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Digital Watermarks for Information Assurance in Acoustic Communications (ACOMMS) Networks

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NUWC Background and Interest in ACOMMS/Networks

- ACOMMS links and networks are increasingly being used for tactical missions (e.g., Atlantic Undersea Test and Evaluation Center (AUTEC))
  - ACOMMS modem research has focused mostly on overcoming environmental issues
  - Currently deployed Systems, such as the network at AUTEC, share many common acquisition, tracking, and modulation features
  - Many interesting problems remain to be solved for these systems

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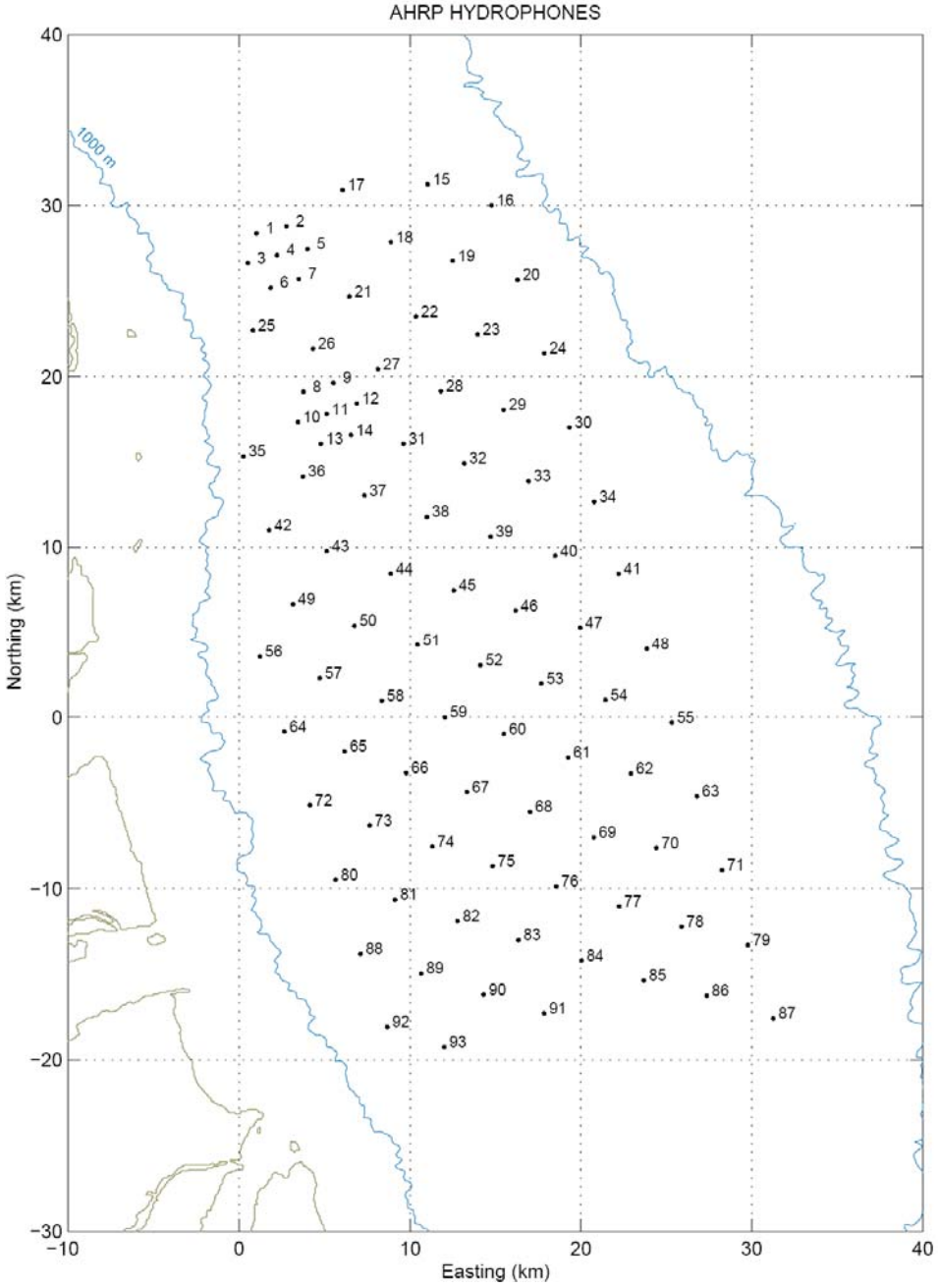
AUTEC Network setup

