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Broadcast Spectrum Under Attack

Chair: Dr. Joseph Flaherty

Broadcast and the RF Spectrum Puzzle : Paul Bush

Unlicensed Operation in the Broadcast Bands: Winston Caldwell

Ultra-Wideband: Charles Einolf

Preparing for the World Communication Conference (WRC-07):
François Conway

Impact of Interference: Paul Bush



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Broadcast Spectrum Under Attack

Broadcast and the RF Spectrum Puzzle

Paul Bush

VP Corporate Development

Telesat Canada

The Foundation of our Industry



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The Foundation of our Industry

- Sound broadcasting
 - Traditional analog
 - Digital Audio Broadcast
- Television broadcasting
 - UHF Off Air
 - Traditional Analog
 - Digital by 2009
 - Direct Broadcast Satellite



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The Foundation of our Industry

- Direct to User



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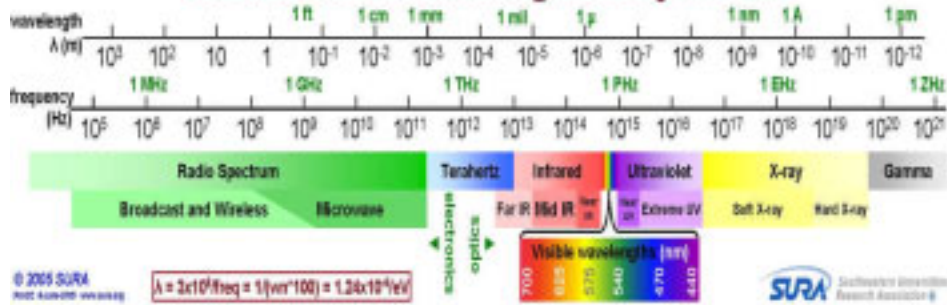
- Content Feeds



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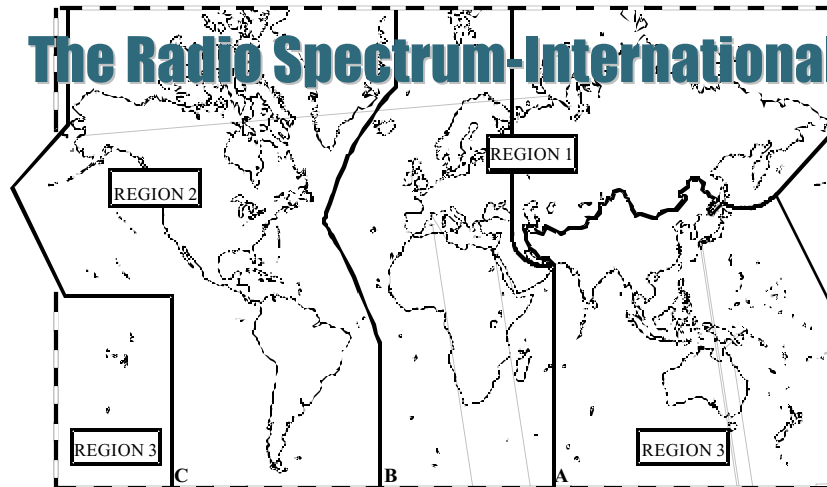
The Spectrum Resource

Chart of the Electromagnetic Spectrum



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The Radio Spectrum-International



- Radio spectrum allocated on Regional basis by International Telecommunication Union (ITU)



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The Radio Spectrum-International

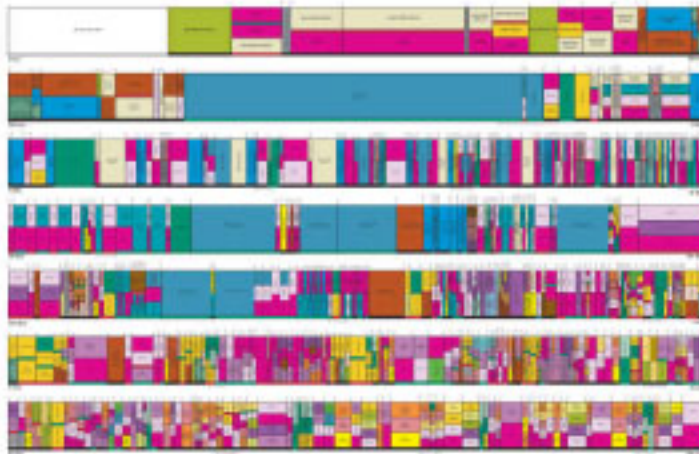
- 9 KHz to 275 GHz allocated to Radiocommunication Services according to ITU Table of Frequency Allocations
- Over 30 defined Services, for example:
 - Broadcast, Fixed, Mobile, Radio-Astronomy, Radiolocation, Broadcasting-satellite, etc.
- Many bands are shared by two or more Services
- ITU Radio Regulations define elaborate technical and regulatory basis for sharing between Services
- Radio Regulations can only be changed by a World Radiocommunication Conference (WRC)



