



Environmentally Associated LF BB Active Sonar Signal-to-Interference Variability

Peter Cable
BBN Technologies

Uncertainty DRI: Review and Planning Meeting
Providence Marriott
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Objectives & Rationale

- *Objective:* Characterize environmentally induced variability of low frequency active sonar signal-to-interference ratio (SIR) in well-behaved continental shelf environments
 - Such environments representative of many operational areas of interest
 - Constitutes baseline for more environmentally stressing scenarios and areas
- *Analysis focus:* Area Characterization Test (ACT) sequence
 - Sonar system measurement and performance characterization based
 - Rich data base
 - Current effort: ACT I signal excess measurements

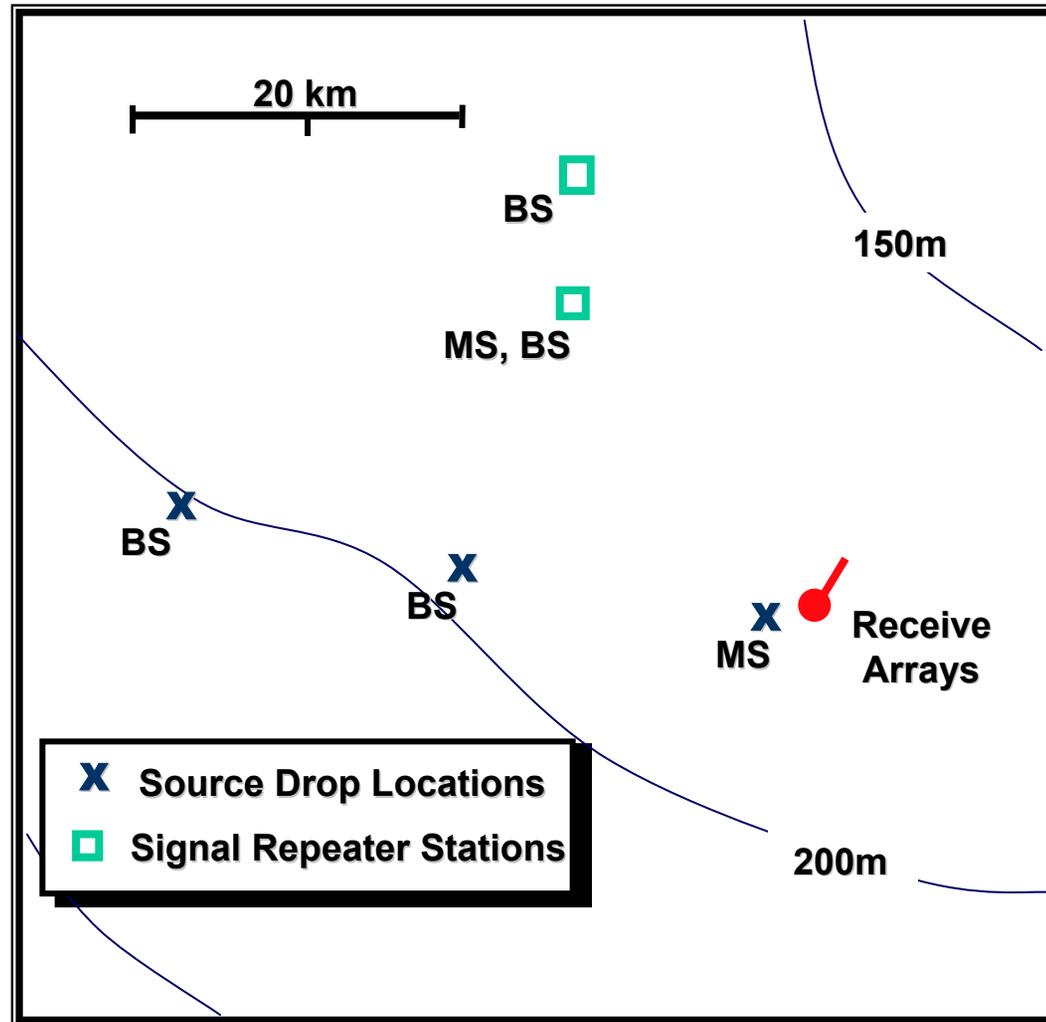
ACT I Environment

- Location
 - West Florida Shelf: 28.4deg N, 85.3 deg W
 - September 1992
- Bathymetry & bottom
 - Water depth: 180m
 - Slope: 0.13 deg
 - Sediment: sand-silt-clay
- Water column
 - SSP: downward refracting (max gradient: 0.3 s^{-1})
 - Currents: 5-10 cm/s (mid-depth)
- Meteorology
 - Winds: $< 2 \text{ m/s}$
 - Sea State: Beaufort 0-1

