

# 100 Mb/s EFM over Copper

Brian Murray



AUTHOR: Brian Murray, Massana Inc.

IEEE 802.3 EFM SG July 2001

[www.massana.com](http://www.massana.com)

# Context

**Previous presentation proposed options to get to 100 Mb/s**

- Study Group raised question over extending bandwidth to 30 MHz

**This presentation shows how it is still possible to get to 100 Mb/s within the 12 MHz band**



AUTHOR: Brian Murray, Massana Inc.

IEEE 802.3 EFM SG July 2001

[www.massana.com](http://www.massana.com)

# Objectives

- Higher Performance: Up to 100 Mb/s on short loops
- Loop lengths of up to 8,000 feet
- Flexible bit-rates, Symmetric or Asymmetric
- Low complexity
- FCC frequency compatible

# Options for Higher Performance

## Can achieve up to 100 Mb/s with TDD

- TDD with single band can reduce NEXT
- Don't need common synchronization
  - One approach is Etherloop which is asynchronous
  - Another is recover synchronization from bundle
    - Can give significant improvement in performance
- TDD can extend loop length to > 8000 feet



# High Performance TDD mode

## TDD single 12.5 MHz band



- 100 Mb/s mode for shorter loops (1000 feet)
- Loop lengths up to 18,000 feet (0.2 Mb/s)
- Flexible symmetric / asymmetric
- Can extend beyond 12 MHz for in-building

# Options to Lower Complexity

- 4 band VDSL has high complexity
  - Complex assembly of frames from multiple bands
  - Multiple analog filters & multiple ADC / DAC

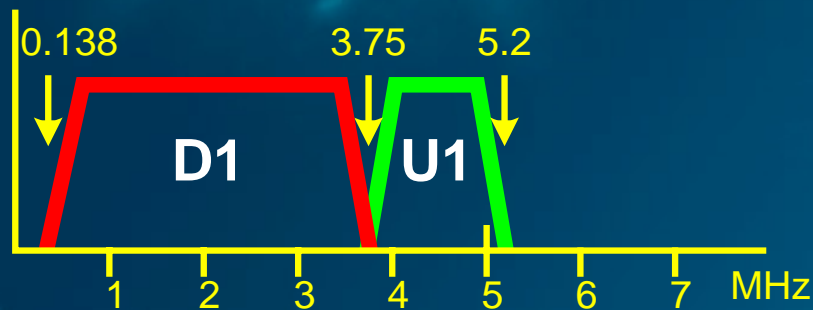
## Use 2 Band FDD and/or use TDD

- Lower implementation cost
  - Simple assembly of frames
  - Simple analog filters (one ADC / DAC)
- Can switch between 2 band FDD and TDD

# Options for xDSL Compatibility

Use FDD with xDSL compatible frequency plans

## D1 & U1 from VDSL



- Similar performance to VDSL in 2500 – 5000 feet range

## U1 from ADSL D1 VDSL



- Loop lengths up to > 8000 feet
- Better at > 4500 feet

# Options for Better Coding Gain (applicable for both modes)

## 4D Trellis Coding

- 1000BASE-T / V.34 / ADSL all use 4D TCM
  - Up to 6.0 dB coding gain
  - Low latency

