The Next ALE
Getting the most out of WBHF

CF HF Conference
November 2013

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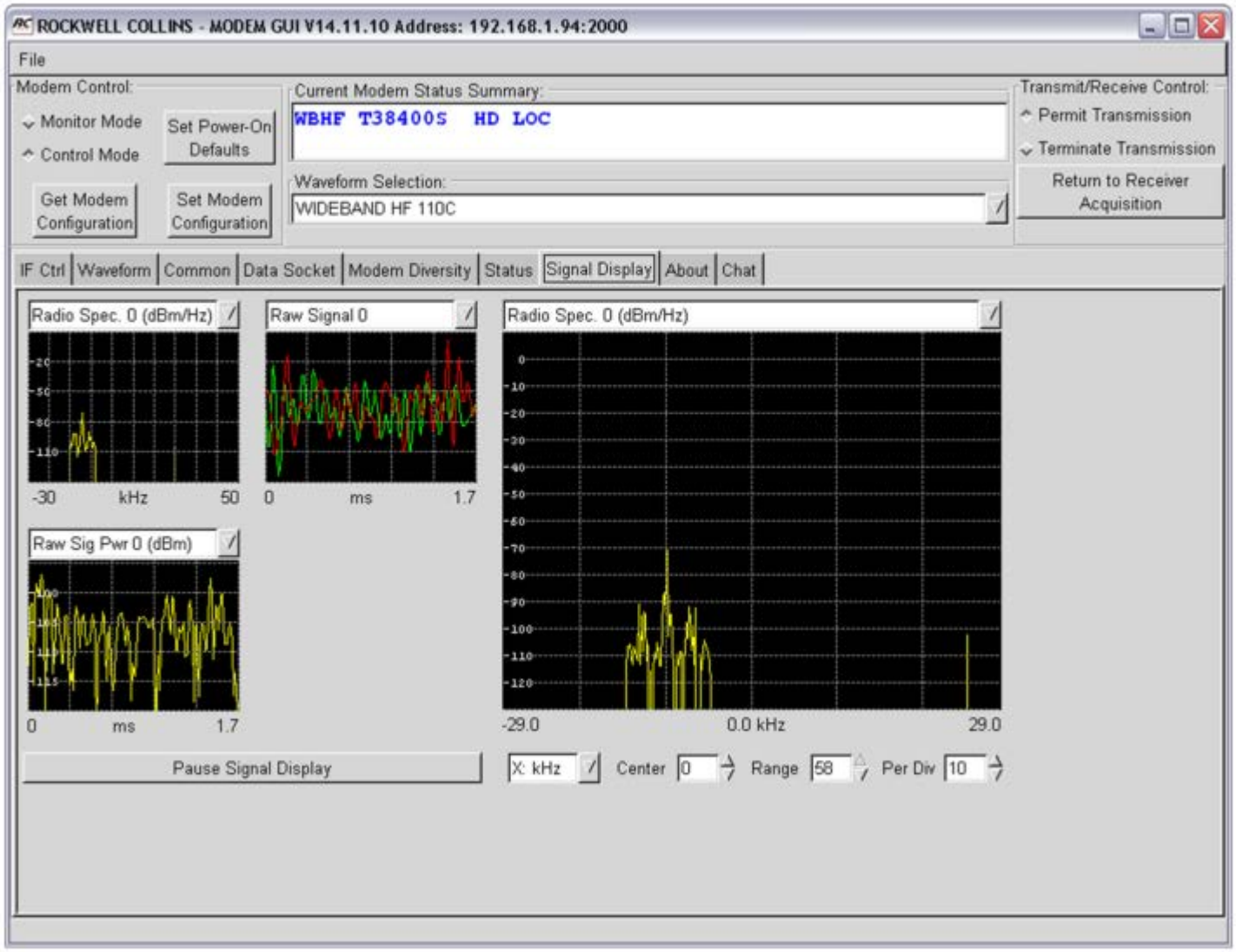
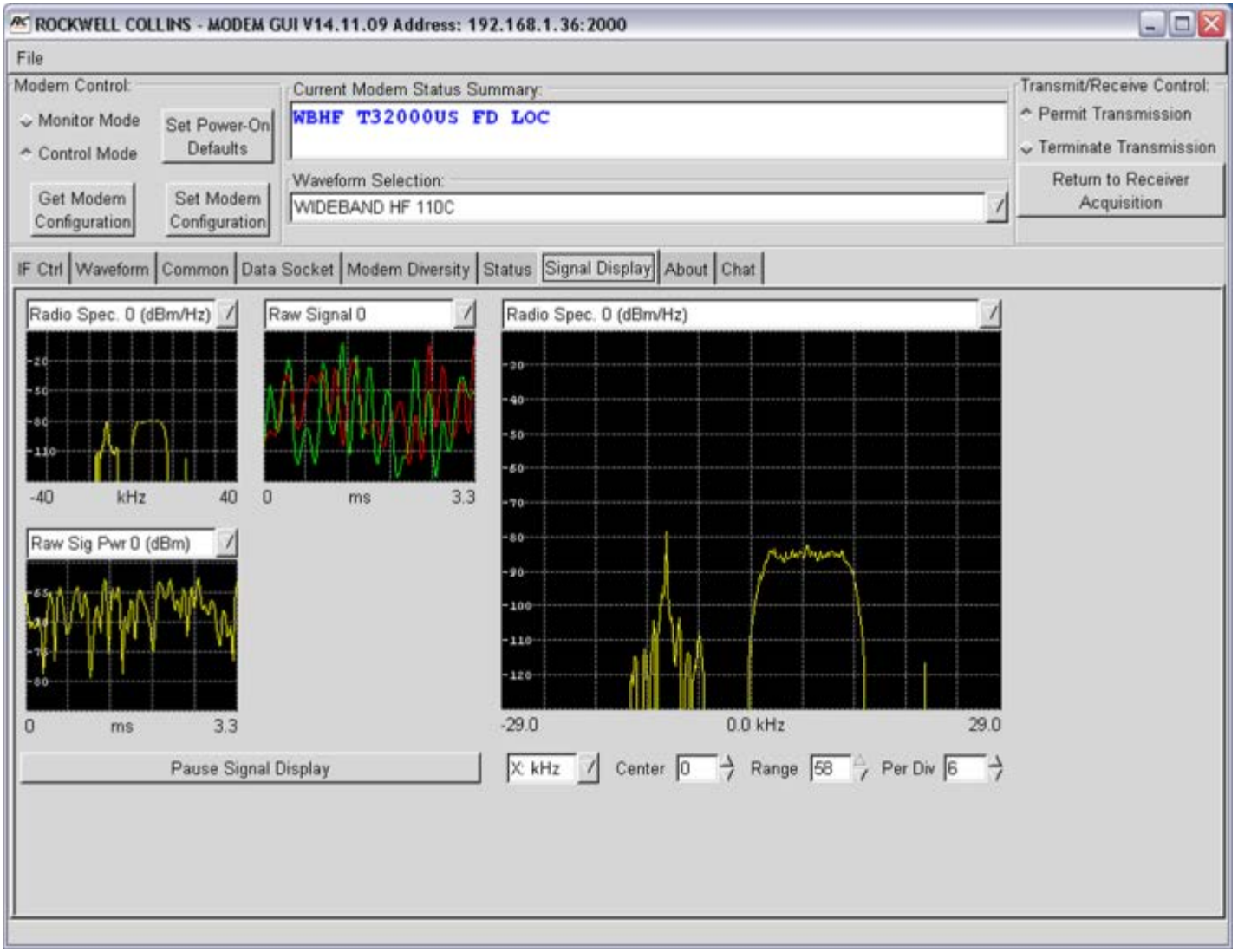
Why ALE?

