



Wideband HF Data Over-the-Air Testing

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Rockwell Collins, Inc.
Feb. 4, 2010



Topics

- Test Station Particulars
- Test Results To Date
- Future OTA Testing

Test Station Particulars

- Received FCC Special Temporary Authority (STA)
- Experimental Call Sign: WE9XAA
 - 29 frequencies authorized; 12 kHz Bandwidth
 - 3.1 to 14.5 MHz
 - 6 Months
- Licensed for three locations:
 - Cedar Rapids, Iowa
 - Oxford Junction, Iowa
 - Richardson, Texas
- Sites chosen to test propagation modes:
 - Ground Wave (Cedar Rapids & Oxford Junction)
 - NVIS (Cedar Rapids & Oxford Junction)
 - 1-hop Skywave (Richardson to either CR or OJ)

Cedar Rapids, IA Lab 13 HF Station



Oxford Junction, IA HF Station

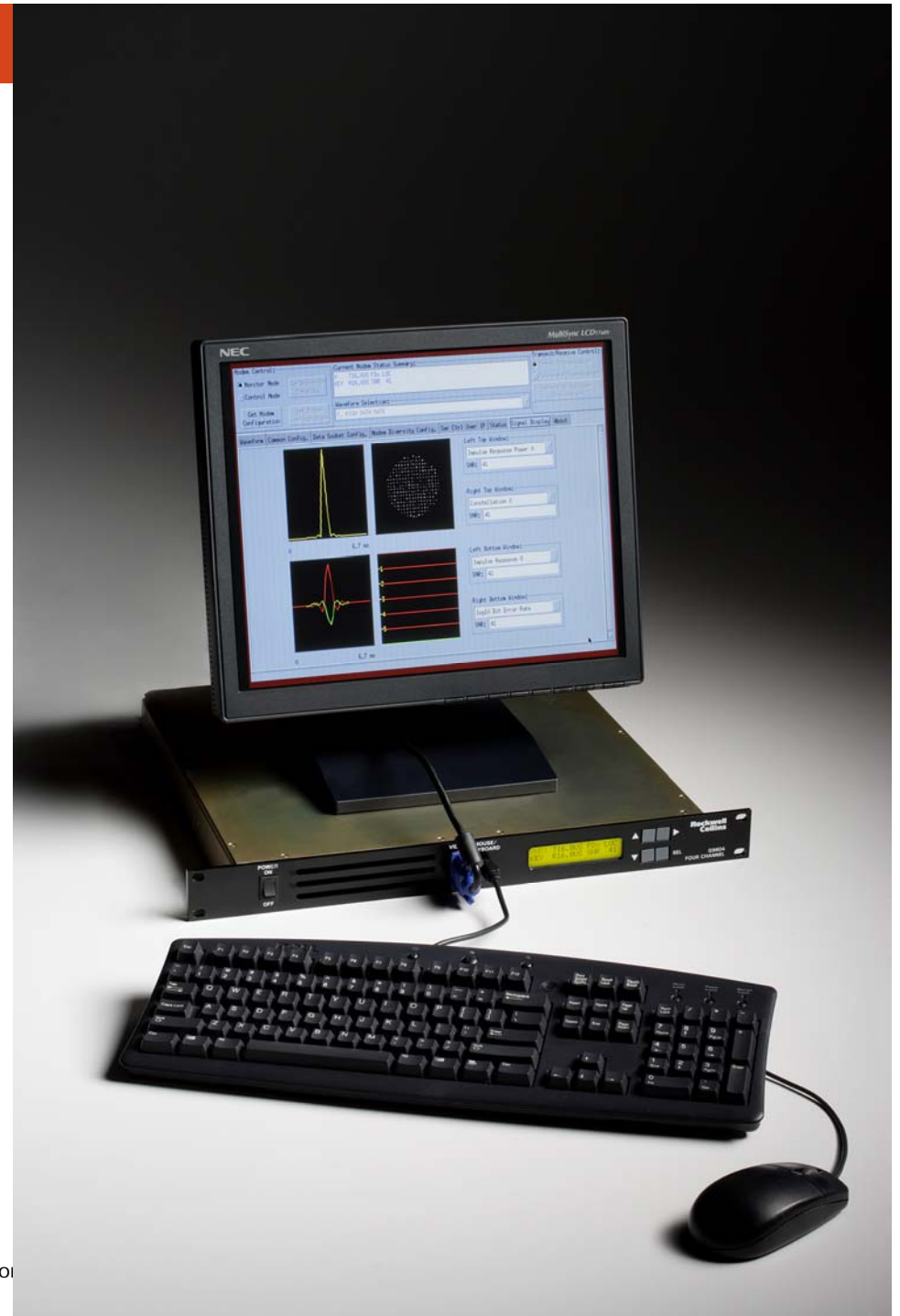


Ricardson, TX HF Station

HF-80 1kW HF Radios



Rockwell Collins MDM-Q9604 Modem

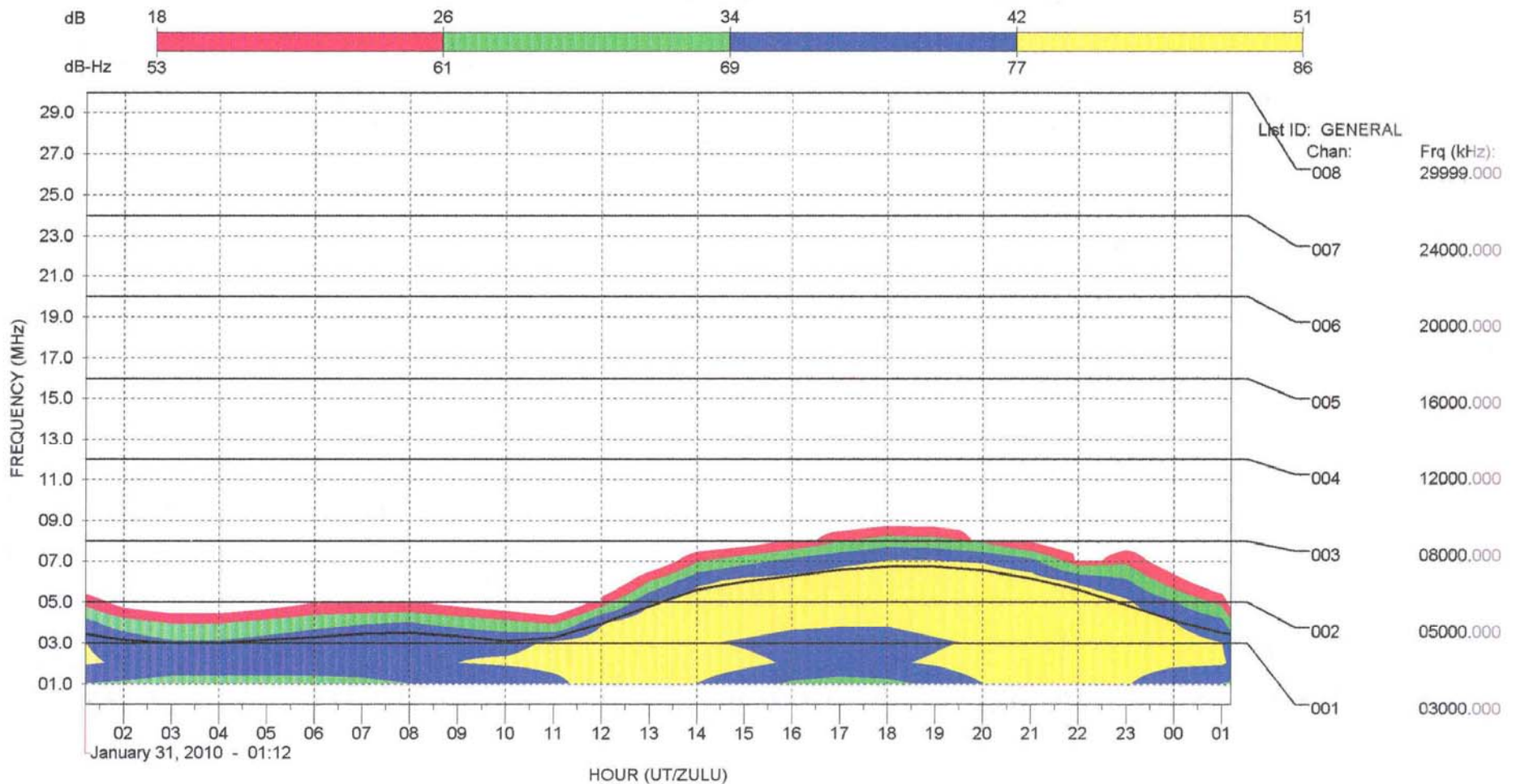


RCI OTA HF Test Links

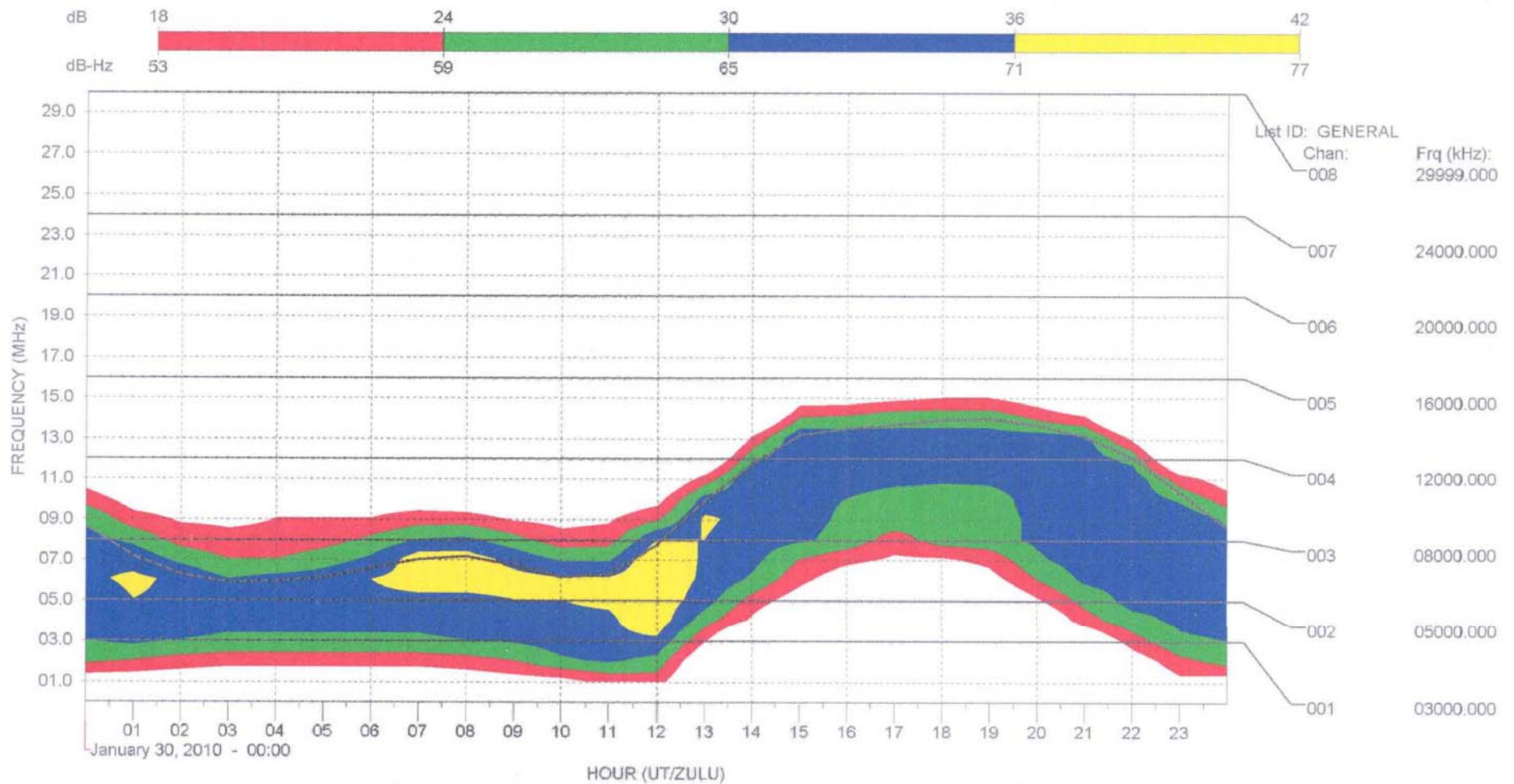


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PropMan 2000 Version: 1.00 (Build 13), Sun Spot Number: 010
