

# **AN INVESTIGATION OF THROUGHPUT VS. INTERLEAVER SIZE FOR ARQ SYSTEMS UTILIZING STANAG 4539 HF WAVEFORMS**

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# ***Presentation Overview***

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- Overview
- ARQ System Definition
- ARQ and Waveform Inefficiencies
- ARQ Parameters
- 9600 bps ARQ Performance on a CCIR Poor Channel
- Conclusions

# ***ARQ System Definition***

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- ARQ System provides “error-free” data delivery
  - Data sub-divided into packets
  - CRC added to determine if each received packet is in error
  - All packets given a unique sequence number
  - All packets have a preamble in order to identify the start of the packet (STANAG 5066)
  - Packets in error are re-transmitted

- ARQ Inefficiencies
  - CRC bits added to packet
  - Preamble bits added to packet
  - Sequence id added to packet
  - STANAG 5066
    - For a 200 byte packet, 22 bytes overhead => 11 % loss of throughput
    - For a 1000 byte packet, 22 bytes overhead => 2.2 % loss of throughput
  - Trade-off determining packet size since larger packets have a greater probability of being received in error but have less overhead
  - ACK transmission to identify which packets to re-send (ACK time can range from 1 second up to 11 seconds)

- Waveform Inefficiencies
  - Delay to fill interleaver block at TX site
  - Delay to receive interleaver block at RX site
  - Modem buffering at both TX/RX to avoid buffer overflows/underflows
  - Fill bits of last interleaver
  - Initial preamble
  - TLC blocks

- Waveform Inefficiencies – cont.
  - Longer interleavers provide better packet error rates on fading channels but add significant latencies
    - Very Long interleaver adds about 18.3 seconds of latency. If maximum forward transmission time is 20 seconds, throughput is degraded significantly (almost by a factor of 2 !)
    - If packet size not well matched to interleaver size, lots of fill bits at end of forward transmission

- Maximum forward transmission time
  - This parameter results from a maximum number of packets per forward transmission and a maximum packet size. For example, STANAG 5066 allows a maximum of 128 packets per forward transmission and a maximum packet size of 1023 bytes
    - For 200 byte packets, max. forward transmission time is 21.333 seconds for 9600 bps
    - For a 1023 byte packet, max. forward transmission time is 109.12 seconds for 9600 bps
    - Absolute maximum forward transmission time (120 sec)
- Selection of modem waveform, data rate and interleaver size