- Automatic Link Establishment (ALE) systems were developed to simplify and automate the use of HF radio
- ALEs use an agreed upon list of channels
  - Large scan list provides a good selection of channels to choose from
  - Small scan list can be scanned more quickly
- When one station wishes to call another
  - Calling station initiates the call
  - Addressed station responds
  - Link is established
    - in some systems calling station confirms first
- Many other features support this capability or expand on it
- WBHF makes the ALE problem more challenging …

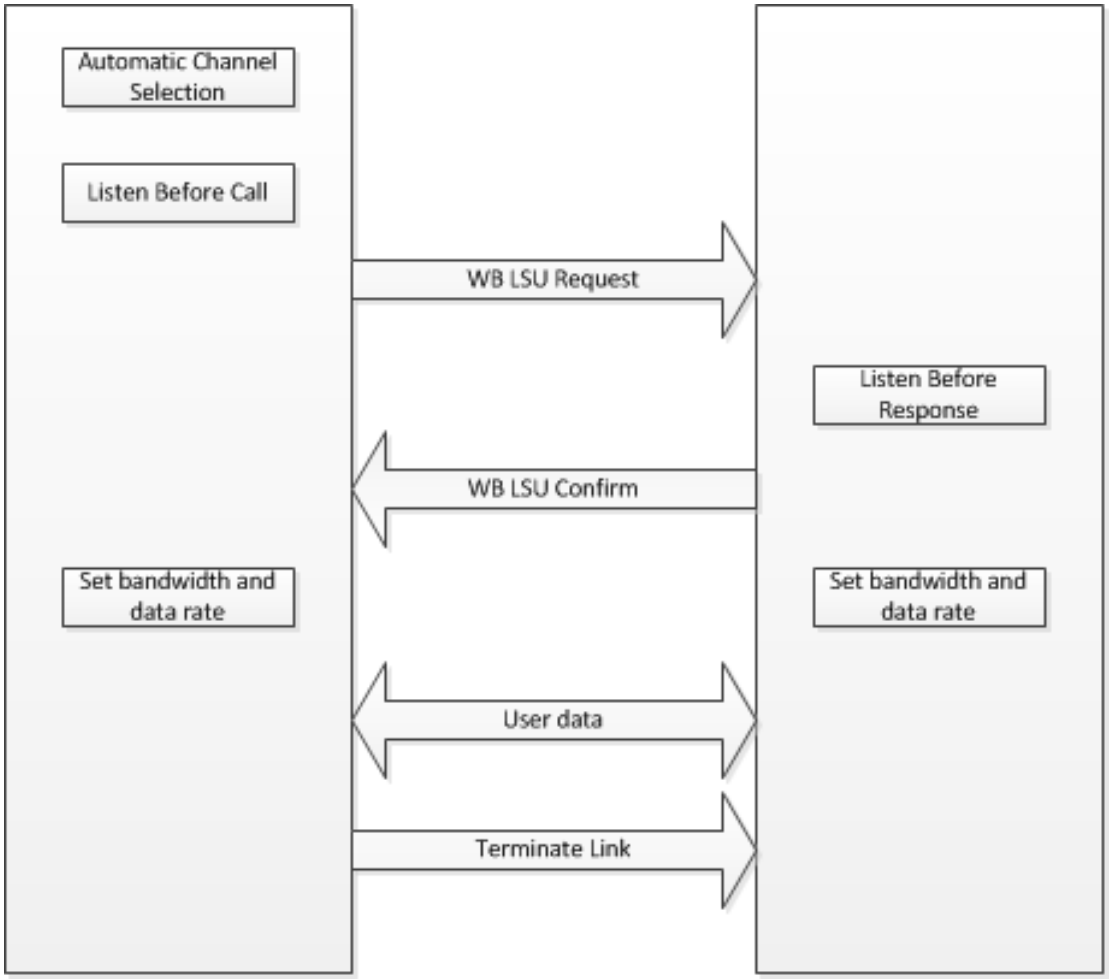
ALE and Spectrum Availability Considerations

- Current ALEs choose
  - Frequency
  - Data rate
  - Link maintenance - adapt data rate or look for a new channel
- WB ALE will have to choose
  - Frequency
  - Bandwidth (and offset)
  - Data rate
  - Adaptation involves data rate, bandwidth, offset or new channel
- May be more desirable for WB ALE to play nicely
  - Attempt to avoid channels with signals on them, even if they would provide good links





Point-to-Point Link setup protocol



Additional Requirements for a WBHF ALE

- Most important
  - Fast linking
- Also
  - Robust linking
  - ALE automatically sets up the traffic waveform to take advantage of available bandwidth and data rate
  - Service oriented link setup
    - Based on what is needed to support the particular traffic type
    - Equal support of voice and particular data link needs
  - Ease of implementation
    - Supporting waveforms based on Appendix D 3 kHz

Impact of Link Setup Time on File Transfer

- Example – transfer of a 50 kB image file
- At 9600 bps, forward transmission is about 42 s, ~50 s overall

- ALE with 8 channels in the scan list
  - 2nd Generation ALE (asynchronous), 1 s per dwell
  - 3 way handshake adds about 10 s

  - 3rd Generation ALE (synchronous), 1.35 s per dwell
  - Link on next available channel adds about 3.5 s on average
  - Link on best available channel adds about 8 s

- At 76.8 kbps, forward transmission is about 5 s, ~10 s overall

- Link setup adds about 20% to file transmission at 9600 bps, but roughly doubles transmission times for higher WBHF rates

Features to support Fast Linking Objective

- Complete link setup with:
  - Two way handshake for non-interfering or one way traffic case
  - Three way handshake for two way traffic when primary user of the frequency
- Short dwell times to support fast asynchronous linking
  - 2 options for dwell time probe selection
- Use a higher data rate (and therefore shorter duration) LSU waveform when setting up high throughput links
  - LSU waveform performance characteristics matched to traffic waveform
- If a time synchronization is available the system may use a shortened probe.