 Naut. miles: 0034.1, Stat. miles: 0039.3, KM: 0063.1 (SHORT Path)
 Xmtr pwr: 1.000 kW Xmtr gain: 2.00 Rcvr gain: 2.00
 Frq. Range: 2 - 30 MHz Minimum Angle of Propagation Mode: 3.0
 Man-made noise: -150 dBW
 Min SNR (3kHz BW): 18 Max SNR: 51 Min LQA: 34 Max LQA: 50
 XMT Station: CEDAR RAPIDS LAB, IA, USA-ROCKWELL COLLINS, Degrees Azimuth: 94.80
 RCV Station: COMM CENTRAL - OJ, IA, USA-ROCKWELL COLLINS, Degrees Azimuth: 275.31



PropMan 2000 Version: 1.00 (Build 13), Sun Spot Number: 010
 Naut. miles: 0658.5, Stat. miles: 0758.3, KM: 1219.4 (SHORT Path)
 Xmtr pwr: 1.000 kW Xmtr gain: 2.00 Rcvr gain: 2.00
 Frq. Range: 2 - 30 MHz Minimum Angle of Propagation Mode: 3.0
 Man-made noise: -150 dBW
 Min SNR (3kHz BW): 18 Max SNR: 42 Min LQA: 34 Max LQA: 50
 XMT Station: RICHARDSON FACILITY, TX, USA-ROCKWELL COLLINS, Degrees Azimuth: 23.14
 RCV Station: COMM CENTRAL - OJ, IA, USA-ROCKWELL COLLINS, Degrees Azimuth: 206.62



Test Station Particulars

- Modified HF-80 1kW Transmitters & Receivers
 - Installed 12.0 kHz wide IF filters
 - Disabled Audio Compression feature