# ***ARQ Performance***

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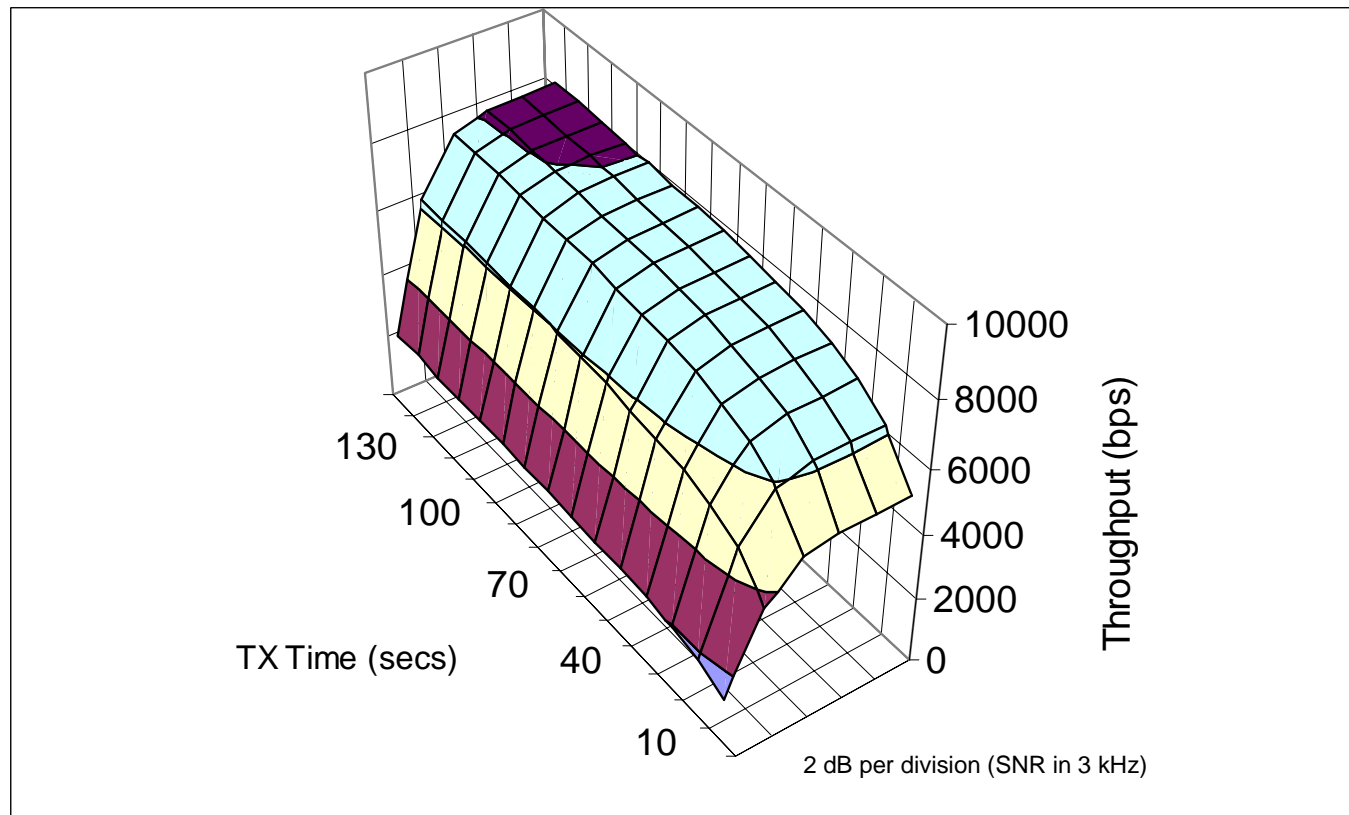


- STANAG 4539 9600 bps waveform
- CCIR Poor Channel
- 6 interleaver sizes investigated
- 3 Message sizes – 5000, 50000 and 5000000 bytes
- Packet sizes of 200 bytes and 1200 bytes
- Max. forward transmission times from 10 seconds to 150 seconds
- Link set-up time not included in throughput computation
- All ACK packets received error-free (ACK time 2.2 seconds)

# ARQ Performance - CCIR Poor



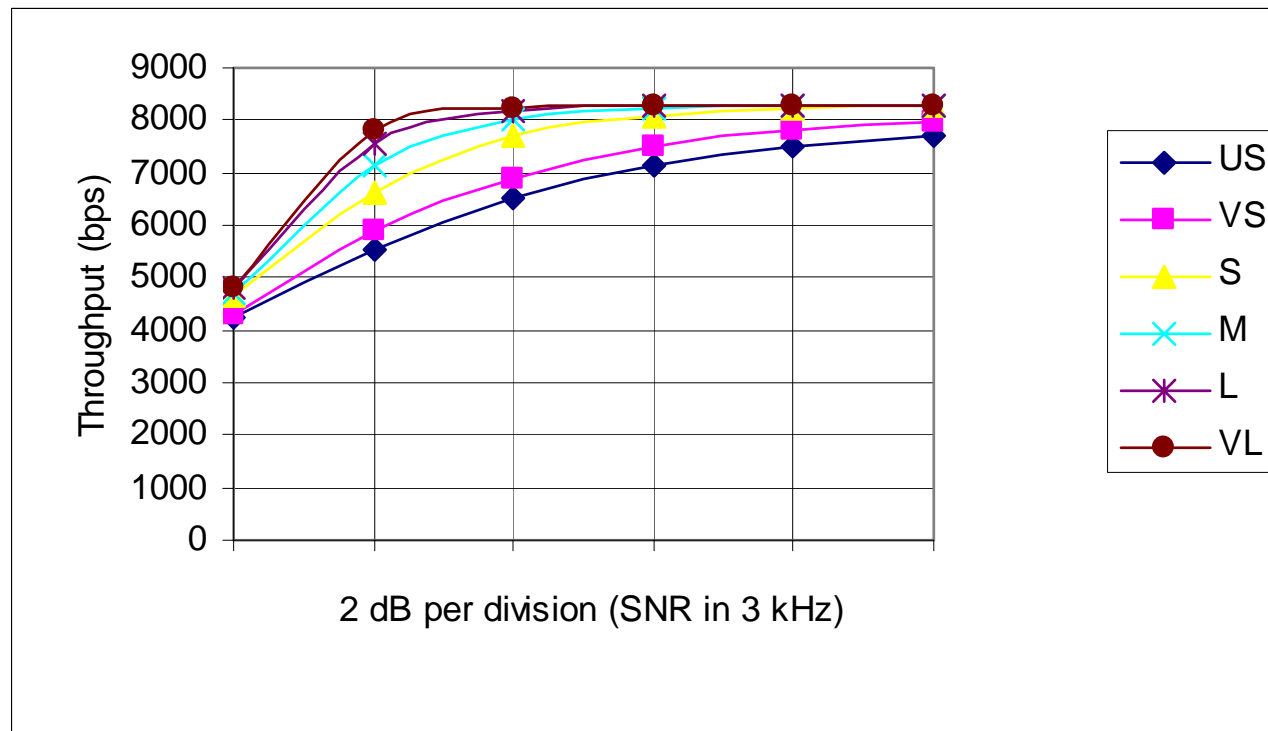
- 9600 L, 1200 byte packet, 5000000 byte message -  
Note that TX Time can also be viewed as # packets