- Located in the Bahamas
- **Provides two-way digital ACOMMS with submarines operating at speed and depth**



- Deep water (2km)
- Network contains 96 receivers, out of which 18 can also transmit

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ACOMMS/Networks: Category 1 Research issues

- Independent of the user, research to enhance system performance includes

1. Multichannel processing
   - Accommodate multiple users simultaneously
   - Effectively mitigate the interference
   - Explore the congestion limits

2. Vulnerability
   - Known system (if the attacker knows the system)
   - Unknown system (the attacker does not know the system)
     - fixed or adaptive

3. Base station
   - Improve the scheduling
   - Extend from one-hop to two-hop networks

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ACOMMS/Networks: Category 2 Research issues

- To further improve the system, user side research changes include

1. Novel coding schemes
   - Collision reconstruction
   - Source coding/compression, network coding
2. Alternative modulation schemes
   - No training signal, less vulnerable
   - Short packet: less collision
3. User-scheduling
   - Minimal impact on other users (MAC etc)
4. Multi channel/band system:
   - User frequency allocation

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ACOMMS/Networks: Category 3 Research issues

- Longer term benefit research

1. Channel capacity (deep or shallow water channels)
2. Network architecture, interference management
3. Other fundamental issues …

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ACOMMS/Networks: System Vulnerability

- As system design details can be found in the open literature, ACOMMS networks are vulnerable to disruption by a jammer
- Two potential types of jammer exist

1. Coherent Jammer
   - Needs knowledge of receiver algorithms
   - Designed to exploit known decoder features

2. Adaptive Jammer
   - May or may not have exact knowledge of the system
   - Can adaptively develop the appropriate waveform

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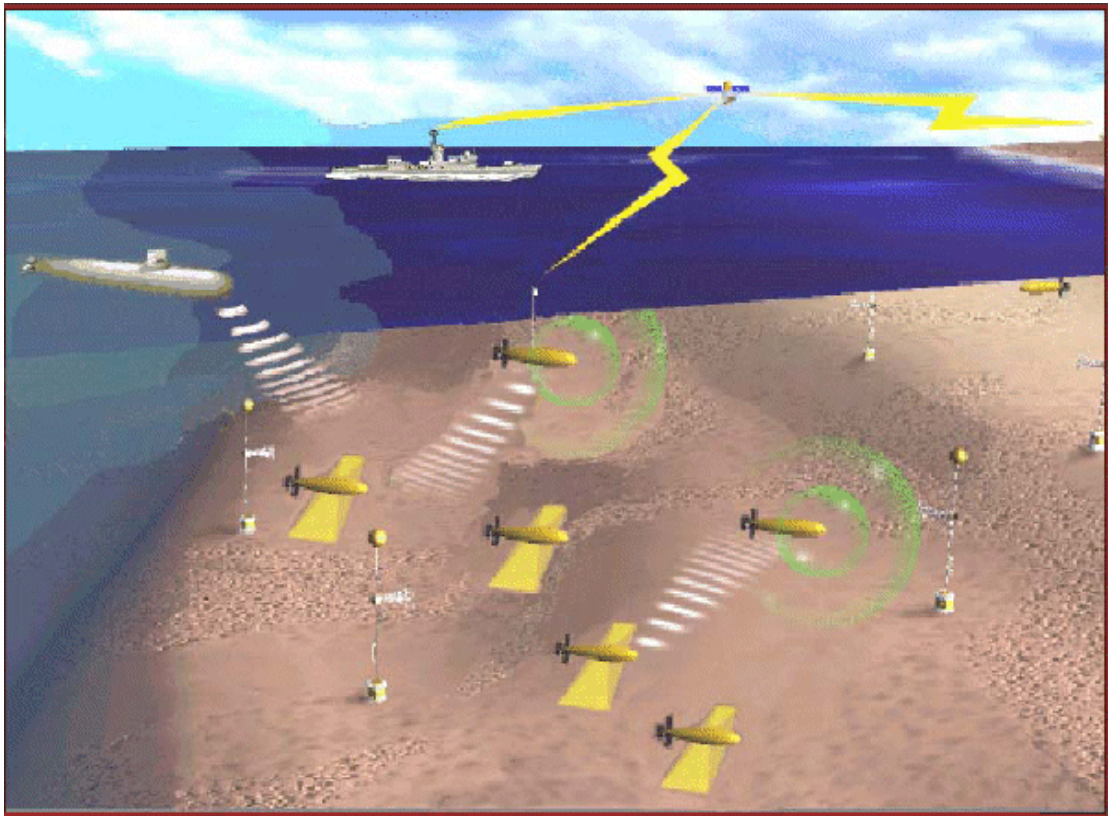
Information Assurance - Embedded Digital Watermarks



