

Technical Consensus in Broadband Wireless Access Technology

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National Institute of Standards and Technology

**Chair, IEEE 802.16 Working Group on
Broadband Wireless Access**



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- Overview of Broadband Wireless Access (BWA)
- **Why is NIST interested in BWA?**
- **What is NIST doing about BWA?**

Broadband Wireless Access (BWA)

- **In this talk, “BWA” means fixed BWA**
- **The “Last Mile” (or the “First Mile”)**
 - **Fast local connection to network**
 - **Data, voice, video**
- **Every customer wants it**
 - **Business**
 - **Residential**
- **Every operator wants it**
 - **Not just telcos or cable service providers**

Broadband Access for Big Business

- **Fiber is nice, but:**
 - **Only ~5% of 750,000 commercial buildings in U.S. have fiber**
 - **Backhoes don't follow Moore's Law (Doug Lockie)**
 - **\$150-250K per fiber mile to install**

Broadband Access for Small Business/Residential

- **Cable Modems**

- **High infrastructure cost; slow rebuild**
- **Shared bandwidth**

- **DSL**

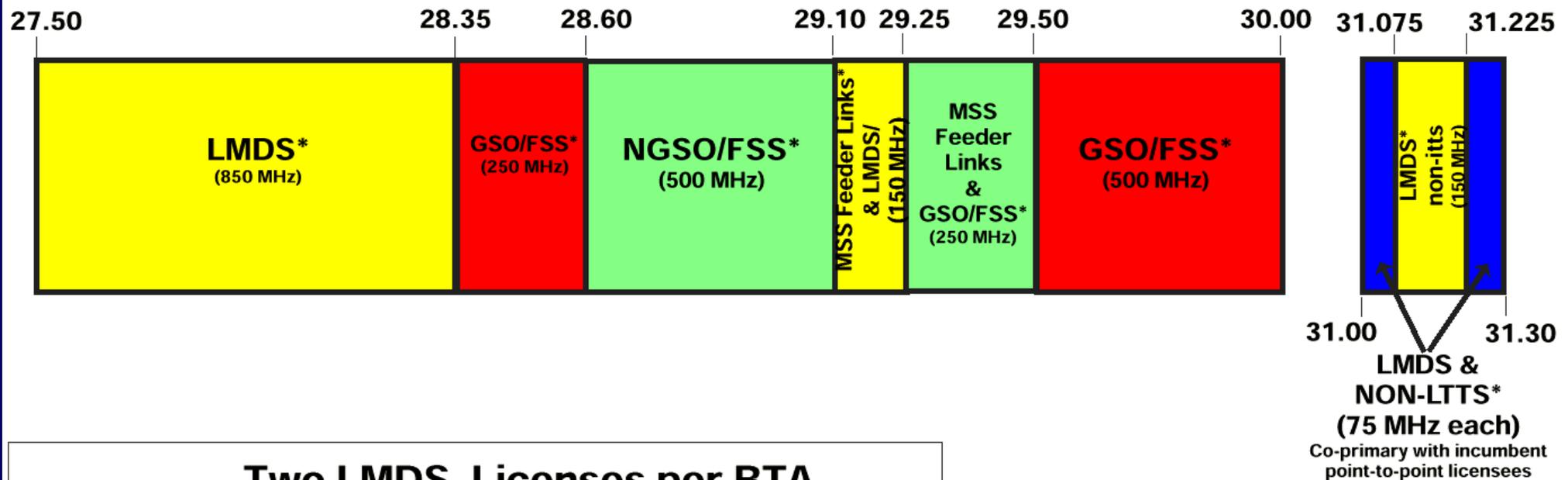
- **Infrastructure cost**
- **Limited range**

- **Satellite**

- **Very high up-front capital cost**

LMDS Band Allocation (Local Multipoint Distribution Service)

28 & 31 GHz Band Plan



Two LMDS Licenses per BTA

Block A - 1150 MHz:

27,500-28,350 MHz

29,100-29,250 MHz

31,075-31,225 MHz

Block B - 150 MHz:

31,000-31,075 MHz

31,225-31,300 MHz

Legend

"*" - Primary Service

FSS - Fixed Satellite Service

GSO - Geostationary Orbit

NON-LTTS - Non-Local Television Transmission Service

MSS - Mobile Satellite Service

NGSO - Non-Geostationary Orbit

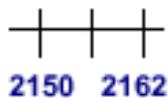
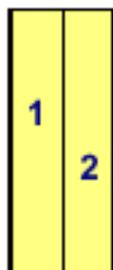