# ARQ Performance - CCIR Pool



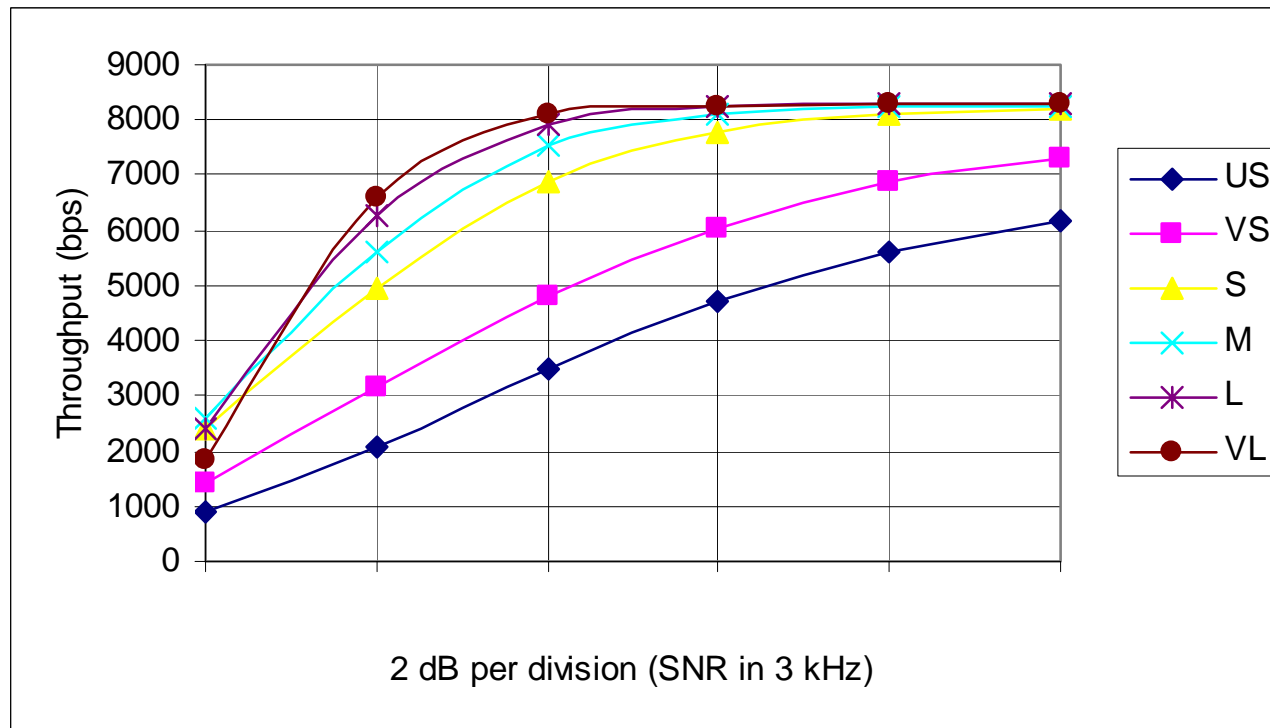
- No modem latencies, instantaneous ACK transmission and 200 byte packets (i.e. throughput a function of block error rate)