Technology Overview:

- Limited Bandwidth in Undersea Environments
- Covert Embedding of Information in Sonar Signals
- Need for authentication and secure transmissions
- U.S. Pat. App. Ser. No. 12/287,156

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Advantages of Digital Watermarks

- Covert – not possible to decode
- Attractive alternative to metadata
- Provides reliability in non-secure environments
- Currently being adapted for undersea environment

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Research Team

- Office of Naval Research funded project
  - Naval Undersea Warfare Center, Division Newport
    - Laboratory partner
      - Robert S. Lynch, Ph. D.
      - G. Clifford Carter, Ph. D. (Retired)
  - Villanova University
    - University collaborator
      - Bijan Mobasseri, Ph.D.

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Watermarking Model

Key

Sonar Signal

STFT

Embed

I-STFT

Delay/ Doppler

+

+

Noise

Swerling

To Watermark Detector

Key

Design WM

Underwater Channel

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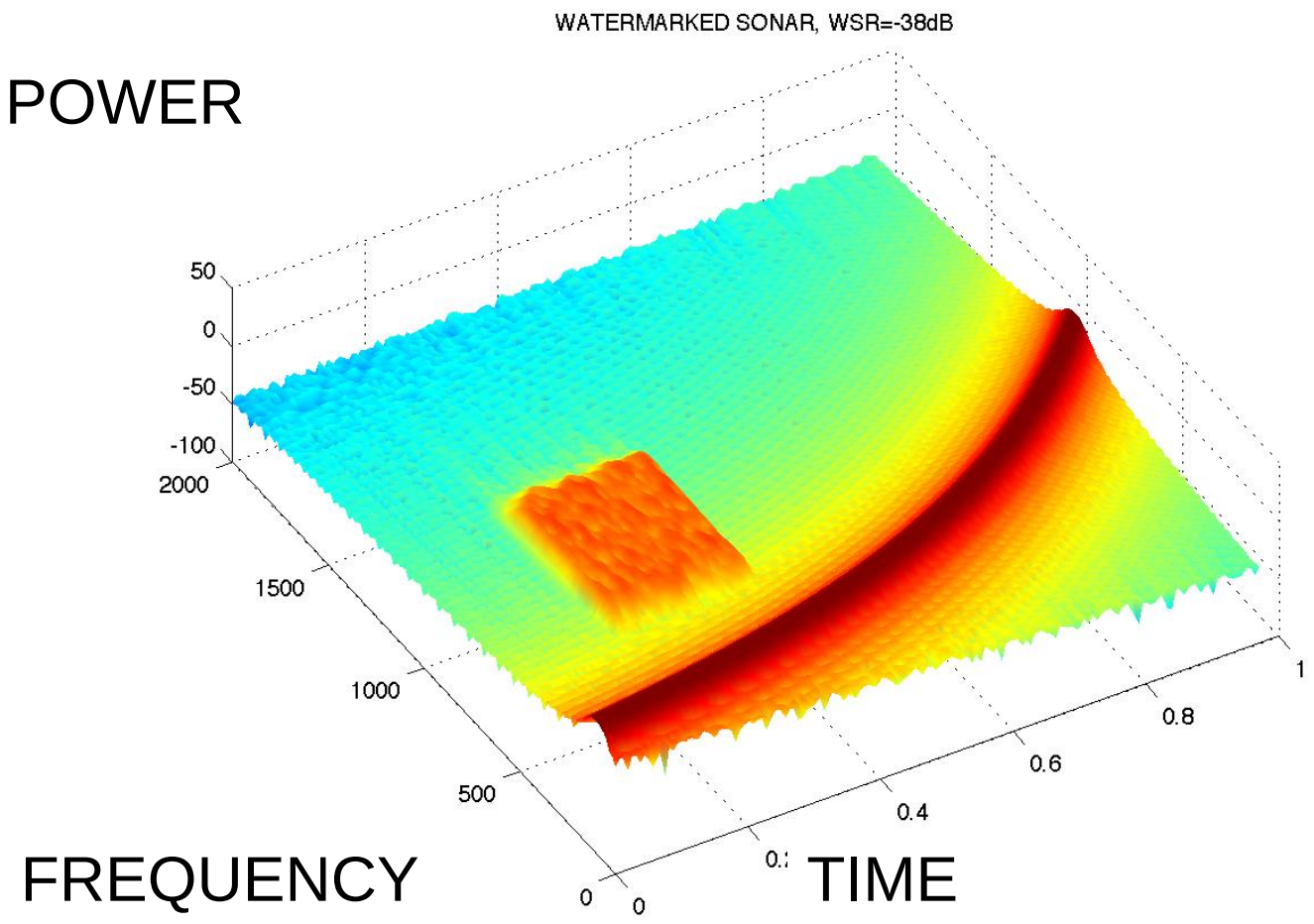
TF Of Watermarked Sonar