## Pre-Coding

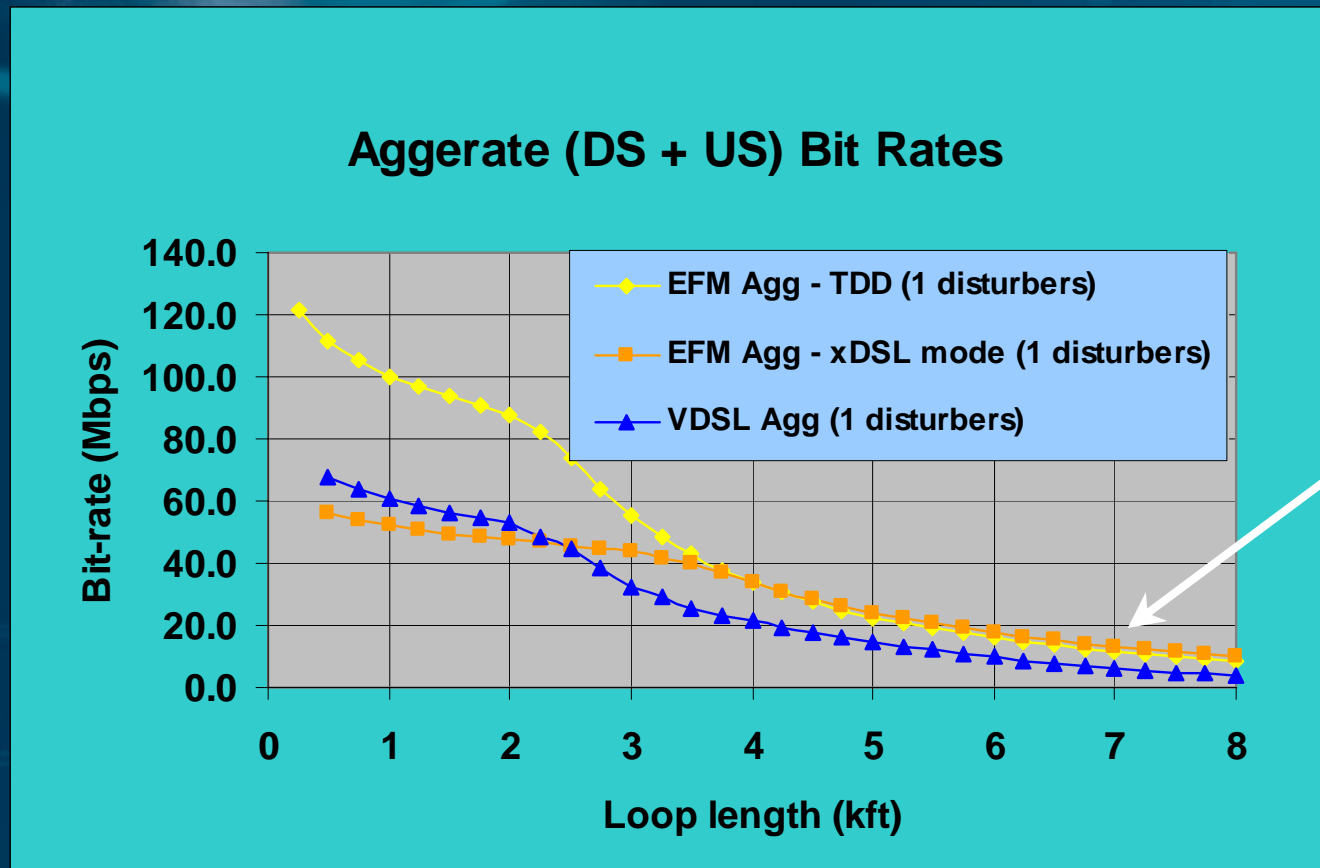
- Used in V.34, (VDSL coalition is discussing)
- Better equalization with HAM radio notches and for ingress/egress control



# Simulation Conditions

- 1 / 10 / 49 Self NEXT/FEXT, no Alien Crosstalk
- -140 dBm/Hz AWGN noise floor
- 1e-7 BER with 6 dB margin
- 5:1 Downstream:Upstream Ratio
- Same spectral mask as VDSL
  - PSD less than -53 dBm/Hz
  - Transmitted power less than 14.5 dBm

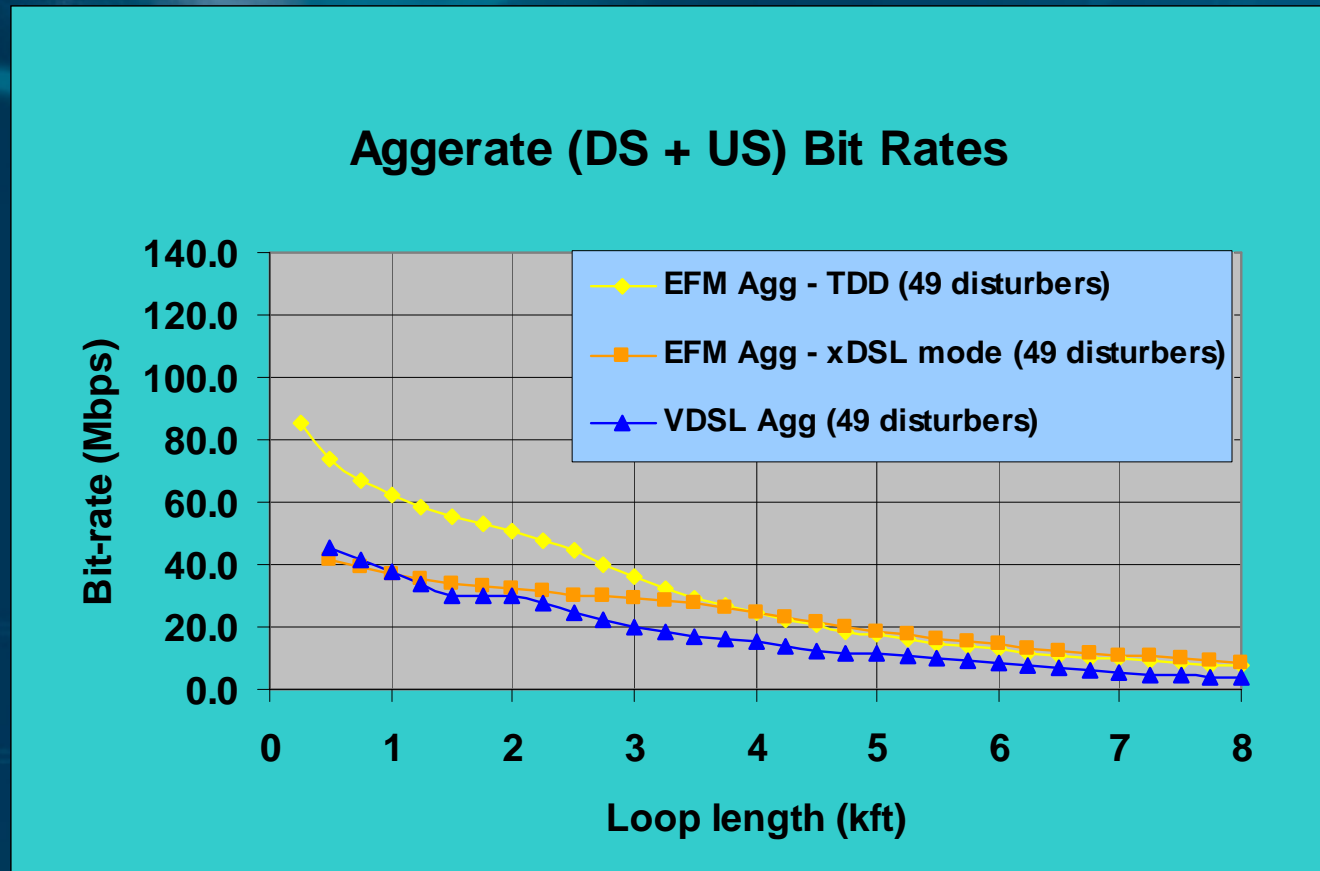
# Aggregate Bit-rate v Distance 1 disturber