- Modified MDM-Q9604 Modem
 - Installed Prototype WBHF Waveforms for 6 and 12 kHz BW

Modulation Particulars

12 kHz BW; 9600 sym/sec

Modulation	Data Mini-Probe Block Size	Code Rate	Bit Rate kbps
256 QAM	1080-72	8/9	64.0
64 QAM	1080-72	8/9	48.0
64 QAM	1024-128	3/4	38.4
32 QAM	1024-128	3/4	32.0
16 QAM	1024-128	3/4	25.6
8PSK	1024-128	3/4	19.2
QPSK	1024-128	3/4	12.8
BPSK	1024-128	3/4	6.4
BPSK	432-144	2/3	4.8
BPSK	432-144	1/3	2.4
BPSK	72-72	1/4	1.2
BPSK	72-72	1/8	0.6

Test Station Particulars

- Modified MDM-Q9604 Modem (continued):
 - Diversity Transmission and Reception Included
- Comparison of Ground Wave in Iowa with Sea Wave over the Ocean:
 - Iowa: 63 km path = -127.3 dB Basic Path Loss at 3171 kHz
 - Ocean: 63 km path = -78.9 dB Basic Path Loss at 3171 kHz
 - Ocean: 696 Km path = -127.3 dB Basic Path Loss at 3171 kHz
- The Iowa Ground Wave Path Loss is the same as Sea Wave over a distance of 433 miles!
- A 200 nm sea wave path would have -105.8 dB Basic Path Loss
- The signal would be 21.5 dB stronger on a 200 nm path on the ocean than it is on the 63 km path over Iowa soil.