# ARQ Performance - CCIR Pool



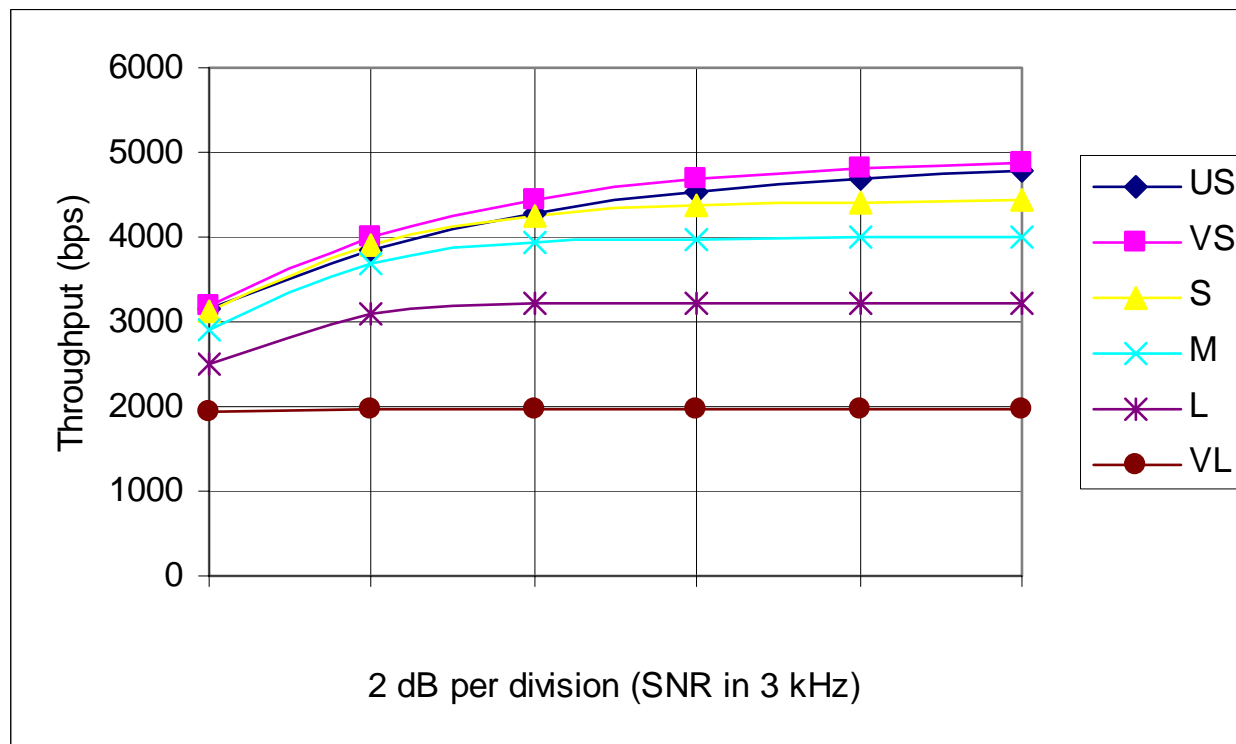
- No modem latencies, instantaneous ACK transmission and 1200 byte packets (i.e. throughput a function of block error rate)