Calling waveform

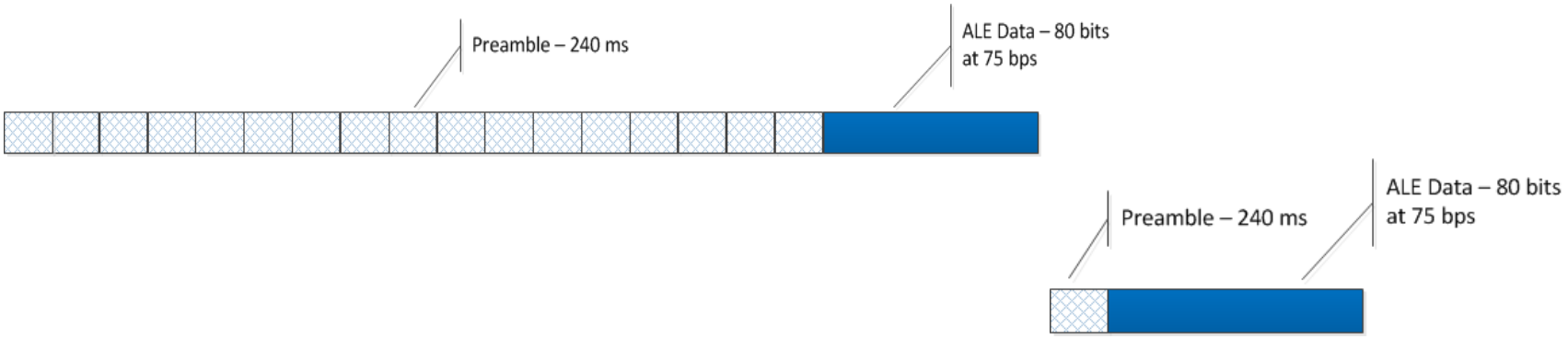
- Probe, Preamble, Data
- Probe
  - Probe repeated long enough to capture the channel
  - Can be based on repeated preambles or TLC blocks
  - Probe is followed by 80 bit payload.
  - If time synchronization is available the probe can be shortened.
- Preamble
  - Appendix D 3 kHz preamble used with minor modifications
- Data
  - Two choices both based on Appendix D 3 kHz waveforms
    - 75 bps
    - 600 bps (with FEC puncturing to bring rate to 750 bps)

Preamble based probe

- Appendix D preamble includes a facility to count down to the final preamble segment
- Using this approach provides for as many preambles as necessary to meet requirements imposed by scan list and dwell time
  - Count can be extended as other preamble bits not needed
- Preamble length is 240 ms
- Asynchronous dwell should be about double this

Async call with preambles and robust ALE data

- Asynchronous calling waveform below includes 17 preambles
  - With a dwell of 480 ms, this would support an 8 channel scan list
  - Number of preambles is matched to the size of the scan list
- Duration of calling phase is just over 5 seconds
- Response phase requires 1.3 s
- 3 way handshake would require about 8 s