MDS

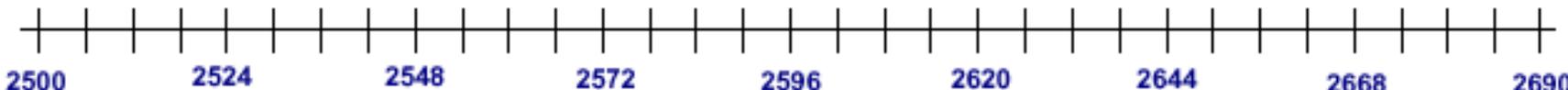
(MDS, MMDS, ITFS, Services)



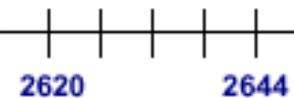
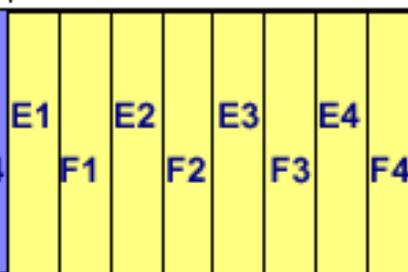
MDS



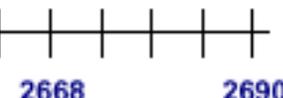
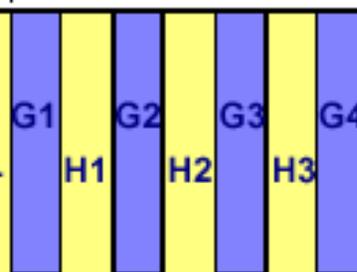
ITFS



MMDS



ITFS & MMDS



Congressional Federal Register References

ITFS 47 C.F.R., Part 74
 MDS (Single And Multichannel) 47 C.F.R., Part 21

Channel 2A: 2156-2160 MHz

2160-2162 MHz reallocated to emerging technologies on a primary basis except for licenses operating on Channel 2, or successful applicants who filed prior to January 16, 1992. See ET Docket 92-9 FCC 93-351

MDS (Multipoint Distribution Service)

MMDS (Multichannel Multipoint Distribution Service)

ITFS (Instructional Television Fixed Service)

Service	Channel Allocation	Number of Channels
MDS & MMDS	1 & 2 E, F & H	2 11
ITFS	A, B, C, D & F	20

Not Included in Auction #6

**Unlicensed
National Information
Infrastructure
(U-NII)**

- **5.15-5.25 GHz**
- **5.25-5.35 GHz**
- **5.725-5.825 GHz**
- **See also 59-64 GHz**

Major U.S. License Holders

- **Millimeter wave (24, 28, 31, 38 GHz)**

- **NextLink**

- **WinStar**

- **Teligent**

- **ART**

- **HighSpeed.Com**

- **Many others**

- **Microwave (2.5-2.7 GHz) [MMDS, ITFS]**

- **MCI WorldCom**

- **Sprint**

- **Many others**



Summary: WW Spectrum for BWA

PMP Frequency Bands

Country	10 GHz ETSI	18-24 GHz	24 GHz DEMS	26 GHz ETSI	25-27 GHz	27.5-29.5 GHz	28 GHz Like US	31 GHz	38 GHz US	38 GHz ETSI	38 GHz Other
North America											
USA			X				X	X	X		
Canada			X		X		X		X		
Asia Pacific											
Australia							X	X			
Japan		X			XU						X
Korea					XU						
Malaysia	P										
New Zealand					X						
Philippines	X	X?			X		X				
Singapore						X?	X				
Taiwan				X							X
Thailand						X					
Central & South America											
Argentina	X		X		X		X	X	X		
Bolivia							X				
Brazil	P			P							
Chile					X		X				
Colombia					X		X				
Ecuador						X					
Mexico	X			X							
Paraguay						X					
Peru						X					
Venezuela						X					

CEPT
Recommendation
for Europe of
40.5-42.5 and
42.5-43.5 GHz not
considered



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Europe, Middle East, Africa											
Czechoslovakia						X					
France						T					
Germany				X							
Hungary				X							
Ireland				X							
Israel				P?							
Netherlands				X							
Norway				X							
Poland						X					
Romania							X				
South Africa						X					
Spain				X			X	X			
United Kingdom	X										

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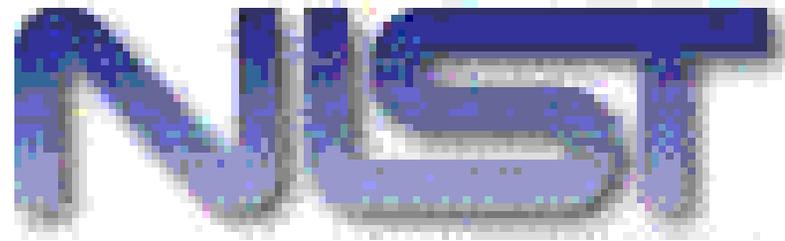
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 - **Note: my personal viewpoint, not that of NIST**
- **What is NIST doing about BWA?**

Why is NIST interested in BWA?