ACT I Signal Excess Measurements

- Sonar system parameters
 - Frequency band: 100Hz-1kHz
 - Sources: Broadband explosive sources (2 types: LO & S)
 - Receiving arrays: 100m HLA/100m VLA
 - HLA for system measurements
 - 6λ subapertures @100, 200, 400Hz
- Target
 - Echo repeater (constant gain = non-fluctuating TS)
 - Fixed transmit level provides target-receiver TL
- Recorded data
 - “Target” echoes for 5 “fixed” bistatic geometries
 - Source/target kept station within 1 km circle
 - 10 echoes each geometry (4 LO, 6 S); 50 events total
 - Sonar performance analysis data
 - Source-target TL; target-receiver TL for each event
 - Background levels at HLA
 - Supporting environmental data: SSP, current at VLA; wind speed

Signal Excess Test Geometries



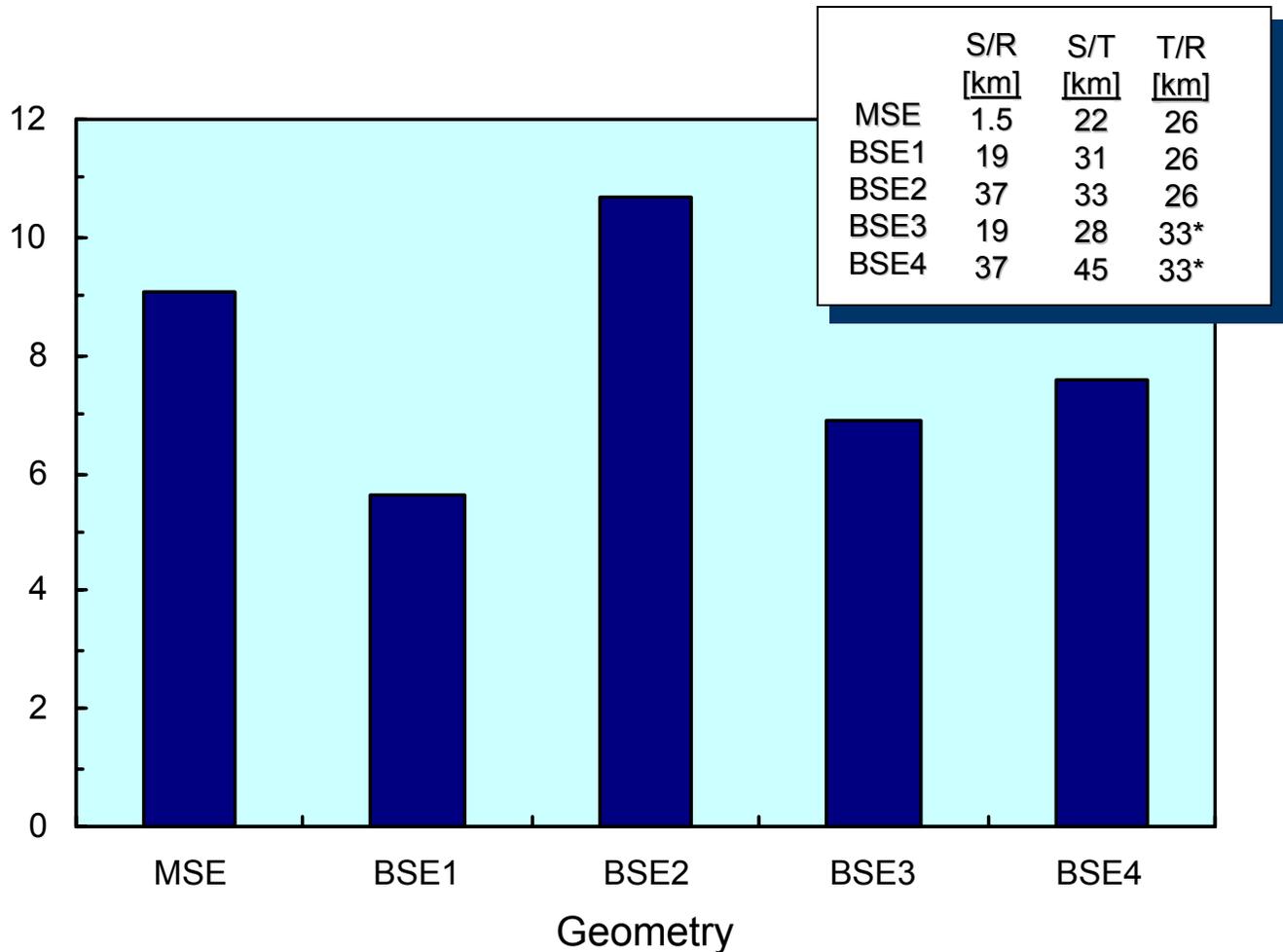
Signal-to-Interference Variability Analysis