# ARQ Performance - CClR Pool



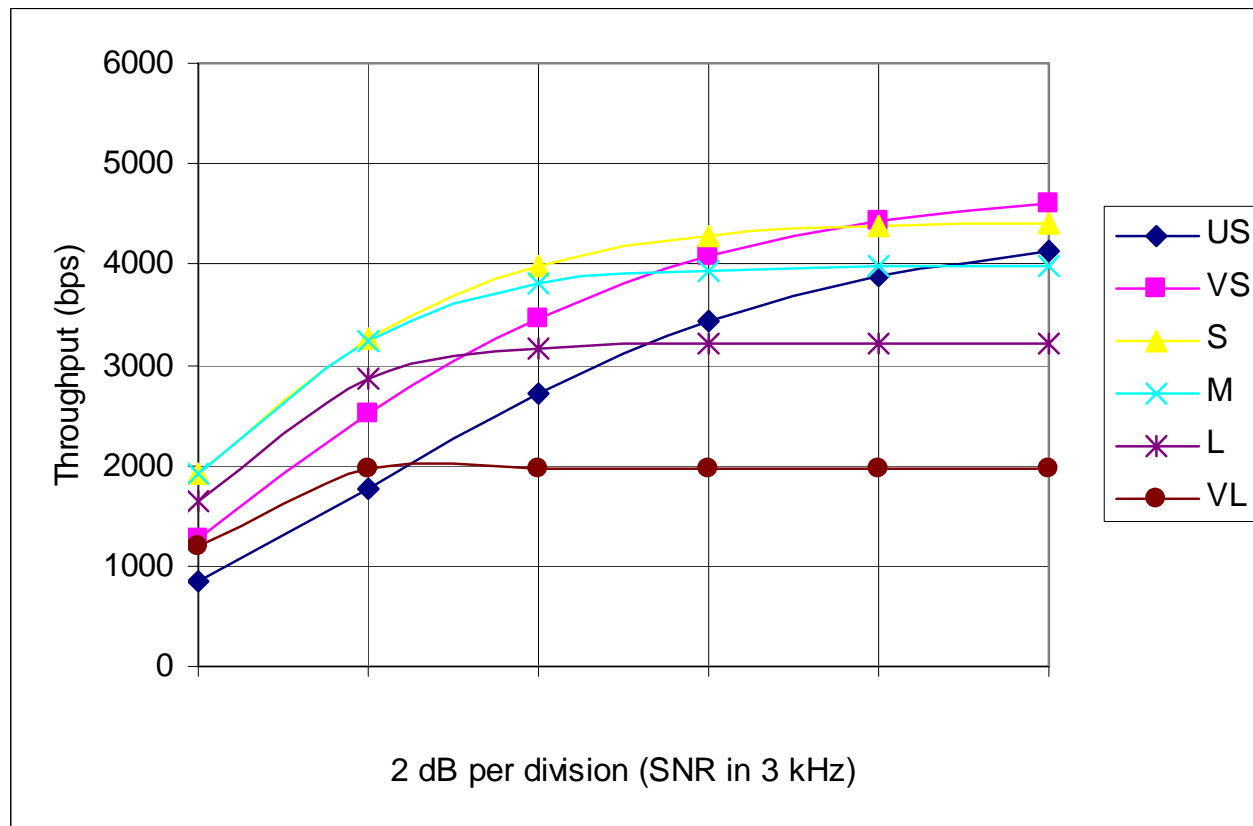
- Including all inefficiencies – 5000 byte message, 200 byte packets