(0) What is NIST?

- **National Institute of Standards and Technology**
- **agency of the U.S. Department of Commerce**
- **Established in 1901 as Nat'l Bureau of Standards**
- **NIST strengthens the U.S. economy and improves the quality of life by working with industry to develop and apply technology, measurements, and standards**
- **non-regulatory**
- **example: atomic clock**

NIST Bumper Sticker?



We Know What Time It Is!

- **Time standards: SCIENCE**
- **Radio standards: ART**

Why is NIST interested in BWA?

(1) Broadband Infrastructure is vital to success of U.S. economy

- The Internet drives the U.S. economic engine**
- Business and consumers require fast links**
- Fiber, cable, and DSL do not support everyone**
 - One aspect of the “Digital Divide”**
 - Satellites provide broad coverage; some problems**
- More competition is good, even where fiber, cable, or DSL are available**

Why is NIST interested in BWA?

(2) BWA is becoming an important service industry

- global service revenues projected to reach \$16.3 billion by 2004
- growth rate of 140% per year
- North America will represent 39% of global market in 2004

–Source: The Strategis Group: “World Wireless Broadband: LMDS, MMDS and Broadband WLL”
(April 2000)

Why is NIST interested in BWA?

(3) Broadband wireless is becoming an important engineering and manufacturing business

- **High-technology driver in economy**
- **Potential for large export markets**

Why is NIST interested in BWA?

(4) BWA needs standards and measurement technology

- **Telecommunications thrives on standards**
- **Standards are in the NIST mission**
- **Measurement technology is difficult for BWA**
 - e.g.: how to specify a power amplifier?
- **Measurements can support the development of sound standards**
- **Measurements needed for compliance tests**

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Why is NIST doing about BWA?

- Developing and planning for a wireless systems testbed**
- Taking the lead in encouraging voluntary open consensus standards**

Wireless Standards in the U.S.

- FCC no longer regulates standards for wireless communications (spectrum auctions since 1994)**
- no coordinated U.S. approach to wireless standardization**
- multiple standards continue indefinitely**
- equipment costs remain high**
- for new services, licensees and vendors may hesitate**

Why Standards?

- People often take the view that standardization is the enemy of creativity. But I think that standards help make creativity possible - by allowing for the establishment of an infrastructure, which then leads to enormous entrepreneurialism, creativity, and competitiveness.
 - Vint Cerf, "Father of the Internet," in *Fast Company*, April 2000
- “Teligent supports the IEEE 802.16 broadband wireless access standardization effort, which we believe will drive down equipment costs and create a framework for new innovation. This will allow us to roll out service faster to more areas and serve more customers. Standards will make wireless a real alternative for residential broadband access and expand the range of customers served.”
 - Louis Olsen, Vice President for Technology Development, Teligent, Inc. and Vice Chair, IEEE 802.16 Working Group on BWA

Need for BWA Standards

**Survey of about 600 people at Broadband
Wireless World Forum (6 March 2000):**

**How important are standards to
the long-term success of this
industry?**

Extremely important: 59%

Somewhat important: 30%

National Wireless Electronic Systems Testbed (N-WEST)

- **measurement testbed at the Department of Commerce to help forge industry consensus standards and specifications**

-NIST

-NTIA's Institute for Telecommunications Sciences

- **a pro-active effort to accelerate development of the broadband wireless industry by encouraging voluntary standards**

N-WEST Philosophy

**Goal: Accelerated Commercialization
of Wireless Systems**

equipment cost reduction (esp. at customer end)

mass production

standardization

voluntary standards bodies

unbiased measurement support

U.S. Dept. of Commerce

Initial Focus: Fixed Broadband Wireless Access

82 N-WEST Supporting Companies

• Industry Associations

- Cellular Tel. Ind. Assn. (CTIA)
- Wireless Comms Assn. (WCAI)

• License Holders

- Antilles Wireless Cable TV Co.
- Charles Brinkman
- Formus Communications, Inc.
- US WEST Adv. Technologies
- Virginia Tech
- Teligent, Inc.
- WinStar Communications, Inc.
- WNP Communications, Inc.