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The Radio Spectrum-Domestic

UNITED STATES
FREQUENCY ALLOCATIONS
THE RADIO SPECTRUM



- National Table of Frequency Allocations
- Domestic policies



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The Radio Spectrum-NABA

- USA/Canada/Mexico have similar allocations
- Big blue chunks are Broadcasting
 - AM Radio: 535-1705 KHz
 - FM Radio : 76-108 MHz
 - UHF TV: 54-72 MHz, 174-216 MHz, 470-794 MHz
- Digital Audio Broadcast: 2310-2360 MHz
- C-band (feeds): 3700-4200 MHz
- Ku-band (feeds): 11.7-12.2 GHz
- Digital Broadcasting Satellite: 12.2-12.7 GHz



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The not-so-silent Insurgents

- License-exempt wireless technologies operate in the Radio Spectrum, but with no formal allocation
 - i.e. they do not show on the allocation chart
- “Sharing” philosophy replaced by “non-interference-basis” philosophy
- Gradual increase in noise floor “pollution” impacts service but is difficult to isolate or pin-point



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The not-so-silent Insurgents

- Next two speakers
 - Specific license-exempt technologies
 - What is the impact on victim allocated Radiocommunication Services?
- Final speaker
 - Preparation in the International Forum - ITU World Radio Conference 2007 (WRC-07)



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Broadcast Spectrum Under Attack

Unlicensed Operation in the TV Bands

Winston Caldwell, P.E.
Senior Engineer
Fox Technology Group

Technologies Intended to Facilitate Unlicensed Operation in a Licensed Band

- Cognitive Radio
- Broadband over Power Lines
- Ultra-Wide Band



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Cognitive Radio

- Allows spectrum sharing on a negotiated or opportunistic basis.
- Adapts a radio's use of spectrum to the real-time conditions of its operating environment.
- Offers the potential for more flexible, efficient, and comprehensive use of available spectrum.
- Reduces the risk of harmful interference.



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Cognitive Radio

The FCC released a Notice of Proposed Rulemaking, May 25, 2004, to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used.



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Cognitive Radio Techniques

- **Database/Geo-Location:** Determine whether the unlicensed device is outside the protected contour of a licensed station using a database with a geo-location device.
- **Control Signal:** Receive a control signal from an established incumbent service indicating which channels are available or are occupied in the area.
- **Sensing:** Sense the RF environment to a certain threshold to detect whether a TV channel is in use.



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Problems with the Proposed Database/Geo-Location Technique

- Databases can have mistakes and can be inaccurate.
- Databases are not updated instantaneously with real-time changes in the RF environment.
- GPS may not have the necessary precision to determine location accurately enough.
- GPS does not operate well indoors.



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Problems with the Proposed Control Signal Technique

- Control signals indicating available channels from different sources may overlap and cause confusion.
- Control signals indicating occupied channels from different sources may overlap and cause confusion.
- No incentives for incumbent services to provide control signals for unlicensed operation.



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Problems with Sensing

- The detectable RF environment changes dramatically with minor changes in location of the sensing device due to multi-path, fading, or shadowing.
- The “hidden node” problem occurs when a sensing device is being shadowed by either a man-made structure or terrain and cannot accurately detect what TV channels are occupied.