- Shallow water reverberation limited sonar equation
$$SIR = TS - SS - 10 \log r - 10 \log(c\theta T)$$
where SS = bottom scattering strength, θ = HLA beamwidth, T = signal extent, r = tgt-rcvr range
 - Only geometry dependence is linear tgt-rcvr range dependence
 - For unchanging environment & target, $10 \log r$ is only variable
 - Describes mean levels; Variability is associated with underlying TL & reverberation fluctuations & environment variability
 - Processing appropriate for sonar reduces fluctuations to small effect
- Examine variability of SIR at receive HLA
 - Temporal (ping-to-ping) variability using fixed geometry data
 - Spatial variability using different mono/bistatic geometries
 - Adjust for change in tgt-rcvr range
 - Environmental sampling scale ~ kilometers

ACT I Variability Results Summary

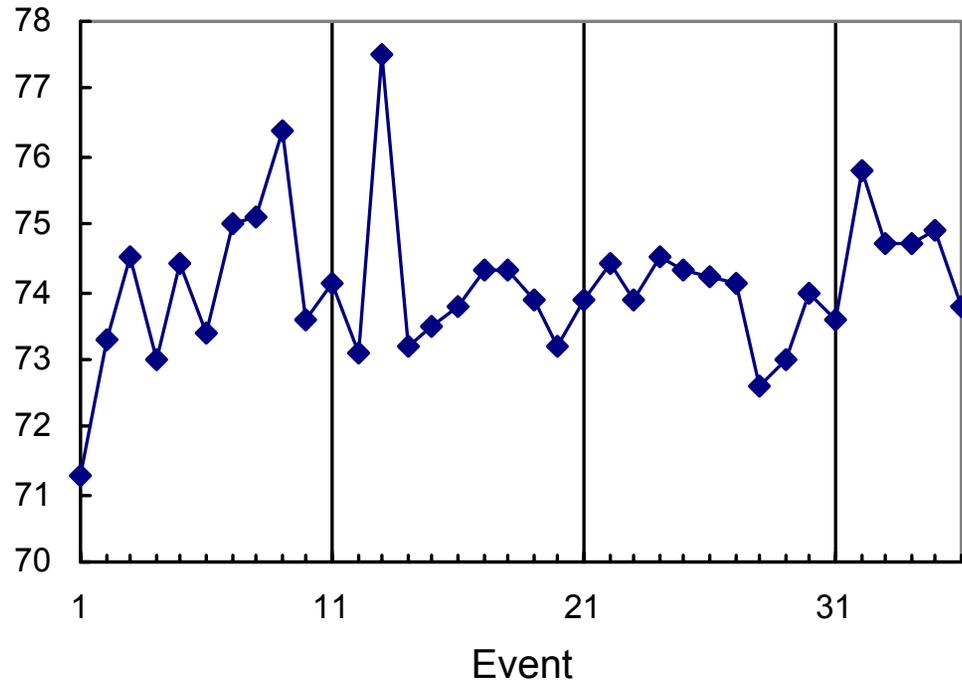
- Summary of measured variability of 100-500Hz SIR for ACT I reverberation limited conditions
 - Temporal variability: SIR standard deviation = 1.6 dB
 - Spatial variability: SIR standard deviation = 2.0 dB
- Transmission loss variability
 - Target-receiver (26 km) variability = 1.1 dB
- Observed environmental dependencies
 - No apparent correlation between tgt-rcvr TL variability & SIR temporal variability
 - No observed systematic dependence of SIR spatial variability & geometry