• Systems Equipment Providers

- 3Com Corporation
- ADC Telecommunications
- Alcatel Network Systems
- Adaptive Broadband, Inc.
- Belstar Systems Corp.
- ComTier, Inc.
- Ensemble Communications
- Ericsson Inc.
- Intraplex
- ioWave, Inc.
- Lucent Technologies
- Motorola Inc.
- NEC America, Inc.
- Netro Corporation
- Newbridge Networks Corp.
- Nortel Networks
- P-COM
- Philips Broadband Networks

- Spike Technologies, Inc.
- WaveCom Electronics Inc.
- WaveSpan Corporation
- Wavtrace
- WinNet MCS
- Wytec Inc.

• Subsystems and Components

- AMP M/A-COM
- Andrew Corp.
- Asvan Technology LLC
- BroadBand Wireless Inc.
- Cable AML Inc.
- CircuitPath Network Systems
- EER Systems
- Endgate Corporation
- ETM Electromatic
- Gigabit Wireless Inc.
- Hewlett-Packard Co.
- IDT Inc.
- ITS Electronics Inc.
- Integrity Communications
- ITS Electronics, Inc.
- MentorData Ltd.
- Micro Interconnect, Inc.
- Millitech Corporation
- Mitsubishi Electronics America
- MMCOMM, Inc.
- Phasecom Inc.

- Raychem Corp.
- Raytheon Systems Company
- Run.com Communications Ltd.
- SiCOM, Inc.
- Siemens Microelectronics, Inc.
- Stanford Wireless Broadband Inc.
- TelesciCOM Ltd.

• RF Semiconductors

- Fujitsu Compound Semiconductor
- Harris Semiconductor
- Sanders, A Lockheed Martin Co.

• Consultants/R&D/Measurements/Misc.

- Anritsu Company
- Bellcore
- C&W Systems, Ltd.
- E B Systems Limited
- EDX Engineering, Inc.
- ETRI
- Gerson Lehrman Group
- Hardin & Associates, Inc.
- HRL Laboratories
- Illinois Institute of Technology
- Istari Design, Inc.
- LCC International Inc.
- MLJ, Inc.
- PSW Technologies, Inc.
- Technical Strategy Associates
- WFI
- Wireless Valley Communications, Inc.

Standardization Body

- **IEEE Standards Association**
 - **IEEE 802: LAN/MAN Standards Committee**
 - IEEE 802.16 Working Group on Broadband Wireless Access
- **802.16 Sponsorship**
 - **IEEE Computer Society**
 - **IEEE Microwave Theory & Techniques Society**

IEEE 802

The LAN/MAN Standards Committee

Wired:

- **802.3 (Ethernet)**

The Wireless Web, 802 Style:

- **802.11: Wireless LAN**

- **Local Area Networks**

- **802.15: Wireless PAN**

- **Personal Area Networks {inc. Bluetooth}**

- **802.16: WirelessMAN™**

- **Metropolitan Area Networks**

Why IEEE 802?

- **Telecom Standardization**

- **National**

- **Political**

- **Datacom Standardization**

- **Global**

- **Open**

- **Driven by technology & business**

- **802 and IETF set the standards**

Who are the Members?

- **Telecom Standardization Bodies**
 - **Governmental Representatives**
 - **Companies**
- **IEEE**
 - **Human beings (engineers)**
- **IEEE 802.16**
 - **106 voting Members**
 - **43 official Observers**
 - **Over 160 people at recent meetings**

802.16's Wide Open Process

- **Anyone can:**
 - **Attend meetings**
 - **Subscribe to email list**
 - **Read documents**
 - **Comment on documents**
- **Members can vote**
 - **Membership acquired by attendance**
- **Finalized through open “Sponsor Ballot”**
- **Parallel to Open Source Code**
 - **Peer Review**

N-WEST/802.16 History in Brief

Part 1

- **April 3, 1998**
 - **N-WEST Web Site went on-line**
(<http://nwest.nist.gov>)
- **August 9-10, 1998**
 - **N-WEST Kickoff Meeting (45 people)**
 - **Alongside 1998 IEEE Radio and Wireless Conference (RAWCON'98)**

Wireless camps' goal: affordable systems

Open-systems push sweeps broadband

By Loring Wirbel

COLORADO SPRINGS, COLO. — Hustling to infuse life into a market perceived as pricey and arcane, proponents of broadband wireless services came to the IEEE Radio & Wireless Conference (Rawcon) last week with strategies for pushing standardization and, by extension, lower-cost, more-accessible systems.