# ARQ Performance - CClR Pool



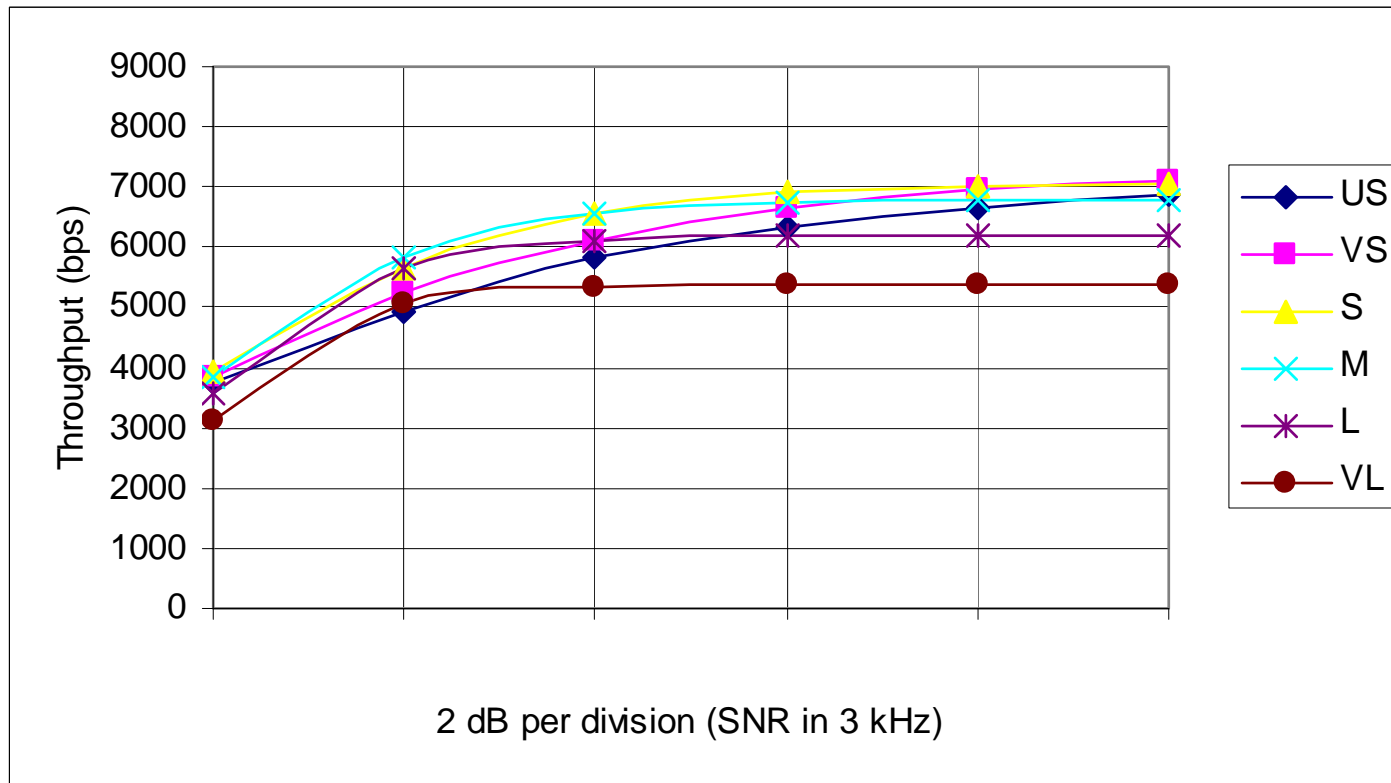
- Including all inefficiencies – 5000 byte message, 1200 byte packets



# ARQ Performance - CClR Pool



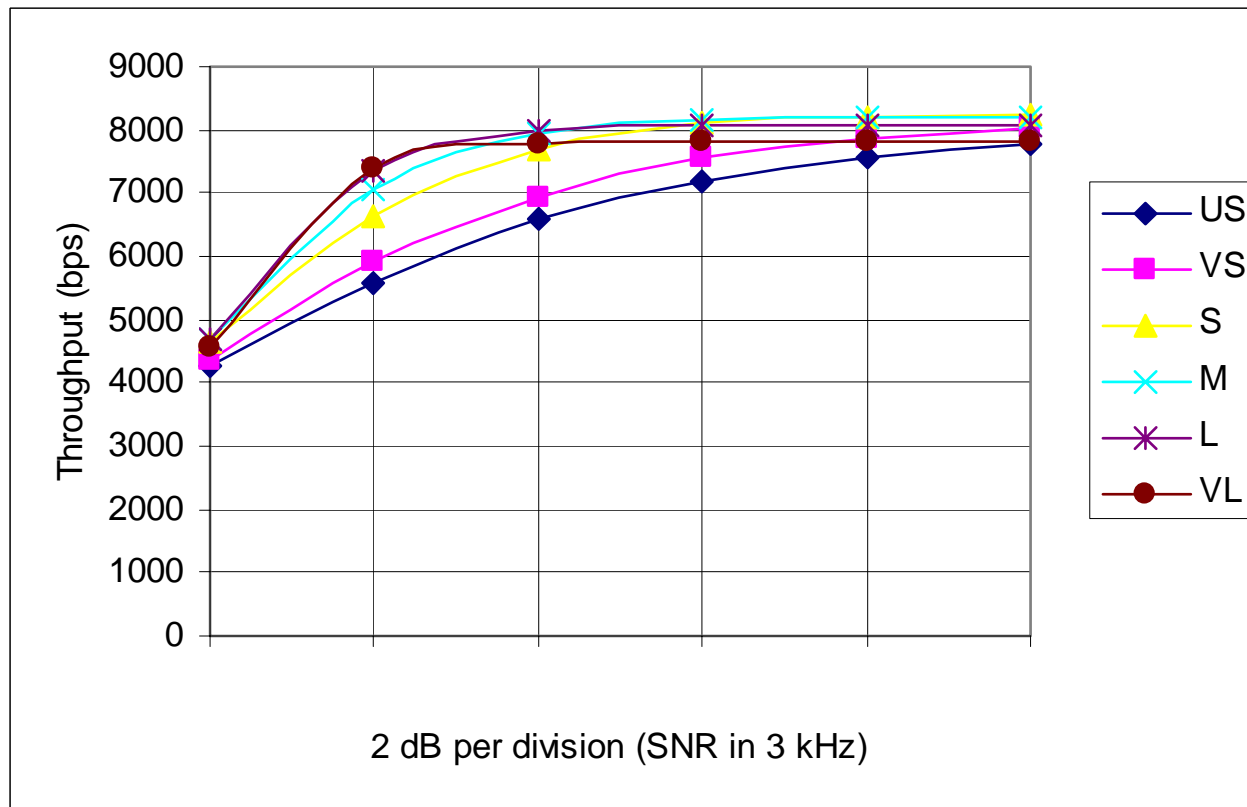
- Including all inefficiencies – 5000000 byte message, 20 second max. TX time and 200 byte packets