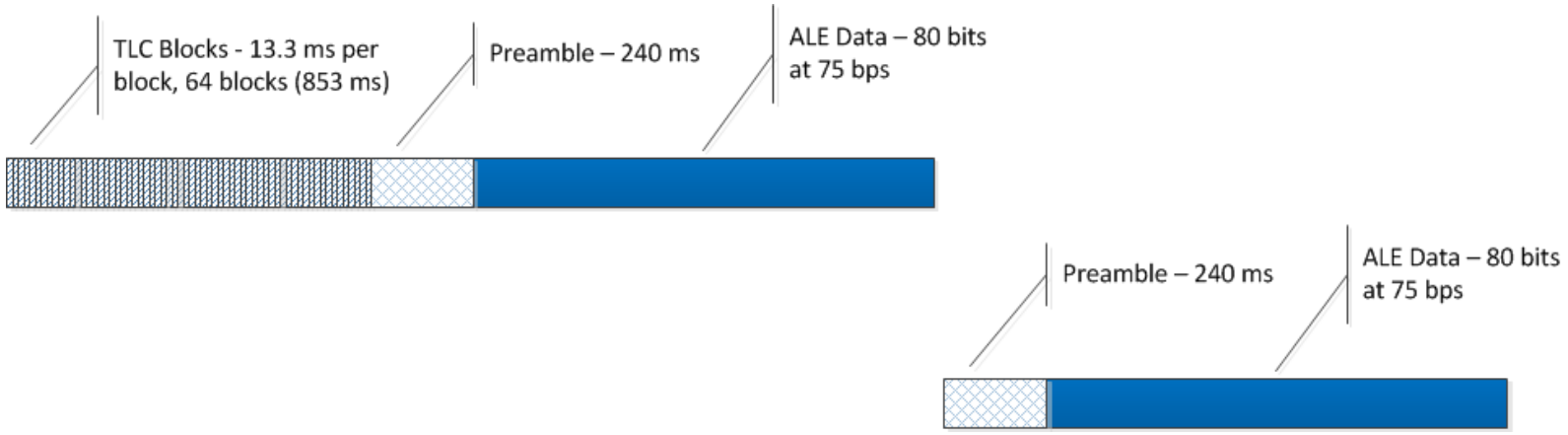


TLC Block probe method

- Mil-Std-188-110C Appendix defines a 13.3 ms TLC block
  - 13.3 ms TLC block sequence repeated as probe
  - Receiver identifies the presence of the signal and stops its scan
- Theoretical dwell of ~27ms is possible.
- Depending on equipment capabilities the practical dwell time is in the 100 ms to 200 ms range

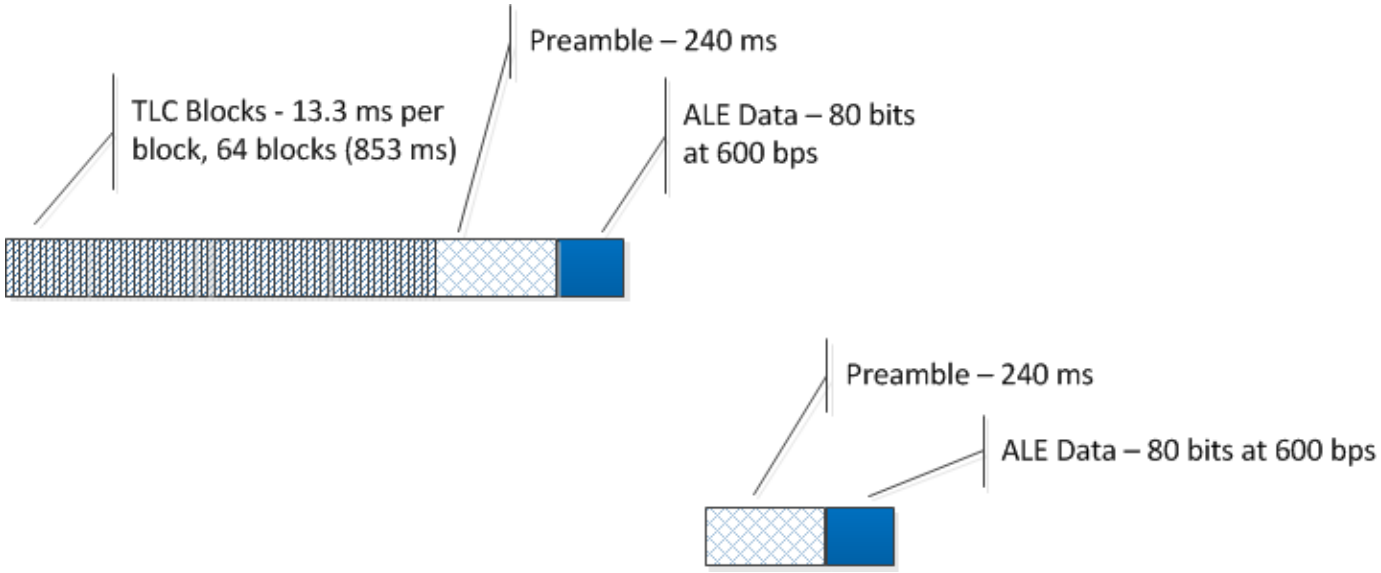
Async call with TLC and robust ALE data

- TLC blocks used to capture the scan
  - 13.3 ms per TLC block
- Example below shows 64 TLC blocks
  - Will support 8 channel scan list with 100 ms dwells
- Calling waveform is 2.16 s
- Response is 1.3 s
- Three way handshake requires about 5 s