Proponents of millimeter-wave broadband systems

are still smarting from the lukewarm response to the FCC's 28-GHz auctions, which raised a less-than-stellar \$570 million from a smaller-than-expected pool of carriers. In a lunch address at Rawcon, National Telecommunication & Information Administration head Larry

Irving told local multipoint distribution service (LMDS) developers that they are perhaps the last great hope for "last-mile" broadband services. But much is riding on their ability to get the cost out of their systems.

"I have seven separate wireless systems in my household, but I'm still stuck with 56k in my wireline service," Irving said. "If we had 'calling party pays,' I'd give

up my wireline phone completely tomorrow, because you guys will be giving me broadband data service a lot faster than my wireline phone company."

A new report from Allied Business Intelligence (Oyster Bay, N.Y.) states that the mul-

▶ CONTINUED ON PAGE 126



N-West's Marks: Nod for NIST as 'facilitator.'

Kickoff Meeting: Press

- **“While there are some squabbles within N-WEST about how generic an RF-to-baseband interface should be, members are universally praising NIST officials for pushing standards efforts through the testbed” (*EE Times*)**
- **“It’s a very important initiative by the Commerce Department to help jump-start this industry. It’s helpful to have a neutral party for manufacturers to be willing to share confidential information.” (Andrew Kreig, President, Wireless Communications Assoc.)**

NTIA View

- August 9-10, 1998: NTIA head Larry Irving said:

We need to figure out how to lower these costs {terminal equipment, etc.} to make wireless technology more widely available. That is why I think the work of N-WEST (the National Wireless Electronics Systems Testbed) is so important.

N-WEST is a collaborative effort of the Department of Commerce's NTIA and National Institute of Standards and Technology (NIST) that just got off the ground... N-WEST is providing technical expertise to assist standardization efforts by the LMDS industry.

Let me clarify that the Department of Commerce is not mandating standards for LMDS... government mandates in this area can only interfere with progress and innovation.

N-WEST is playing a different role... assisting and evaluating industry efforts to reach a consensus on standards. The theory is that, if there is greater standardization of customer equipment, that equipment is more likely to be sold on a mass market basis. Collaboration within the industry could help lower the cost of user terminals and, I hope, make broadband wireless an accessible alternative for more Americans.

N-WEST/802.16 History in Brief

Part 2

- November 9-10, 1998**
- January 13-15, 1999**
 - Study Group meetings**
- March 9-11, 1999**
 - 802 created the IEEE 802.16 Working Group on Broadband Wireless Access**

802.16 Meetings

- **Bi-monthly week-long sessions**
- **Session #9: September 11-15, 2000, Denver**
 - **alongside 2000 IEEE Radio and Wireless Conference (RAWCON2000)**

802.16 Projects

802.16.1: Air Interface, 10-66 GHz

- 34 proposals in November 1999
- unified final draft by November 2000

802.16.2: Coexistence

802.16.3: Air Interface, 2-11 GHz (licensed)

Wireless High-Speed Unlicensed MAN

-WirelessHUMAN™

-Study Group (not yet an established project)

Current 802.16.1 Proposal

Backed by 35 participants from:

3Com

Adaptive Broadband Inc.

BreezeCOM

CircuitPath Network

Systems

**Communications Consulting
Services**

Crossspan (A Raytheon Co.)

**Digital Microwave
Corporation**

Ensemble Communications

Ericsson

iSKY

Lucent

Motorola

Newbridge

Nokia

Nortel

Oren Semiconductor Ltd.

SiCOM, Inc.

Siemens

Spacebridge Networks Corp.

SpectraPoint

TelesciCOM Ltd.

Vyyo

802.16 Press Treatment

- ***Telecommunications* magazine (May 2000) chose "The 10 Hottest Technologies"**
- **“Air interface standards, currently being worked on in the IEEE's 802.16 committee to deal with issues such as interference and interoperability, could help change {the slow deployment of LMDS}, propelling broadband wireless to a \$7.4 billion market for services by 2003, according to the Strategis Group.”**

Summary

- **Standards create markets and business opportunities**
- **NIST is leading consensus standardization efforts in Broadband Wireless Access**
- **NIST and NTIA/ITS hope to develop measurement testbed in support of wireless standardization**

Resources

- **802.16 Web Site**

<http://wirelessman.org>

>350,000 downloads/month

- **802.16 email reflector**

>400 subscribers

- **N-WEST News**

<http://nwest.nist.gov>

~850 subscribers