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The FCC Has Proposed Two Classifications of Unlicensed Devices to Operate in the TV Bands

- Fixed/Access
- Personal/Portable



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Fixed/Access

- Transmitter power limit: 1 W
- Transmitter antenna gain limit: 6 dBi
- A base station acts as a central controller.
- A database is required.
- Geo-location technique is required using either a GPS or professional installation.
- Transmission of a unique identifier is necessary.
- Spectrum sensing approach is postulated.



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Personal/Portable

- Transmitter power limit: 100 mW
- Transmitter antenna gain limit: 6 dBi
- Devices cannot transmit unless they receive a control signal from an incumbent broadcaster.



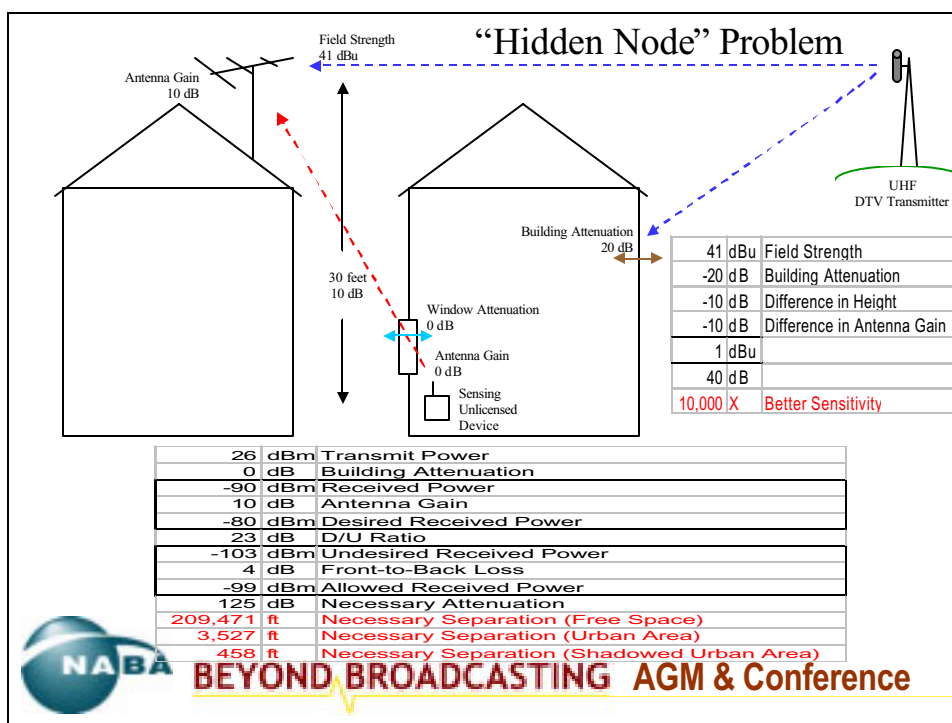
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Personal/Portable

- Unlicensed device manufacturers and wireless internet providers (WISPs) have expressed a desire for autonomous personal/portable unlicensed operation through a spectrum sensing approach.
- These consortiums are actively lobbying government to allow the deployment of autonomously sensing type personal/portable devices.



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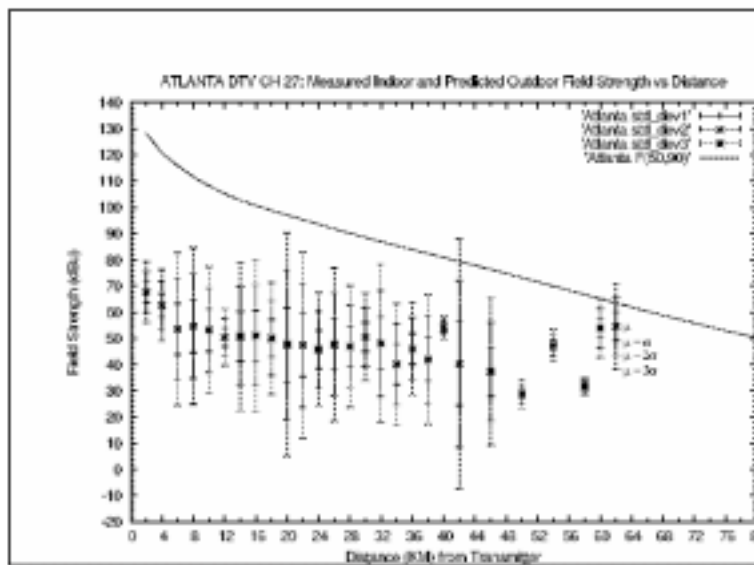