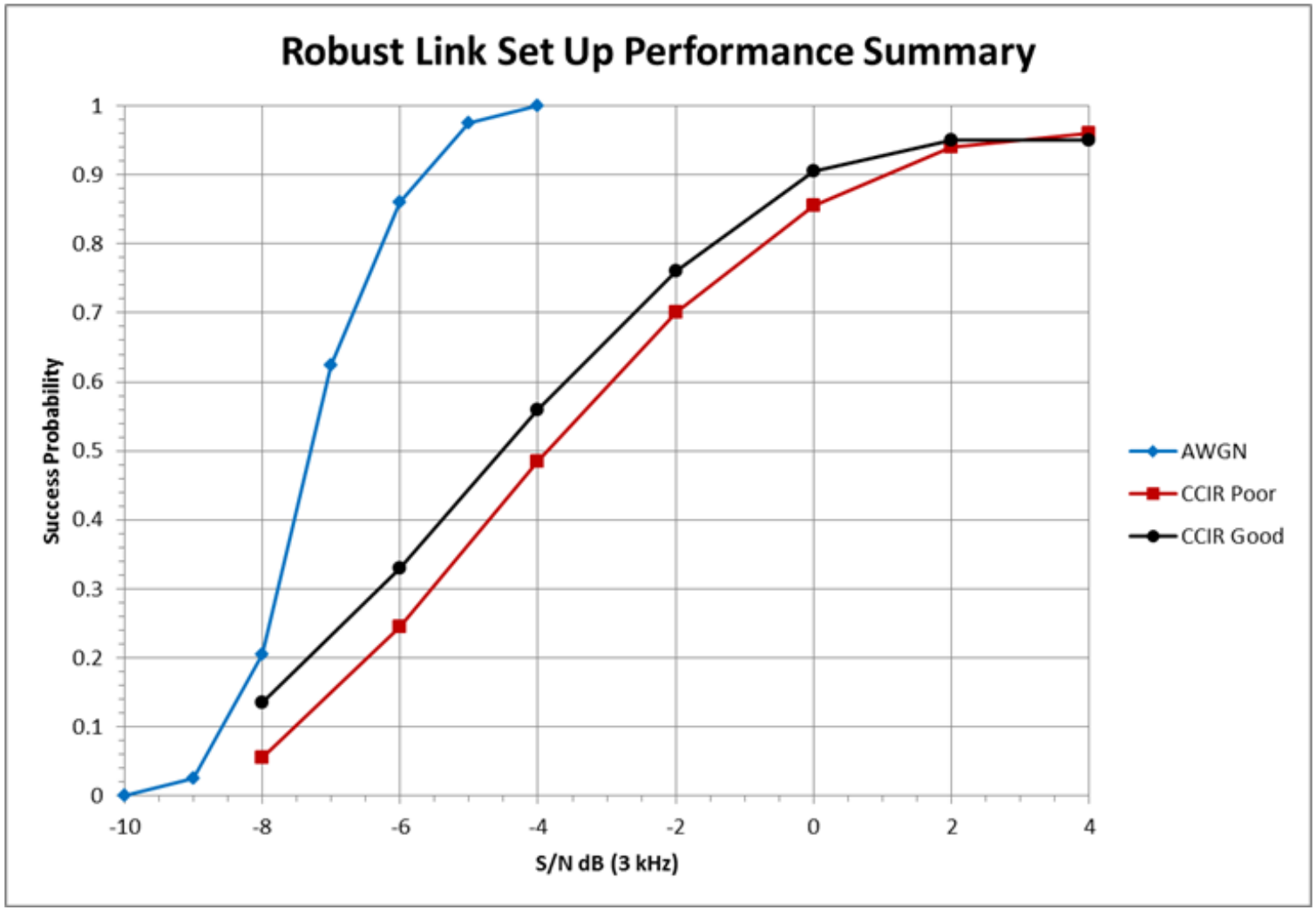


Async call with TLC and faster ALE data

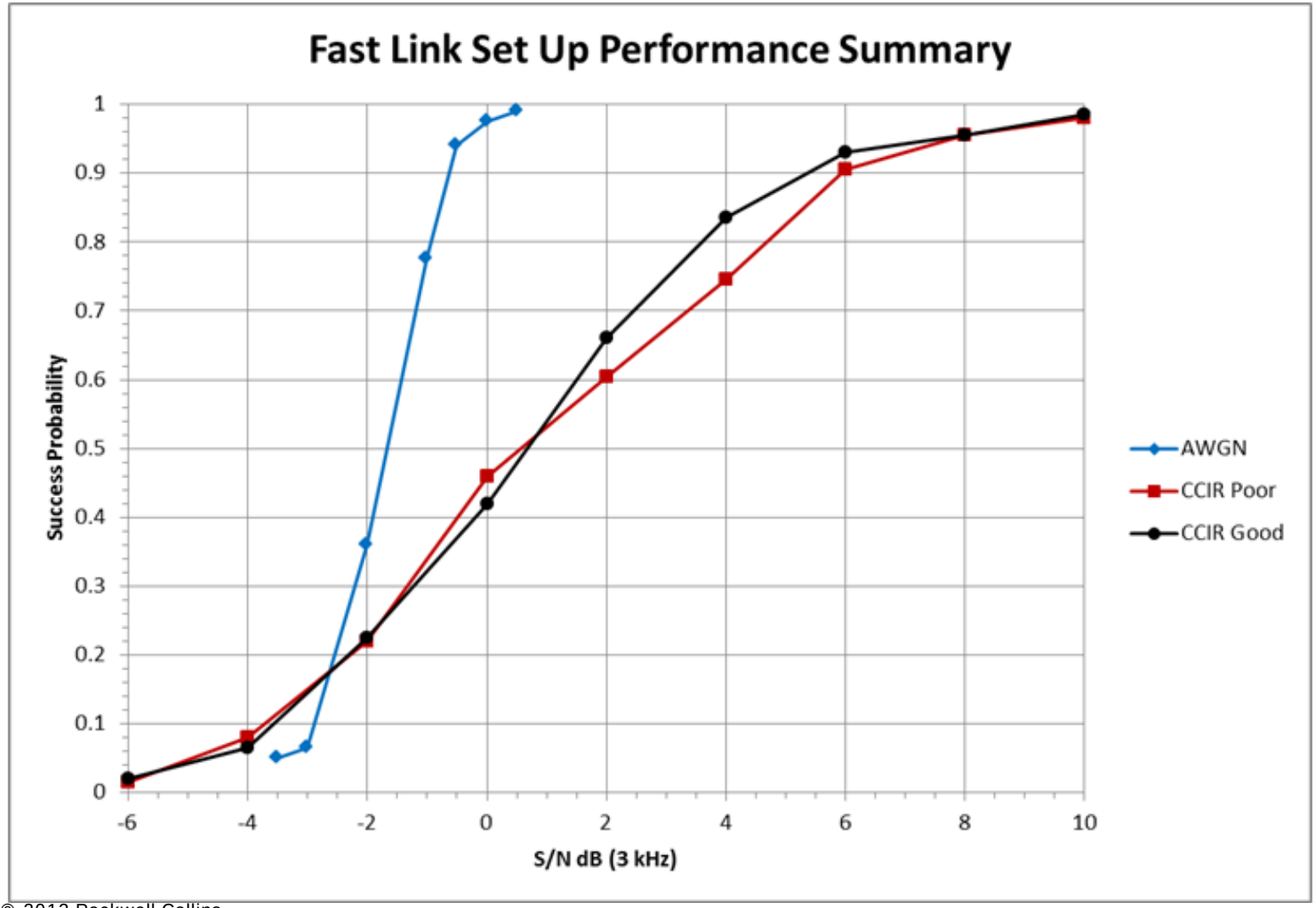
- Time to sync can be reduced by sending ALE data at a higher rate
- With 750 bps waveform (tweaked 600), and 64 TLC blocks
  - Call waveform is shortened to 1.2 s
  - Response is less than 400 ms
  - Three way handshake requires less than 2 s on air and will be limited by turn around times for equipment