# ARQ Performance - CCIR Poor



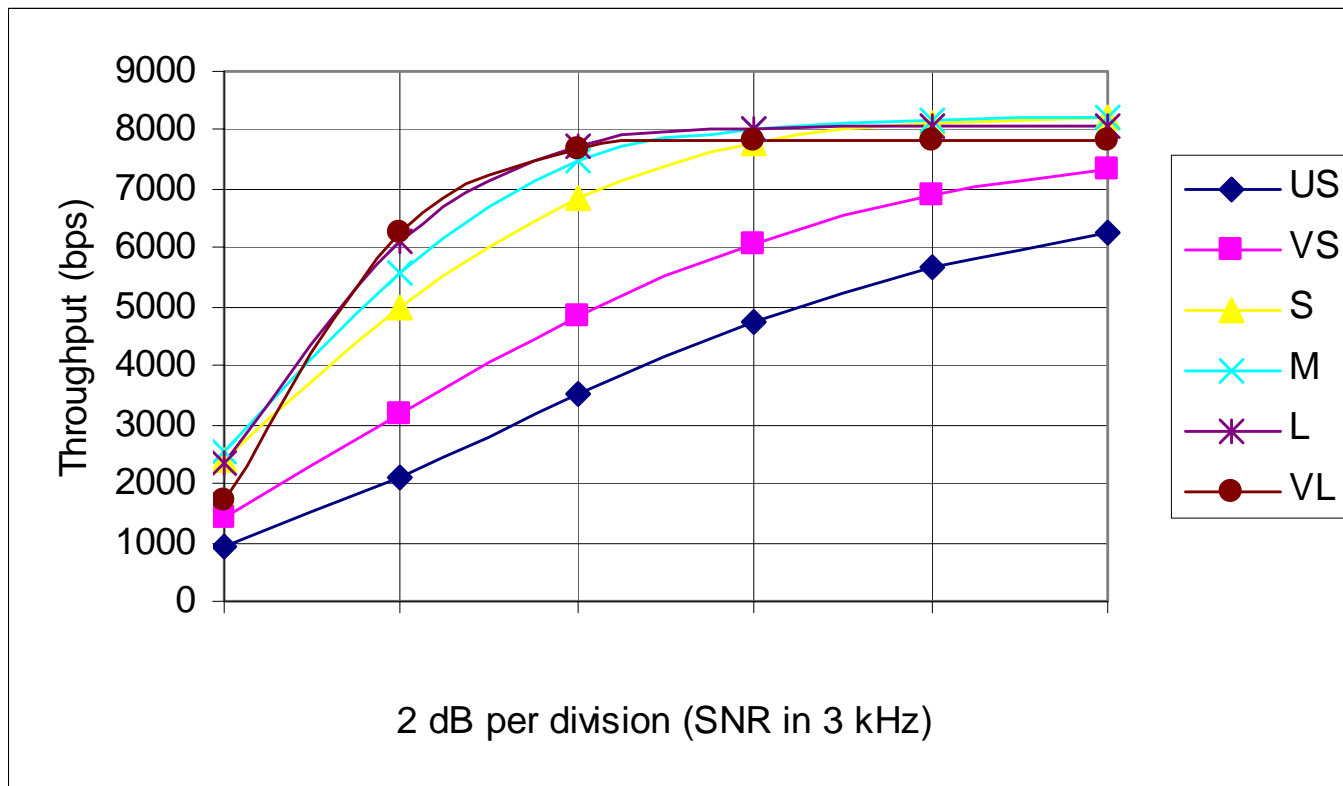
- Including all inefficiencies – 5000000 byte message, 130 second max. TX time and 200 byte packets