Ground Wave Link Analysis, 3171 kHz

- Lab 13 Tx Avg. Power (180W): +52.6 dBm
- Coupler + Coax Loss: -1 dB
- Antenna Gain: +5 dBi
- 63 km path loss: -127.3 dB (GRWAVE)
- OJ Rx Antenna Gain: +5 dBi
- OJ Coax Loss: -0.5 dB
- Receive Signal (calc.): -72.2 dBm
- Rural Noise Model (12 kHz): -79 dBm
- **Modeled SNR: 12.8 dB**
- Measured SNR: 16 to 18 dB (Modem)
- Measured SNR: 11 to 15 dB (HF Receiver)

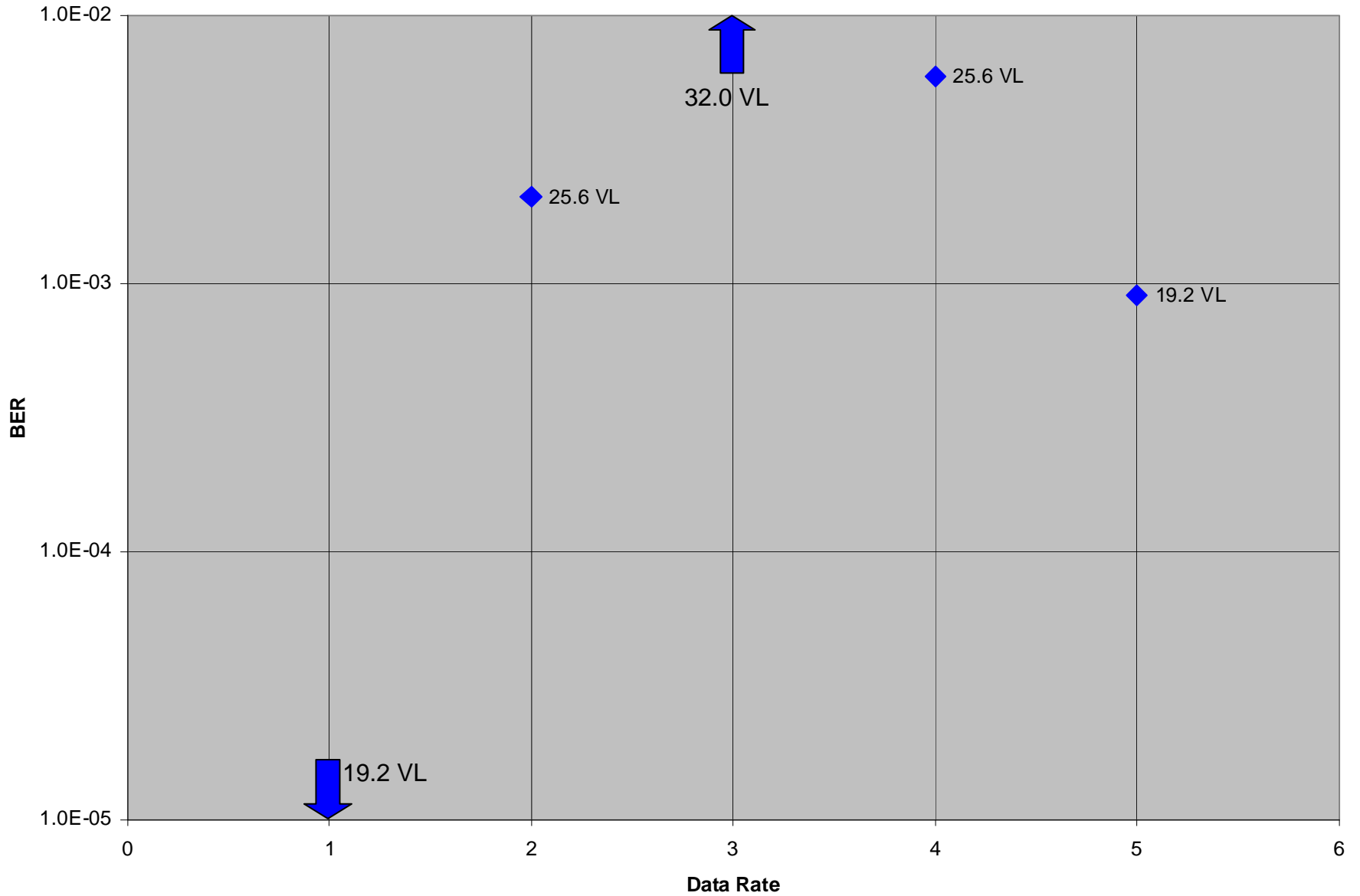
Test Results To Date

- Ground Wave Propagation between Cedar Rapids and Oxford Junction
 - Cedar Rapids HF Station Particulars
 - Antenna: 35-ft. Whip and Antenna Coupler on metal roof building
 - Radio: Modified HF-80 1kW Transmitter and Receiver
 - Modem: Modified MDM-Q9604
 - Oxford Junction HF Station Particulars
 - Antenna: CMV-330 Vertical Monopole
 - Radio: Modified HF-80 1kW Transmitter and Receiver
 - Modem: Modified MDM-Q9604
- Diversity Reception
 - Cedar Rapids Transmit only
 - Oxford Junction Receive only
 - Two Receivers
 - Two CMV-330 Antennas separated by approximately 1,000 feet

