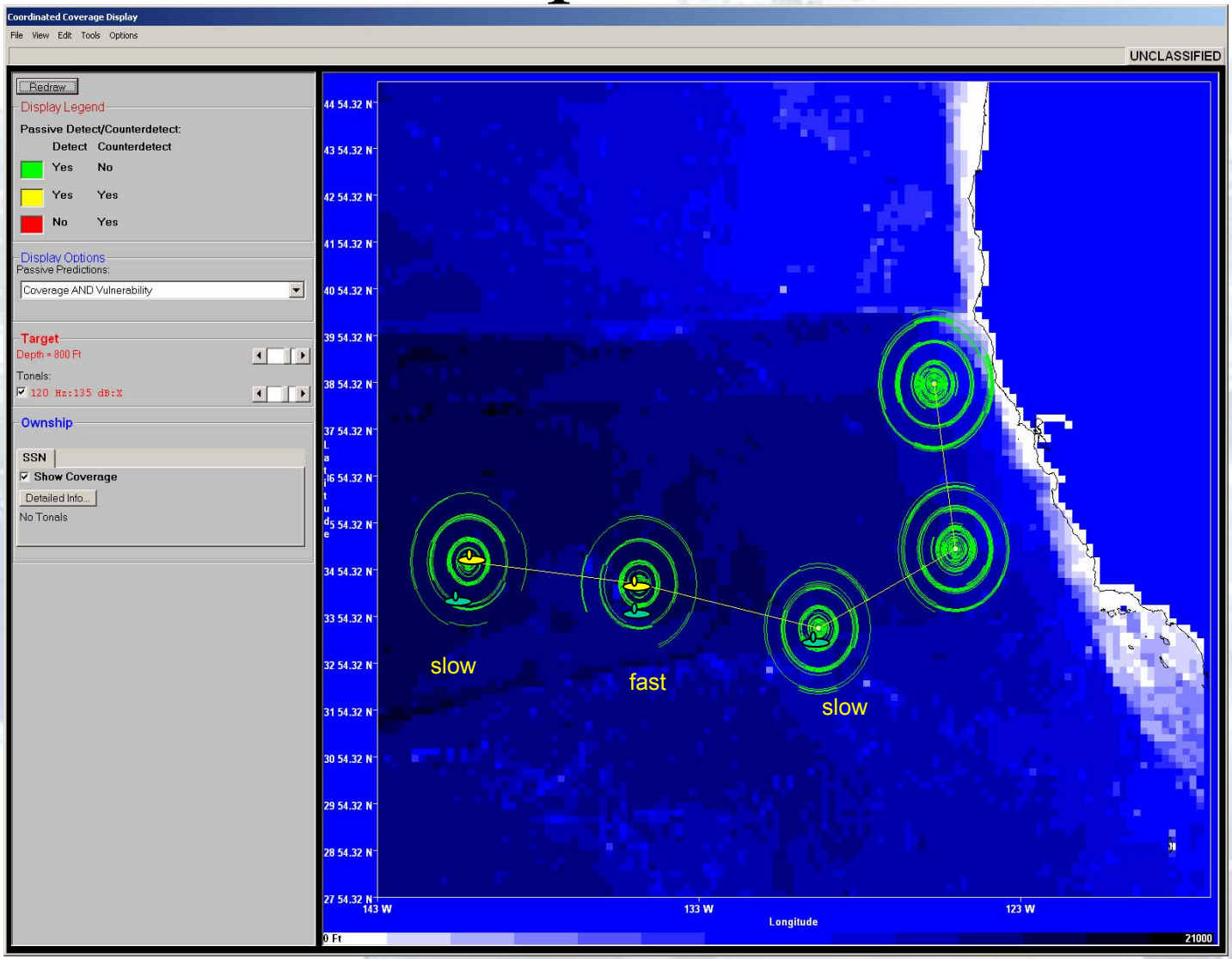
Pt 1: 33-70 nm
Pt 2: 30-70 nm
Pt 3: 30-50 nm
Pt 4: 20-45 nm

Pacific CZ Example

Conditions

- Well-Known parameters
  - Environment, and specifically Sound Speed (MODAS)
  - Ambient Noise
- Parameters with large uncertainty
  - Target Source Level (± 10 dB)