# ARQ Performance - CClR Pool



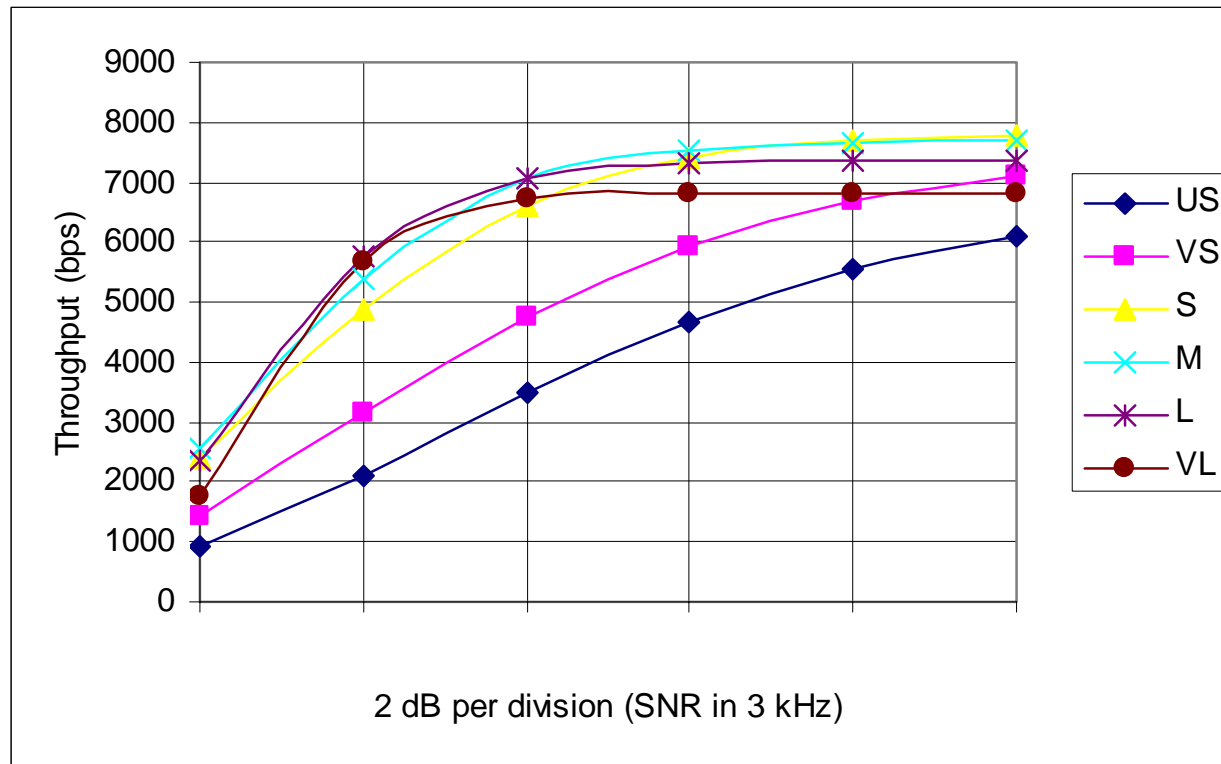
- Including all inefficiencies – 5000000 byte message, 130 second max. TX time and 1200 byte packets



# ARQ Performance - CClR Pool



- Including all inefficiencies – 50000 byte message, 130 second max. forward transmission time and 1200 byte packets



# Conclusions



- Throughput very dependent on size of message, maximum forward transmission time and channel conditions
- US interleaver setting should only be used for very short messages, small packet sizes and good channel conditions
- VL interleaver setting should never be used
- Additional investigation of 8000 and 6400 bps waveforms to determine best maximum data rate to select for a given message size
- ARQ systems need to be optimized at lower SNR values (not at largest SNRs, which are less likely to occur On-Air)