Overview of Very High Data Rate HF Communications

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Outline

- Introduction
- Requirement Drivers
- Multi-channel HF concept
- Air Interface Design
- Current Status
- What’s Ahead
- Evolution
Introduction

- Mil-Std-188-110B and STANAG 4539 high-data-rate HF waveforms achieve bandwidth efficiency of 4 bits/s/Hz
- much better than currently achieved in VHF/UHF bands
- never enough bandwidth - insatiable demand for higher data rates
Very High Data Rate (VHDR) HF

Requirement Drivers

• NATO Maritime Working Group - Naval operators have military requirements for HF tactical communications at data rates above 9.6 kbps

• US Navy’s IT-21 requirement - 128 kbps to frigate class combatants
VHDR Multi-Channel HF

- Main obstacle to increased data rates at HF is regulatory - 3 kHz allocations
- Practical solution - develop a multi-channel architecture, which uses 3 kHz channels that do not need to be contiguous, and will work with existing radios
- Architecture must be designed to support evolutionary development
Multi-channel HF: Rx block diagram

Data Sink → Crypto → Sync Data Interface → FEC → De-Interleaver → Demod → Analog Interface → Receiver

MODEM

Radio Rx
VHDR HF : Air Interface Design

- Done under contract for Rockwell-Collins
- Extension of Mil-Std 188-110B SSB & ISB modes to 3, 4, 6 or 8 independent 3 kHz channels
- Autobaud waveform (# of SB’s, DR, Interleaver)
- Rate ½ convolutional code punctured to rate ¾
- Puncturing to rate 15/16 with 64-QAM and 256-QAM constellations used to achieve ultra-high data rates for surface wave applications
# VHDR HF: Modulation & Coding

## Modulation & Coding Table

<table>
<thead>
<tr>
<th>Modulation</th>
<th>Code Rate</th>
<th>Data Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>8PSK</td>
<td>3/4</td>
<td>9.6</td>
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<tr>
<td>16QAM</td>
<td>3/4</td>
<td>12.8</td>
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<td>32QAM</td>
<td>3/4</td>
<td>16</td>
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<tr>
<td>64QAM</td>
<td>3/4</td>
<td>19.2</td>
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<tr>
<td>64QAM</td>
<td>15/16</td>
<td>24</td>
</tr>
<tr>
<td>256QAM</td>
<td>15/16</td>
<td>32</td>
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**2 side bands**

<table>
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<td>64QAM</td>
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<td>256QAM</td>
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<td>64</td>
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**4 side bands**

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<td>64QAM</td>
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<td>96</td>
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<tr>
<td>256QAM</td>
<td>15/16</td>
<td>128</td>
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</tbody>
</table>

**8 side bands**
VHDR HF: Example Constellations

16 QAM Constellation

64 QAM Constellation
VHDDR HF : 256 QAM
VHDR 4-Channel: AWGN PER

1024-bit packet error rate
VHDR 4-Channel: CCIR-Poor PER

CCIR Poor Channel

1024-bit packet error rate
VHDR HF : Current Status

- VHDR waveform designed and documented
- 4 channel VHDR prototype implemented on Q9600 production hardware

Q9600 Platform

Data and Audio Interface Card
VHDR HF : Current Status

- Prototype under test at Rockwell-Collins to set performance baseline and benchmarks
- have lab demonstrated
  - web-browsing
  - file transfer
  - e-mail
using this modem at 64 kbps
VHDR HF : What's Ahead

- laboratory demonstration of 64-kbps video
- over-the-air field trial between IP Unwired, Ottawa and Rockwell Collins, Cedar Rapids
- submission of VHDR waveform specification to standardization bodies for consideration
- VHDR demo at SPAWAR San Diego by the IP Unwired/Rockwell Collins team in the coming few months
- Public demonstration of the capability is scheduled for the January 2003 AFCEA
VHDR Standardization Issues

- waveform
- systems issues such as
  - channel selection (# of SB’s, DR, Int)
  - link establishment
  - link maintenance and adaptation
  - DLP optimization
- solutions to meet needs of operational community
VHHD Multi-Channel HF: Summary

Features/Capabilities:
- does not require contiguous 3 kHz channel assignments
- easily interfaced to existing inventory HF radio equipment
- expeditious and cost effective means of evaluating multi-sideband concept

Disadvantage:
- heavy demand on radio resources
Multi-Channel HF: Evolution of the Concept

- Data Source / Sink
- Crypto
- Sync Data Interface
- FEC and Interleaver
- Mod / Demod 1
- Mod / Demod 2
- Mod / Demod N
- N-channel Radio Interface Board
- Single Wideband HF Transceiver

MODEM
Wideband HF Radio Board