Indoor Television Reception Measurements

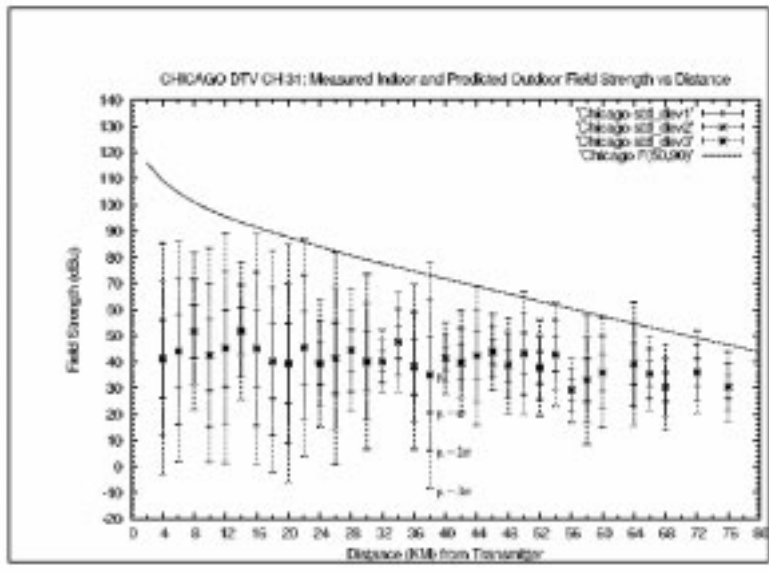
City	# Dwellings	# Measurement Locations
Los Angeles, CA	211	485
Chicago, IL	251	547
New York, NY	237	472
Atlanta, GA	213	422
Totals	912	1926



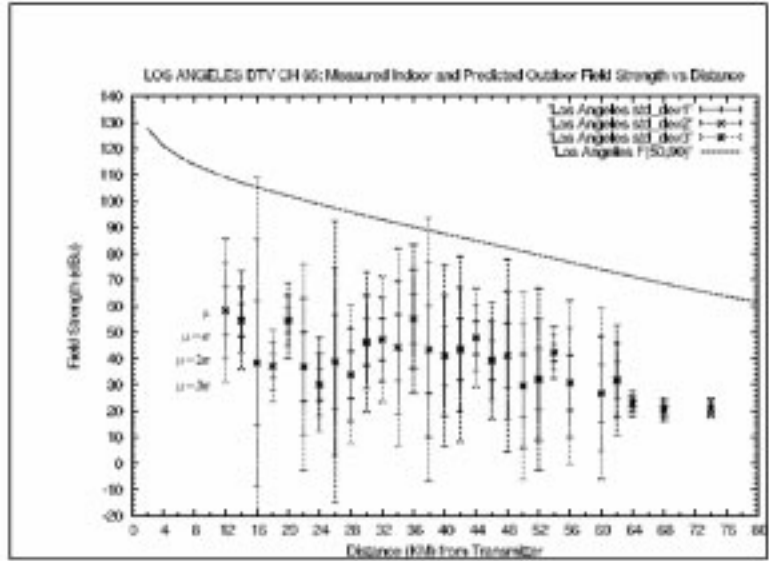
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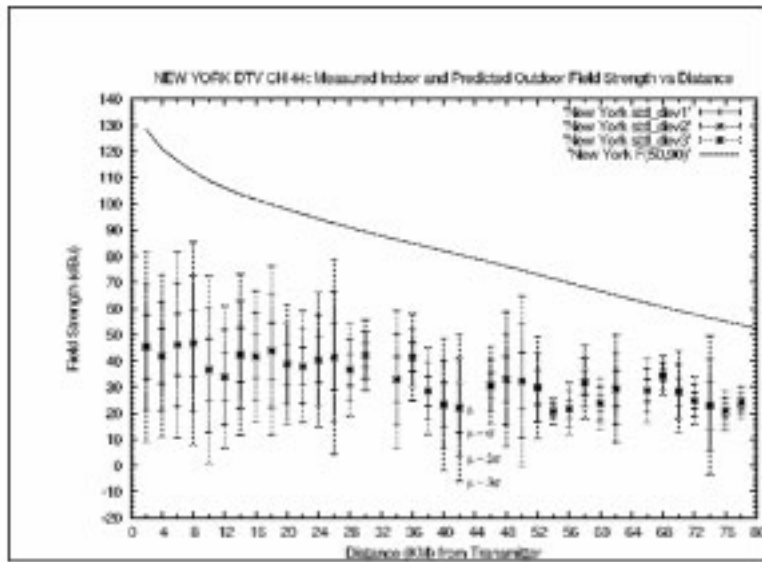
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IEEE 802.22 Requirements