Watermark Is Spread In Time (T) and Frequency (F)

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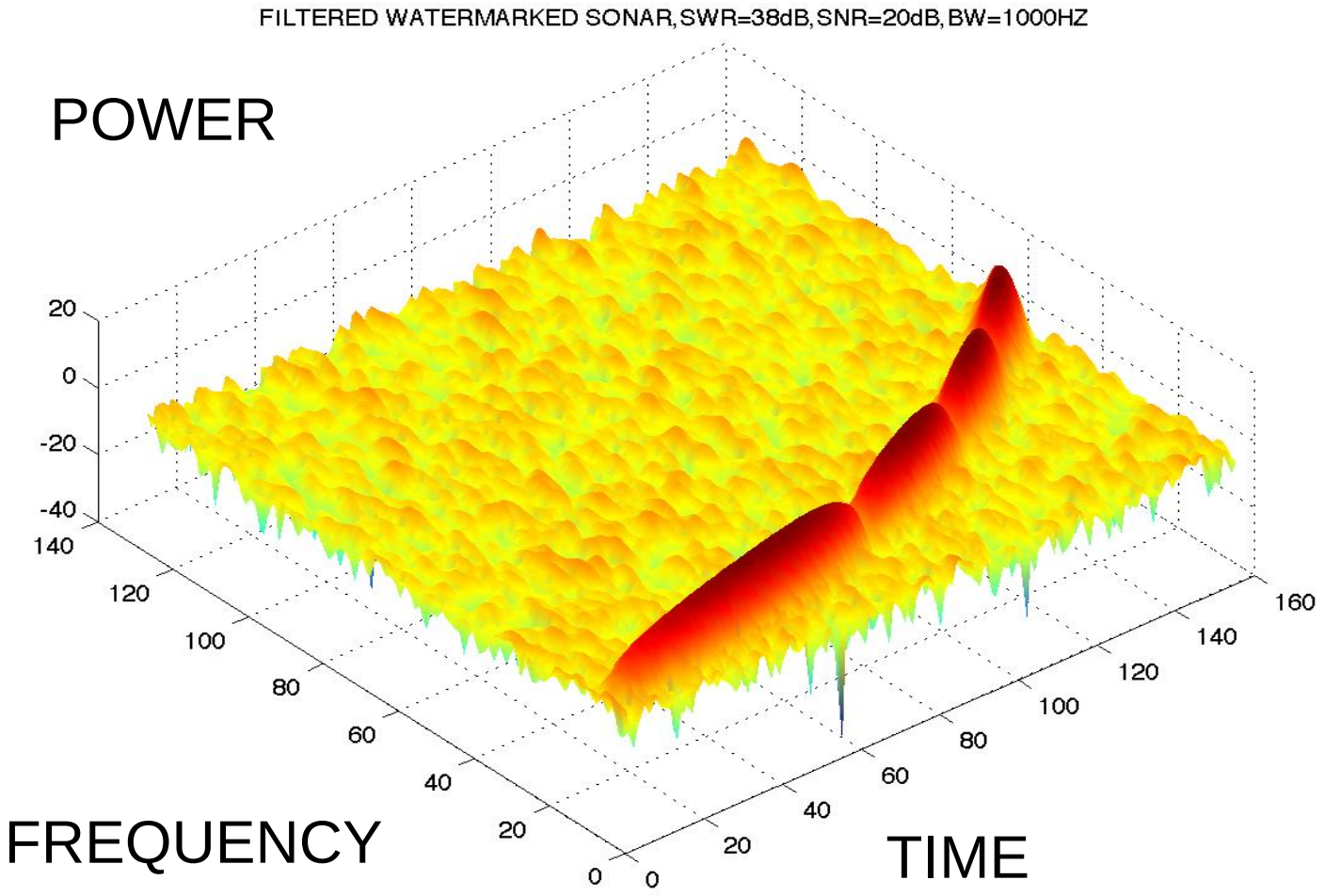
Sonar With Noise And Clutter