Data Rate Comparison

CR Tx; OJ Rx; WBHF; 12 kHz; 3171 kHz

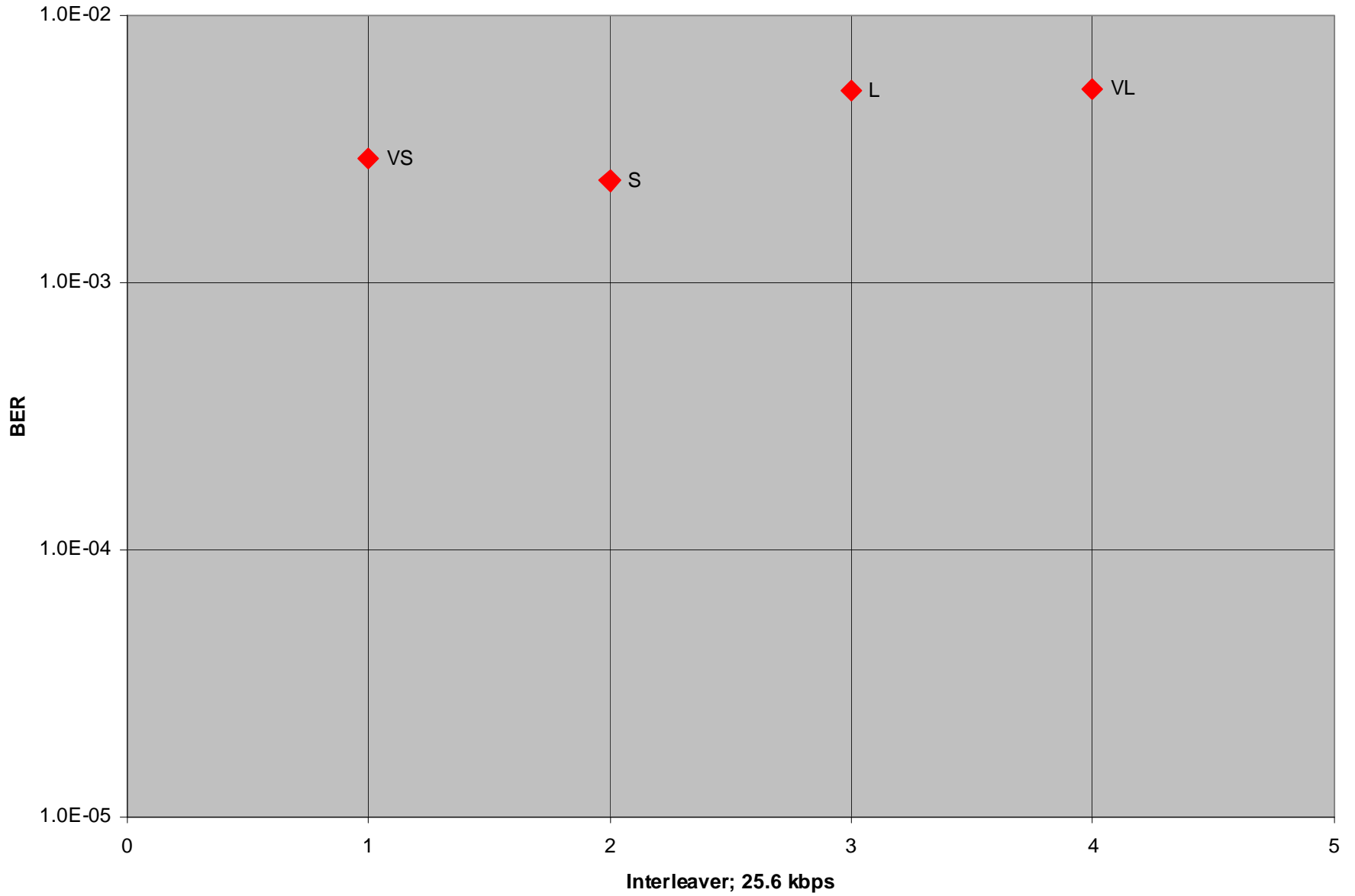
UTC Date/Time	27/2002	27/2020	27/2025	28/1530	28/1533
Data Rate Kbps	19.2	25.6	32.0	25.6	19.2
Interleaver	VL	VL	VL	VL	VL
Modem SNR (dB)	+16	+15	+10 / +12	+13 / +14	+12 / +15
Data Blocks	4,000	4,000	No Sync	4,100	10,000
BER	No errors	2.1×10^{-3}	-----	5.9×10^{-3}	9.0×10^{-4}