- 1 W transmitter power with a maximum of 6 dBi transmit antenna gain.
- Fixed point -to-multi-point access only.
- Base station is professionally installed and maintained.
- Base station uses an up-to-date database to determine channel availability.
- Location awareness for all devices in the network.
- Customer Premise Equipment (CPE) antenna is to be installed outdoors at least 10 ft above ground.
- CPE cannot transmit unless it has successfully associated with a base station.
- Base station controls all transmit parameters and characteristics in the network.
- All devices associated with the network use spectrum sensing as an auxiliary interference avoidance method.
- All devices must be able to sense to a threshold of -116 dBm.



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Senate Bill to Require the FCC to Issue Final Order Regarding “White Spaces”

- Permit unlicensed, non-exclusive use of unassigned, non-licensed television broadcast channels between 54 MHz and 698 MHz.
- Establish technical guidelines and requirements for the offering of unlicensed service in such bands to protect incumbent licensed services and licensees from harmful interference.
- Require unlicensed devices operating in such bands to comply with existing certification processes.



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Upcoming IEEE 802 Meetings

- May, Jacksonville, FL
- July, San Diego, CA



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Summary of Cognitive Radio

- Allows spectrum sharing on a negotiated or opportunistic basis.
- The sensing technique by itself does not assure coexistence on a non-interfering basis due to shadowing and building attenuation.
- The IEEE 802.22 standard is developing techniques to make coexistence possible in the TV bands
- IEEE 802.22 participation by NABA members would be highly desirable.



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Broadband over Power Line (BPL)

A technique to provide broadband services to the home or in the home by coupling to the power line network.



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Broadband over Power Line (BPL)

The FCC reported final rule making for BPL in the January 7, 2005 Federal Register



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BPL Systems

- **Access Broadband over Power Line (Access BPL)** - A carrier current system installed and operated on an electric utility service as an unintentional radiator that sends radio frequency ... located on the supply side of the utility service's points of interconnection with customer premises. (**Amperion**)
- **In-House Broadband over Power Line (In-House BPL)** - A carrier current system, operating as an unintentional radiator, that sends radio frequency energy by conduction over electric power lines that are not owned, operated, or controlled by an electric service provider. (**Home Plug**)



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BPL Frequencies

BPL is allowed to operate from:
1.705 MHz to 80 MHz
(low-VHF channels 2 - 4: 54 - 72 MHz &
mid-VHF channel 5: 76 - 82 MHz)



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BPL Compliance Measurement Guidelines

For frequencies above 30 MHz,

- Electric field sensing antenna.
- Signal is maximized for sense antenna heights from 1 to 4 m above ground level (AGL).
- Both horizontal and vertical polarizations are measured.
- Measurements are taken along the length of the power line at distances 0, 1/4, 1/2, 3/4, and 1 wavelength.
- Measurement bandwidth of 120 kHz.



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NTIA Recommendations on BPL Guidelines

- Measurement provisions most important to prevention of interference should be codified as rules rather than guidelines.
- Measurement bandwidths, for example, other than the intended 120 kHz value could yield significant error and elevated risk of interference.