Watermark Obscured By Noise And Clutter

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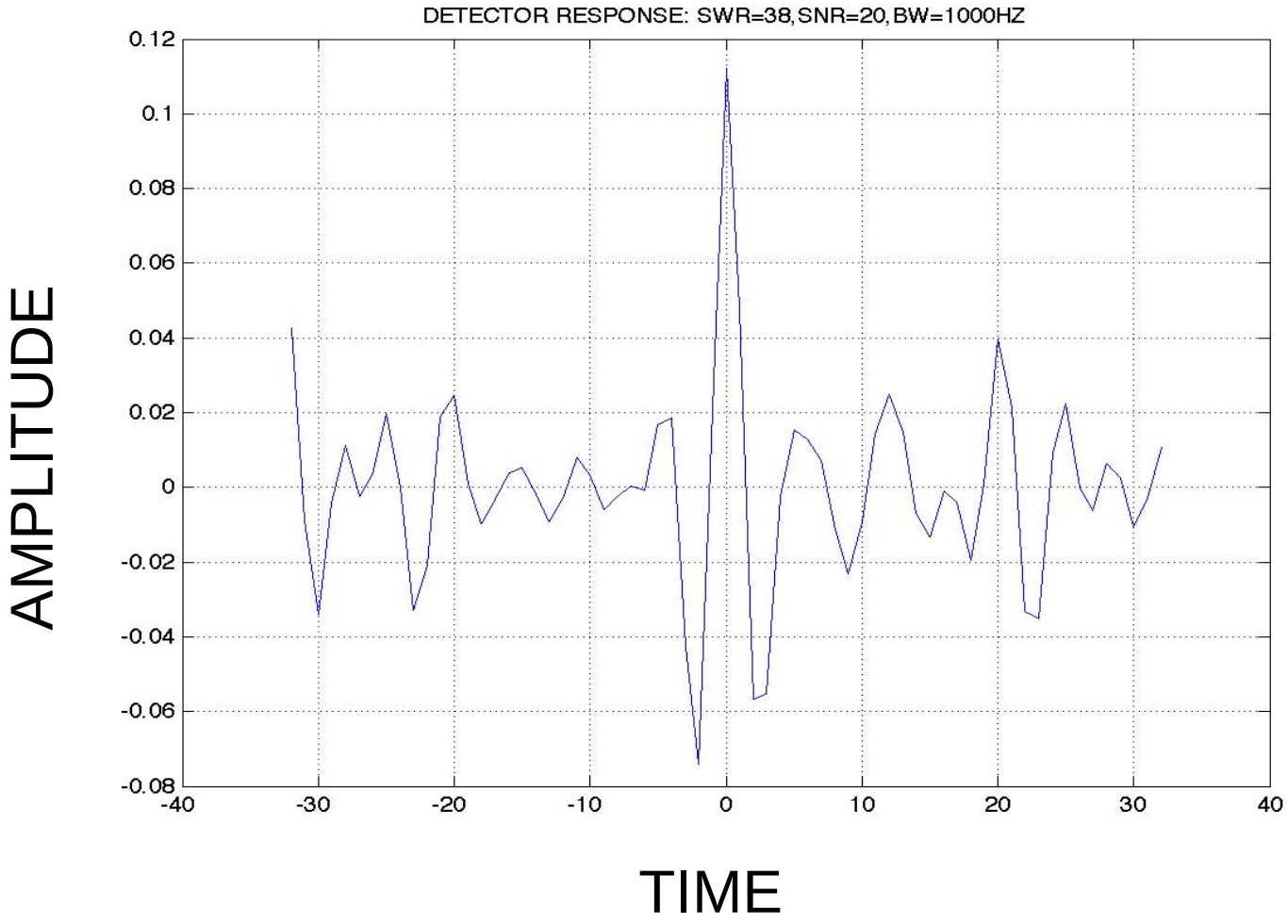
Detector Response



Watermark Is Detectable In Noise And Clutter

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Adaptation of Digital Watermarks to ACOMMS

- Currently working with more realistic sonar simulation models (e.g., Sonar Simulation Toolkit)
- To improve detection in harsh environments, need to determine if watermarks can be broken up and sequentially transmitted with data communications messages
- Need to determine if channel response of watermark can be reliably estimated for improved detector performance
- Need to determine the degree that channel effects have on watermarks resulting in a degrading of ACOMMS signals