Mean Signal-to-Interference Variation with Geometry



*Signal-to-Interference adjusted for T/R range change
 Processing Band: 100-500Hz
 Processing Integration Time: 100 ms
 TL Standard Deviation = 2 dB

Fixed Geometry TL Temporal Variability

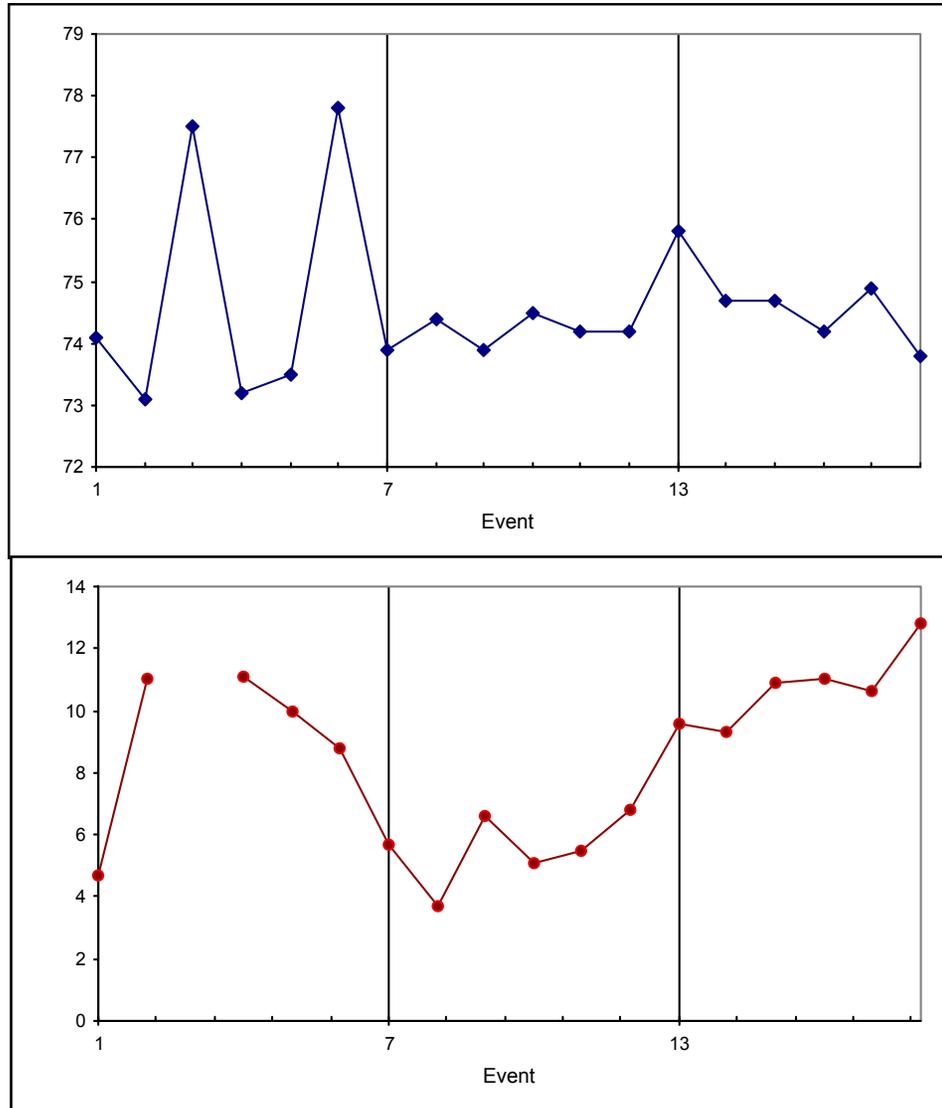


Frequency Band: 100-500 Hz
 Group Event Separation: 5min
 Mean TL = 74 dB
 TL Standard Deviation = 1 dB