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BPL Interference Analyses

- ARRL analyses
- Radio Advisory Board of Canada analysis to respond to Canada Gazette Consultation
- ITU-R Working Party 6E DNR Doc 6/229 In-House BPL analysis
- Fox Technology Group Access BPL Analysis



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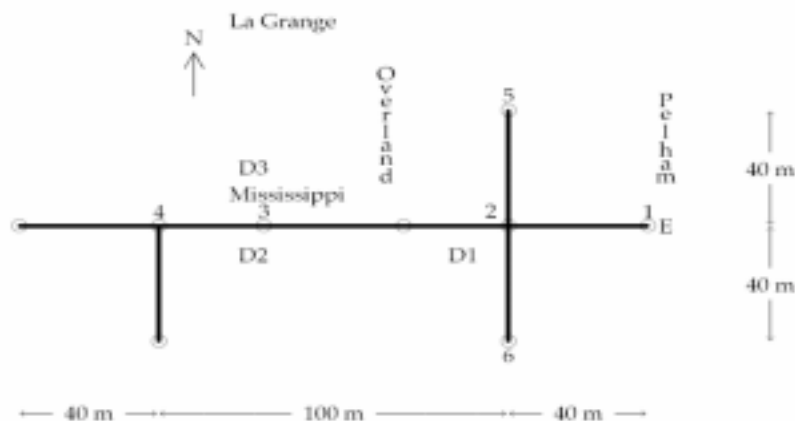
Fox Technology Group Access BPL Analysis

- Investigates the level of interference that could be introduced from Part 15 compliant BPL into nearby consumer TV antennas.
- Study is available at:
http://mail.foxpico.com/wc/bopl_study.pdf



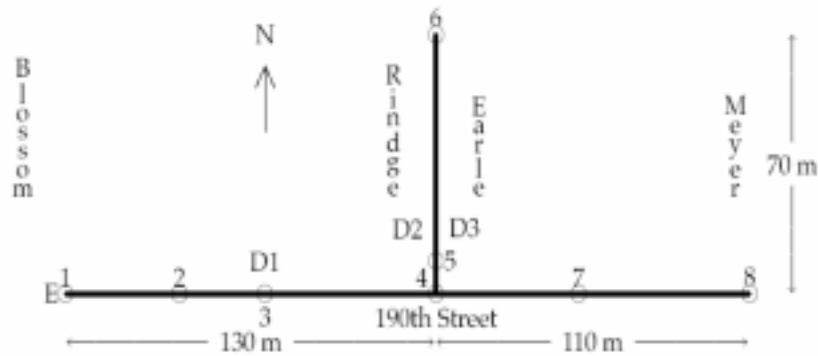
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West Los Angeles (LADWP)



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Redondo Beach (SCE)



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TV Receive Antennas

- Dipoles lengths tuned to the desired frequency.
- Located at various locations at distances between 18 to 33 feet.
- Located at 30 feet above ground level
- Based on the houses in the surveyed locations, these would be the actual locations of consumer TV antennas.



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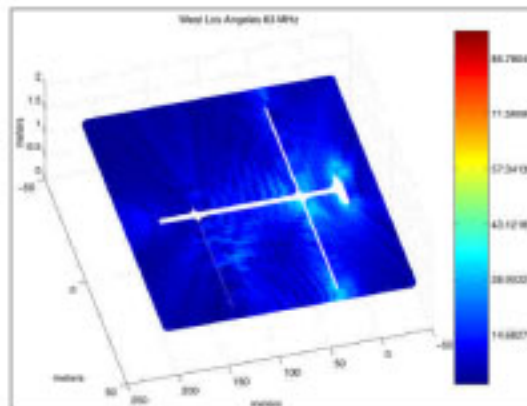
Compliance Testing Results: West Los Angeles (LADWP)

- | | |
|---|--|
| <ul style="list-style-type: none"> • Ch 2 - 57 MHz • average near electricfield 20.09 $\mu V/m$ • maximum near electricfield 146.77 $\mu V/m$ • minimum near electricfield 0.950 $\mu V/m$ • percent compliant 99.63 % • Ch 3 - 63 MHz • average near electricfield 9.70 $\mu V/m$ • maximum near electricfield 43.86 $\mu V/m$ • minimum near electricfield 0.463 $\mu V/m$ • percent compliant 100.00 % | <ul style="list-style-type: none"> • Ch 4 - 69 MHz • average near electricfield 6.20 $\mu V/m$ • maximum near electricfield 25.53 $\mu V/m$ • minimum near electricfield 0.359 $\mu V/m$ • percent compliant 100.00 % • Ch 5 - 79 MHz • average near electricfield 87.28 $\mu V/m$ • maximum near electricfield 939.83 $\mu V/m$ • minimum near electricfield 4.40 $\mu V/m$ • percent compliant 71.55 % |
|---|--|