CZ Example – No uncertainty

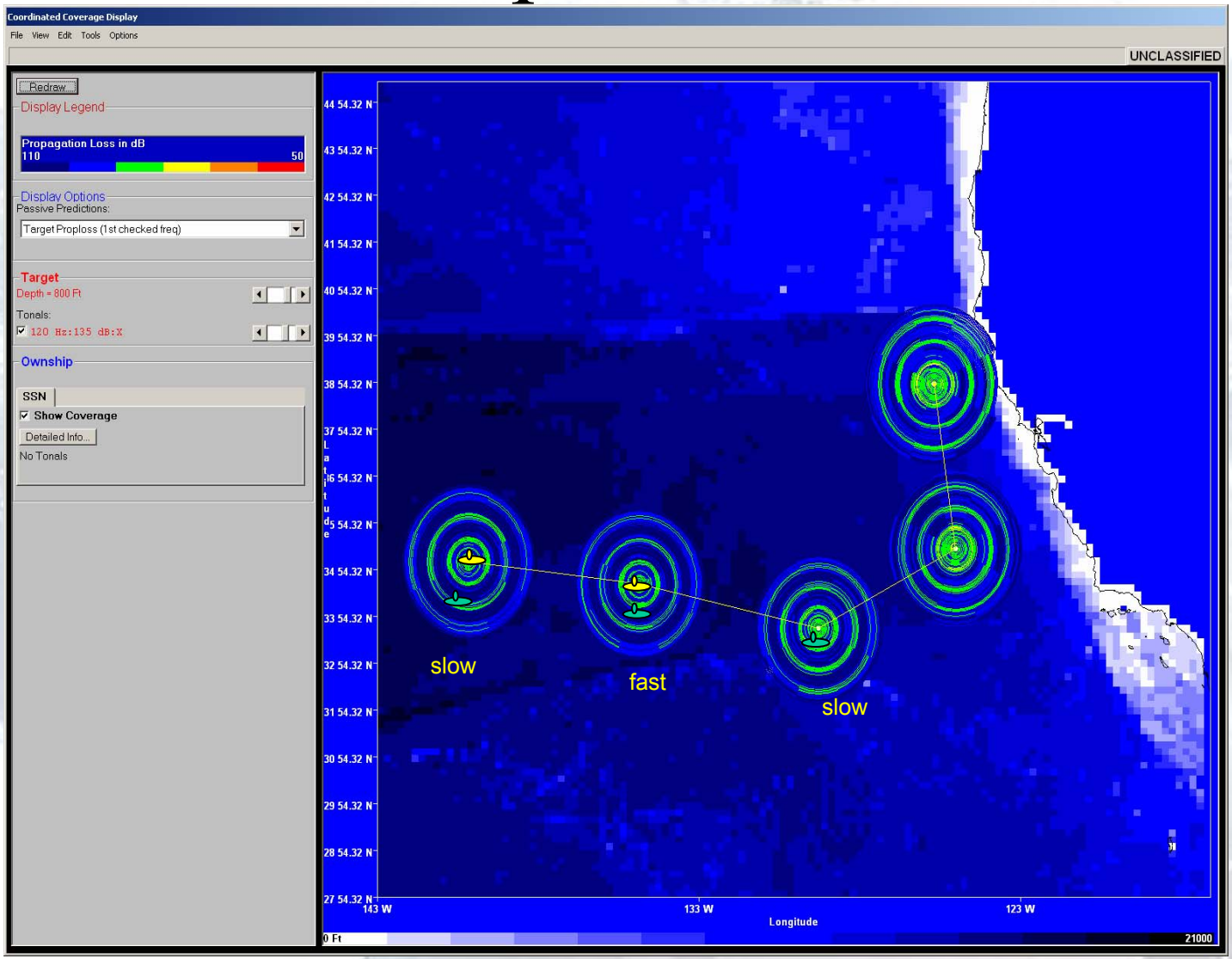


1) Leftmost coverage pattern: target in center, ownship at 2nd CZ, planning to close to 1st CZ

2) Signal excess, in this case with no uncertainty, used to estimate periods where no detection (or counterdetection) is possible – ownship speeds through "shadow zone"

3) 1st CZ, ownship slows to re-acquire target

CZ Example – With uncertainty



No difference in ownship decisions based on large uncertainty (±10 dB).

However, *knowing* that the areas of positive signal excess and areas of shadow zones are this robust is very useful.

Summary

- Current Sonar-equation-based applications assume fixed dB uncertainty
- Next "upgrade" to STDA will allow individual manipulation/constraints on uncertainty and compute and display total "sigma"
- We're looking for something better in each of the terms
  - Transmission loss – need *much* better characterization for change in sound speed profile shape (i.e., duct vs. no duct)
  - NRD
  - Source Level
  - Ambient Noise
- We welcome suggestions for:
  - Better displays
  - Better combination of terms