Coding gain of 6 dB improves bit-rate for same bandwidth

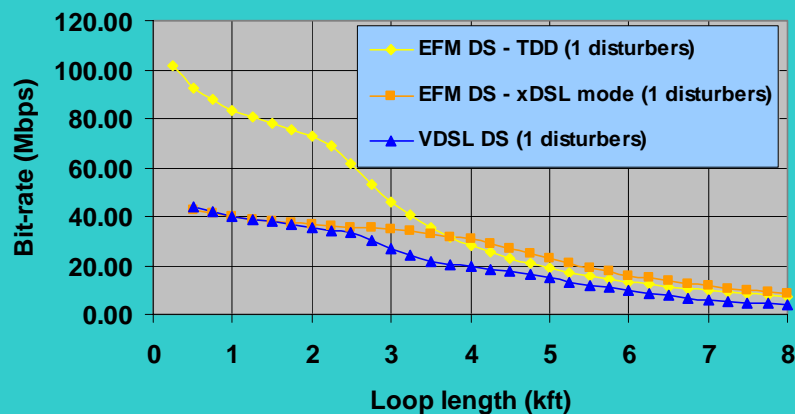
# Aggregate Bit-rate v Distance

## 49 disturbers

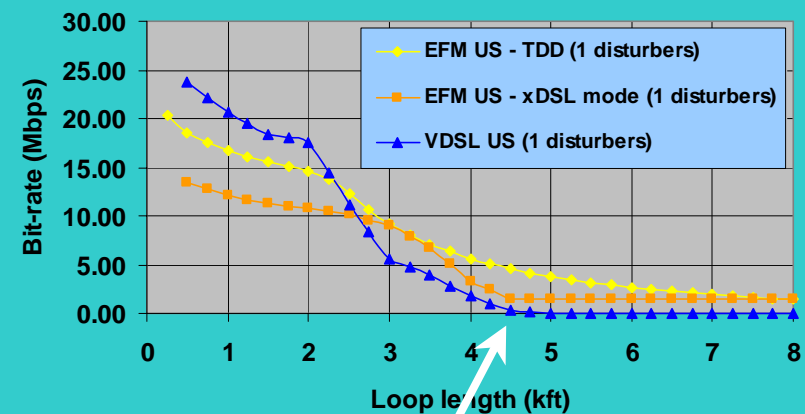


# Downstream & Upstream Bit-rate 1 disturber

Down Stream Bit Rates



Up Stream Bit Rates



Standard VDSL upstream goes  
to zero at about 4500 feet



# Conclusions

## EFM over Copper can become a truly differentiated standard

- 100 Mb/s over short distance
  - For example: A TDD mode within the 12 MHz band when there are no xDSL interferers
- An xDSL compatible mode for up to 8000 feet
  - For example: low complexity 2 band plan