Interleaver Comparison

CR Tx; OJ Rx; WBHF; 12 kHz; 3171 kHz

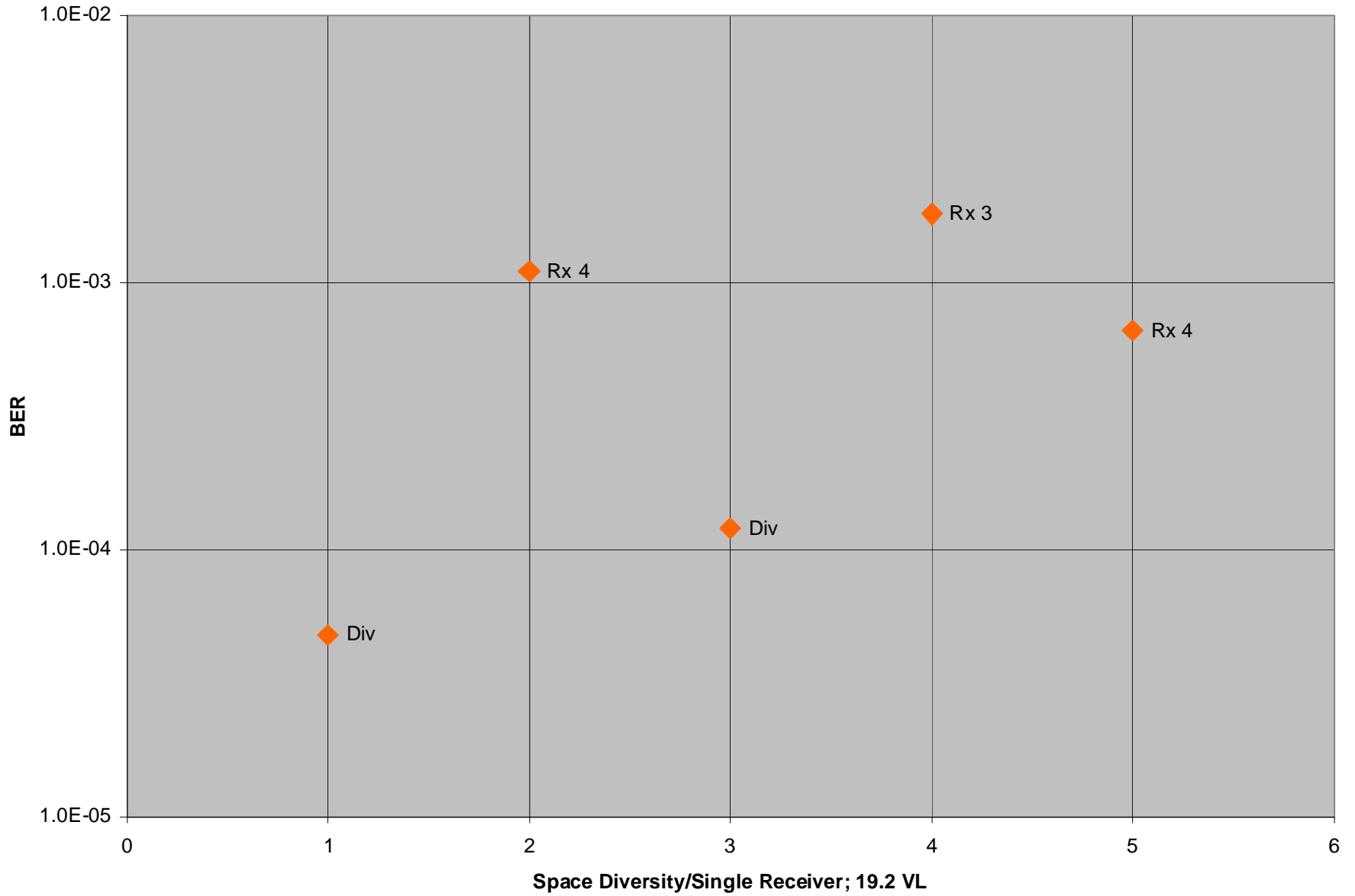
UTC Date/Time	28/1732	28/1740	28/1748	28/1755
Data Rate Kbps	25.6	25.6	25.6	25.6
Interleaver	Long	Very Long	Short	Very Short
Modem SNR (dB)	+14	+13	+14	+14
Data Blocks	7,000	10,000	4,000	4,100
BER	2.9×10^{-3}	2.4×10^{-3}	5.2×10^{-3}	5.3×10^{-3}



Diversity Reception Comparison

CR Tx; OJ Rx; WBHF; 12 kHz; 3171 kHz

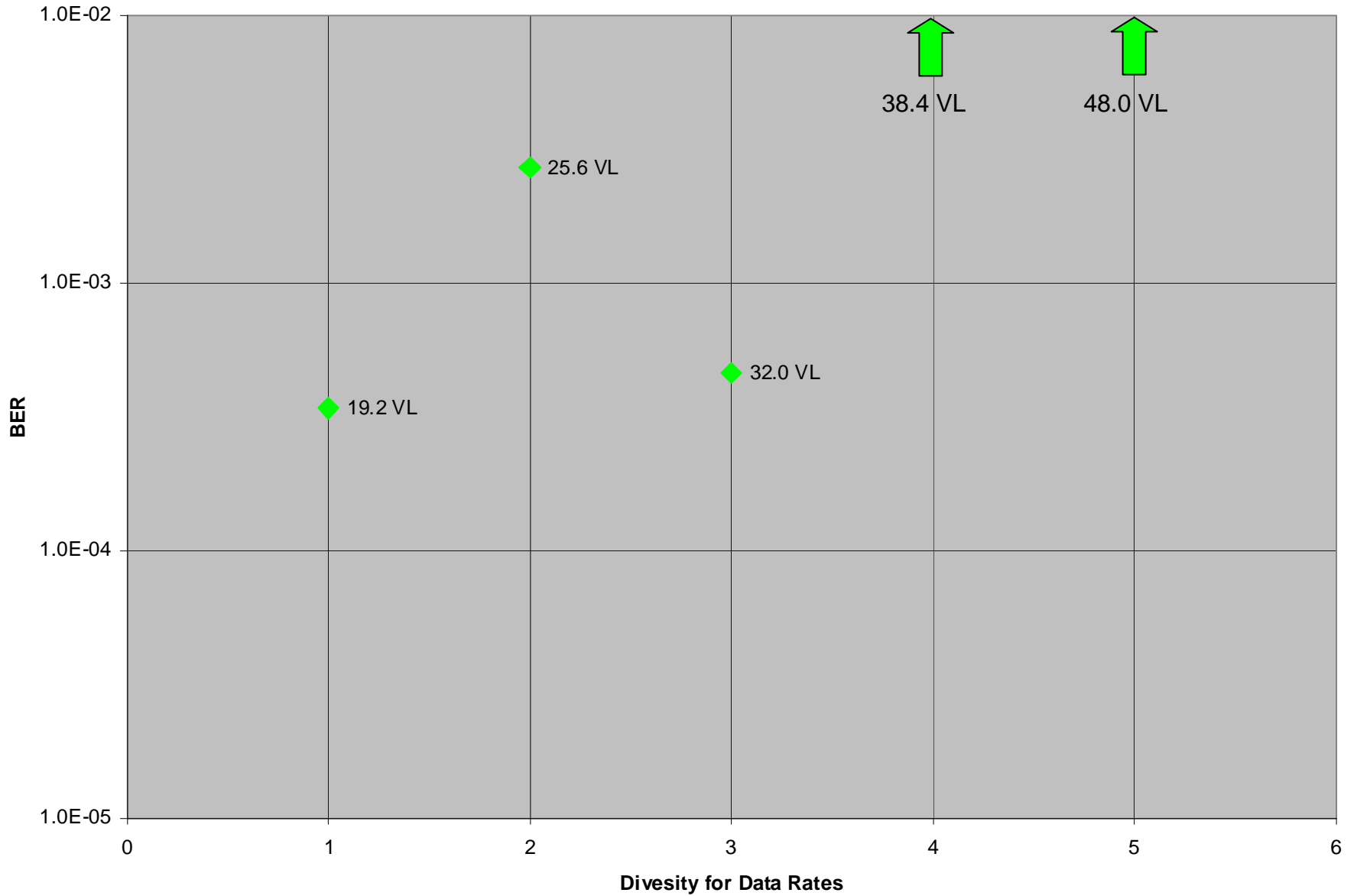
UTC Date/Time	29/1745	29/1825	29/1836	29/1841	29/1854
Receiver	Rx3 & Rx4	Rx4	Rx3 & Rx4	Rx3	Rx4
Data Rate Kbps	19.2	19.2	19.2	19.2	19.2
Interleaver	VL	VL	VL	VL	VL
Modem SNR (dB)	+16 / +18	+14 / +15	+15 / +17	+16	+11 / +13
Data Blocks	10,000	7,276	10,000	6,800	6,643
BER	4.8×10^{-5}	1.1×10^{-3}	1.2×10^{-4}	1.8×10^{-3}	6.6×10^{-4}