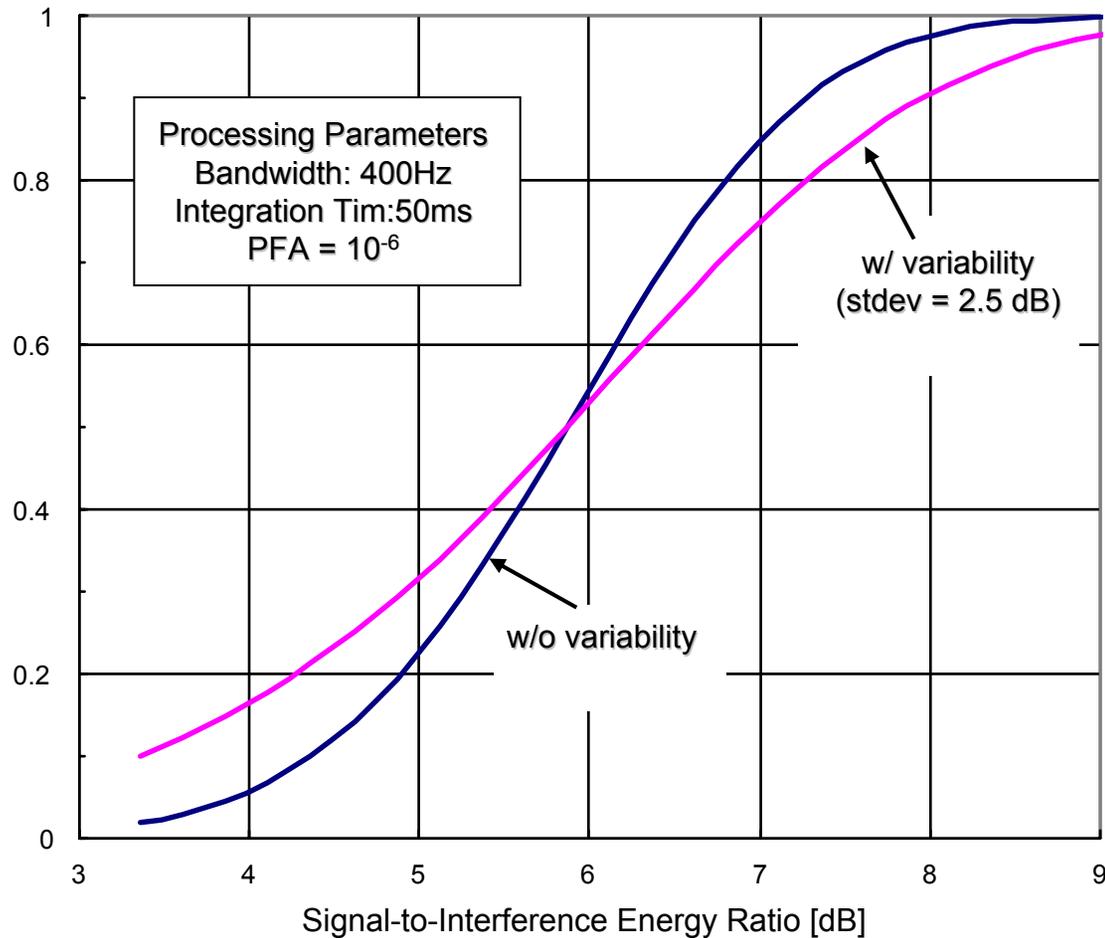
SIR and TL Temporal Variability

Frequency Band: 100-500 Hz
Processing Integration: 100 ms

Group Event Separation: 5min
SIR Standard Deviation = 2 dB
TL Standard Deviation = 1 dB



Effect of Environmental Variability on Detection Performance



Ref: Cable, "On Distant Thunder Detection Index", BBN Memorandum (Nov. 1999)

Summary, Issues and Plans

- Summary
 - SIR variability for (well-behaved) ACT I signal excess measurements determined
 - SIR std dev = 2.5 dB (1.5 dB temporal; 2 dB spatial)
- Issues
 - Measurement error yet to be analyzed
 - Absolute calibration not an issue
 - Limitations of reverberation limited sonar equation as basis for analysis
 - Potential physical sources for observed temporal & spatial variability
- Plans
 - Complete ACT I analysis
 - Compare ACT I results with other continental shelf sites
 - ACT II (more bottom structure)
 - ACT III (more oceanographic activity)