

# Wireless Technology - Rural Networks

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# My Background

- BSEE Case Institute of Technology 1981
- MSEE Stanford University 1985 (Master's project: digital radio)
- Founded LARIAT as a 501(c)(12) non-profit co-op to serve unserved/underserved areas in and around Laramie, WY in 1992 -- well before most people had dial-up. LARIAT was likely the first WISP (terrestrial, Wireless high speed Internet Service Provider)
- Took LARIAT private in 2003 at the request of the membership
- 17+ years of experience in deployment of high speed rural Internet
- Growing network coverage by approximately the size of the District of Columbia every year; pace is accelerating

## **Terrestrial Fixed Wireless Technology: The Most Cost-Effective "Last Mile" Solution for Rural Areas**

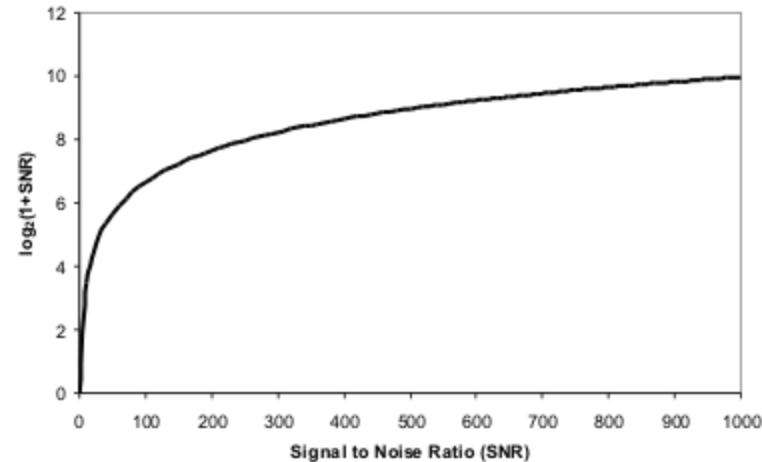
- Deployment cost: Substantially less than \$100 per square mile (see figures from "Unserved/Underserved" session)
- Speeds comparable or superior to those of DSL or satellite
- Latencies lower than DSL and much lower than satellite
- End user equipment/installation costs similar to those of DSL, lower than satellite
- End user's recurring cost mostly determined by backbone bandwidth costs and the price of "middle mile" backhaul (special access), which costs the same for any technology other than satellite
- Spectral efficiency of equipment continues to increase
- Alas, wireless doesn't help as much with the "middle mile;" fiber still best for the backbone and long haul transmission

## The Primary Constraints on Fixed Wireless Coverage and Performance are Regulatory, not Technological

- Interference in Part 15 unlicensed "jungle" limits coverage and stability of unlicensed systems. A baby monitor can radiate as much as an access point serving dozens of broadband customers!
- Current spectrum auction regime precludes small, local, and independent carriers from winning exclusively licensed spectrum, encourages spectrum "hoarding"
- Dearth of non-exclusively ("lightly") licensed spectrum which is not polluted by consumer devices
  - Use of 3650 MHz prohibited in many areas
  - Only half the band is available
  - No spectrum etiquettes in that half
  - A band that's usable nationwide is necessary to create equipment economies of scale
- Additional regulation ("wireless network neutrality") imposed for political rather than sound technical reasons would further encumber wireless deployment and could dramatically harm performance of some systems (e.g. 802.11b equipment on 802.11g networks)

# Shannon's Law Dictates Enlightened Spectrum Policy

$$\text{Shannon's Law: } C = BW \times \log_2(1 + \text{SNR})$$



- Capacity increases linearly with bandwidth but only logarithmically with SNR. Returns diminish dramatically above SNR of 20 dB (past the "knee" of the curve)
- It follows directly from Shannon's Law that nonexclusive licensing of large, contiguous regions of radio spectrum, combined with interference mitigation techniques such as antenna gain requirements and cognitive radio technology, maximize the utility of spectrum

## Broadband Plan Elements: Facilitating Rural Wireless

- . Devote more nonexclusively licensed spectrum to wireless broadband, with mandatory spectrum etiquettes to enable cognitive radio and effective spectrum sharing. Possibilities:
  - . AWS-3 Spectrum (Could become "National Broadband Deployment Band")
  - . 700 MHz "D Block" (Cellular industry would not share with public safety, but WISPs would)
- . Open upper half of 3650 MHz band with IEEE 802.11y; consider phasing 802.11y in on the lower half as well to relieve congestion
- . Increase power limits in rural counties (Population <200K) by 9 dB for Part 15 WISPs on 900 MHz, 2.4 GHz, 5.3-5.8 GHz, 60 GHz (for inter-tower links)
- . For exclusively licensed spectrum, revise auction rules to increase geographic granularity of licenses; allow providers to pay as they go rather than paying in bulk before they can make a dime using the spectrum
- . Do not impose "wireless network neutrality" regulations until and unless there is actually a problem to be solved
- . Because fiber is still the correct solution for backbone links, fix the broken "middle mile" (special access) market