Diversity Data Rate Comparison

CR Tx; OJ Rx; WBHF; 12 kHz; 3171 kHz

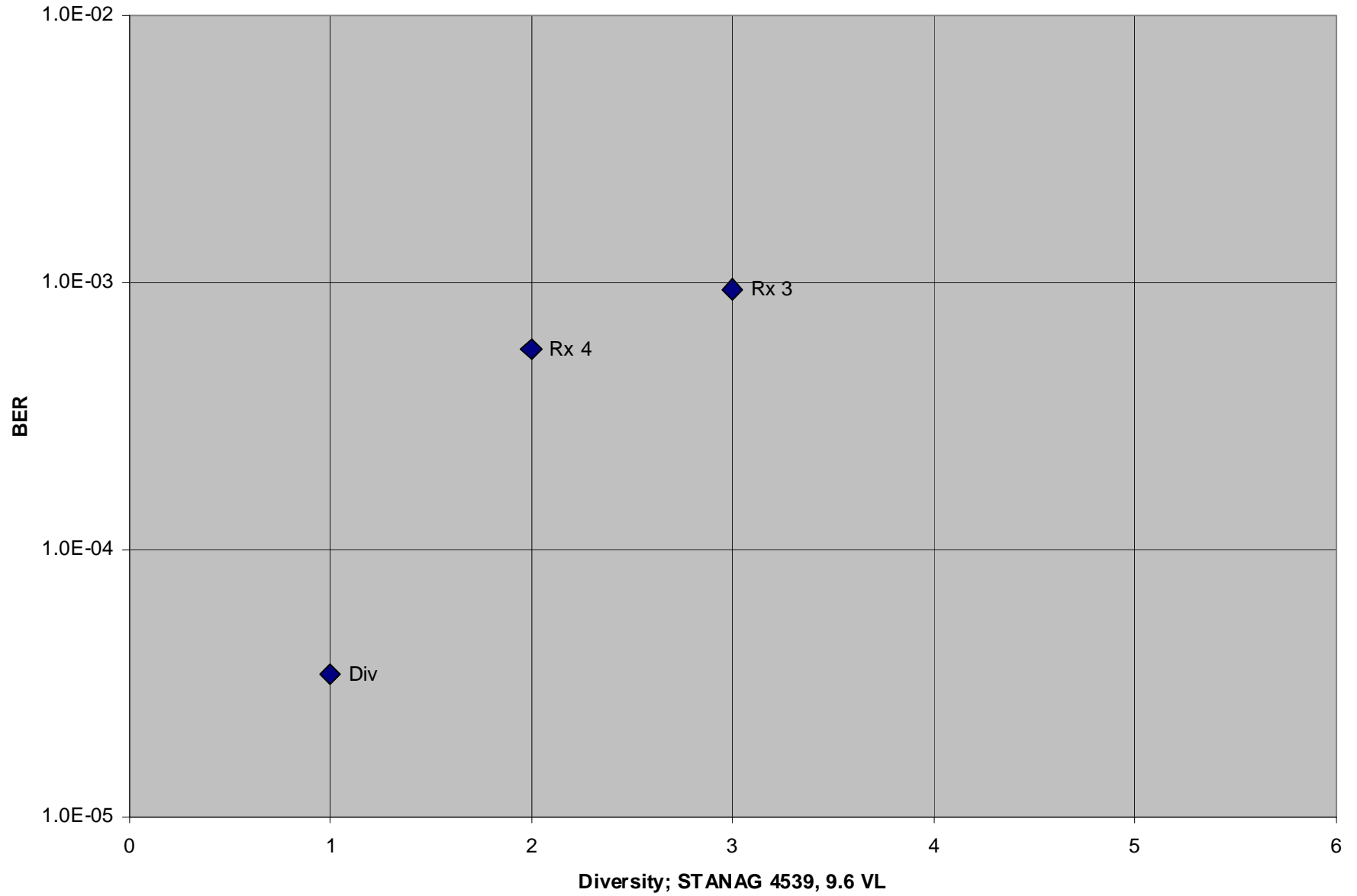
UTC Date/Time	29/1854	29/1915	29/2010	29/2025	29/2030
Receiver	Rx3 & Rx4	Rx3 & Rx4	Rx3 & Rx4	Rx3 & Rx4	Rx3 & Rx4
Data Rate Kbps	19.2	25.6	32.0	38.4	48.0
Interleaver	VL	VL	VL	VL	VL
Modem SNR (dB)	+15 / +17	+15 / +17	+22	No Sync	No Sync
Data Blocks	15,000	8,000	10,000		
BER	3.4×10^{-4}	2.7×10^{-3}	4.6×10^{-4}		