Robust Link Set Up Data

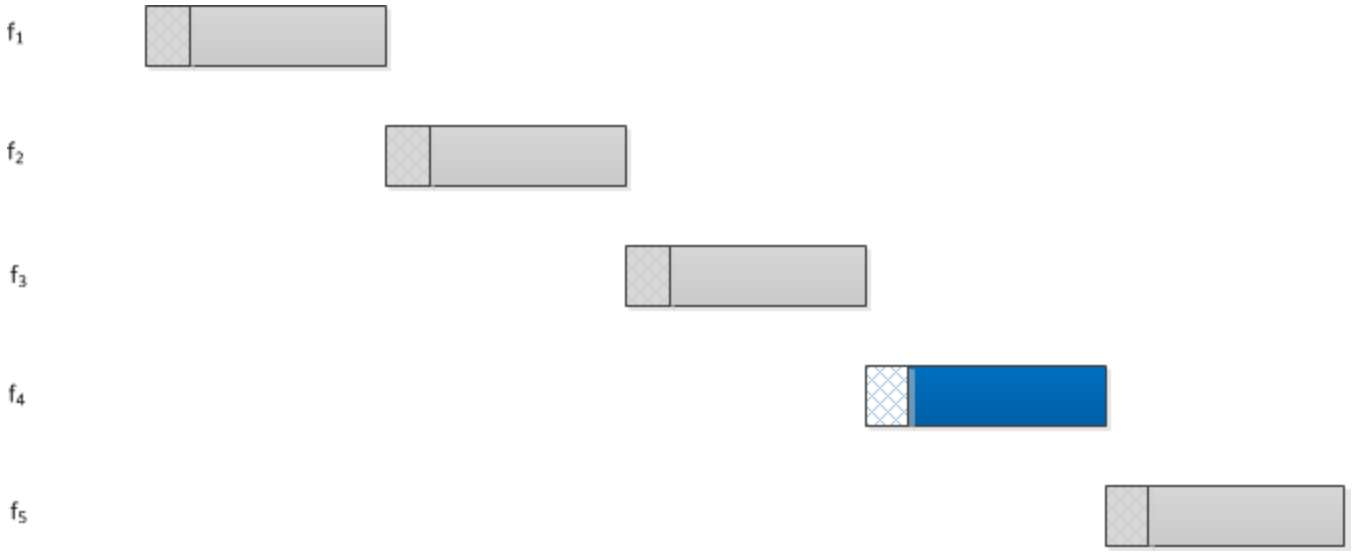


Fast Link Setup Data



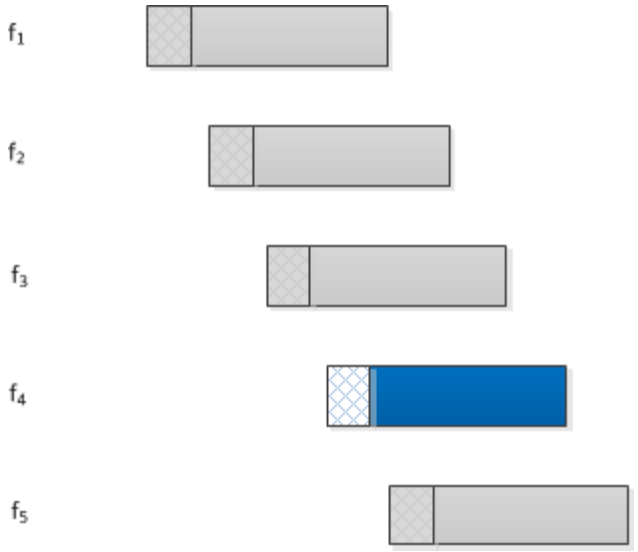
Synchronous Scanning (like 3G)

- Synchronous scanning can be supported
  - If 75 bps ALE waveform used, 1.3 s per dwell
- Non-overlapping dwell intervals means orthogonal nets could be supported
- In the example below, the receiver would dwell on f1, f2 and f3 before detecting the signal that had been transmitted on f4



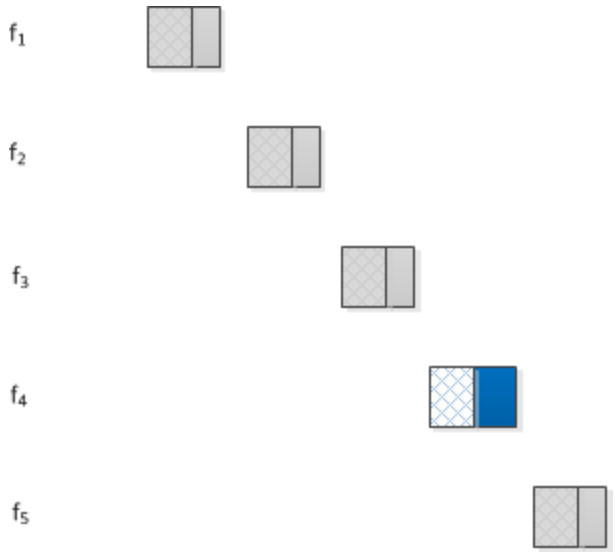
Accelerated Synchronous Scanning - Overlap

- In many operational scenarios, no advantage is gained from the ability to have orthogonal nets on the same frequency pool
  - No separate traffic channel
  - Traffic takes substantial time on channel relative to calling
- In this case, scanning can be accelerated by terminating receive dwell if nothing is detected and moving to next channel
- If preamble detected, have to wait for data (addressee info)
- With a 325 ms dwell, the scan time could be reduced by a factor of 4



Accelerated Synchronous Scanning – Faster WF

- Alternatively, shorter dwells are possible with higher rate (600 bps) ALE waveform
- Duration for the basic ALE call is 240 ms + 133 ms
- Scanning dwell could be on the order of 400 ms
- Retains orthogonal net support at the cost of robustness



Current Status and Future Work

- WBHF ALE asynchronous modes have been implemented
- Asynchronous modes have been tested successfully on relatively benign mid-latitude links
- WBHF ALE implementation was successfully used to select channels for the Trident Warrior exercise this year
- Need to complete synchronous modes
- Optimization, based on test results
- Standardization …