Diversity STANAG 4539 Comparison

CR Tx; OJ Rx; S4539; 3 kHz; 3171 kHz

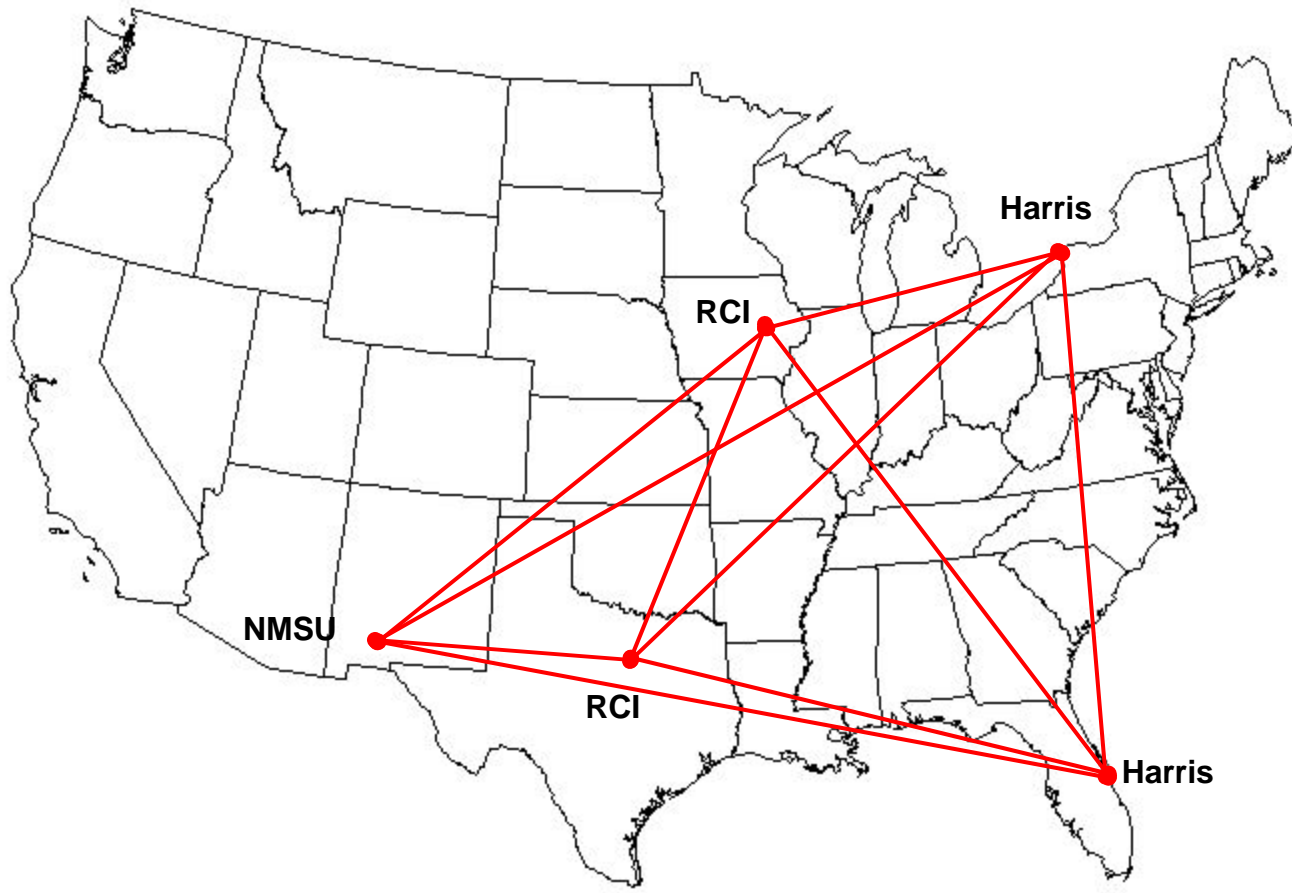
UTC Date/Time	29/2140	29/2148	29/2154		
Receiver	Rx3 & Rx4	Rx4	Rx3		
Data Rate Kbps	9.6	9.6	9.6		
Interleaver	VL	VL	VL		
Modem SNR (dB)	+19 / +21	+18 / +20	+18 / +20		
Data Blocks	5,000	3,000	3,000		
BER	3.4×10^{-5}	5.6×10^{-4}	9.4×10^{-4}		



Future OTA Testing

- Immediate phase:
 - NVIS testing between CR and OJ
 - Sky Wave testing between Richardson, TX and CR/OJ
 - Include Diversity Reception tests
 - Improvements to waveform design
 - ARQ links
- Future Phases Include:
 - Sea Wave Tests
 - Further waveform refinements
 - Interoperability OTA testing with Harris and NMSU
 - Rochester, NY
 - Melbourne, FL
 - Las Cruces, NM
 - Richardson, TX
 - Cedar Rapids, IA
 - Oxford Junction, IA

Future Interoperability HF OTA Test Links





The End

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