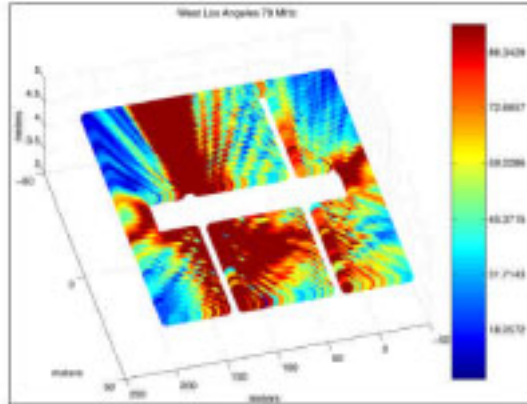
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Compliance Testing Results: West Los Angeles (LADWP)



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Compliance Testing Results: West Los Angeles (LADWP)



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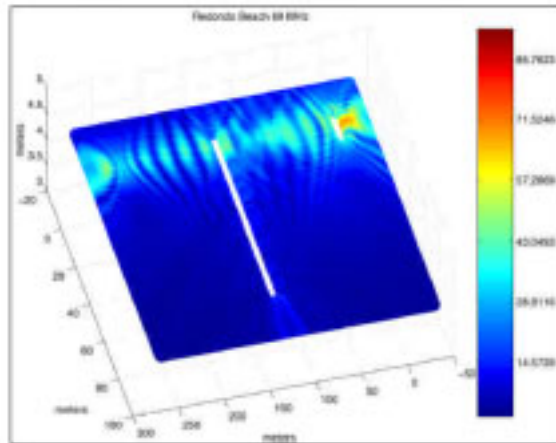
Compliance Testing Results: Redondo Beach (SCE)

- **Ch 2 - 57 MHz**
- average near electric field 5.94 $\mu V/m$
- maximum near electric field 44.37 $\mu V/m$
- minimum near electric field 0.23 $\mu V/m$
- percent compliant **100.00 %**
- **Ch 3 - 63 MHz**
- average near electric field 4.98 $\mu V/m$
- maximum near electric field 53.37 $\mu V/m$
- minimum near electric field 0.15 $\mu V/m$
- percent compliant **100.00 %**
- **Ch 4 - 69 MHz**
- average near electric field 9.59 $\mu V/m$
- maximum near electric field 73.28 $\mu V/m$
- minimum near electric field 0.34 $\mu V/m$
- percent compliant **100.00 %**
- **Ch 5 - 79 MHz**
- average near electric field 8.92 $\mu V/m$
- maximum near electric field 71.21 $\mu V/m$
- minimum near electric field 0.48 $\mu V/m$
- percent compliant **100.00 %**



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Compliance Testing Results: Redondo Beach (SCE)



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Interference Power Introduced into Nearby TV Receive Antennas

- Measurement Bandwidth Correction
- D/U Ratio
- Tabulated results



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Measurement Bandwidth Correction

OFDM Carrier Spacing	Number of Carriers in 6 MHz	Aggregated Power Increase
120 kHz	50	17 dB
240 kHz	25	14 dB
1.2 MHz	5	7 dB



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Desired-to-Undesired Interference Ratio (D/U)

- Desired power assumed are 28 dBu (fringe of coverage), 38 dBu, and 48 dBu.
- Undesired power is the resulting power induced into each of the analyzed TV receiving antennas at each of the analyzed channels.
- Co-channel D/U ratio for DTV is 23 dB for fringe of coverage service and 15 dB otherwise.



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West Los Angeles D/U Tables

BPL Dipole Power	Desired Field Strength =				28	dBu
	Equivalent Received Power =				-83.8	dBm
-123.30	22.5	25.5	32.5	39.5		
-119.74	18.9	21.9	28.9	35.9		
-117.95	17.2	20.2	27.2	34.2		
-114.94	14.1	17.1	24.1	31.1		
-114.40	13.6	16.6	23.6	30.6		
-113.76	13.0	16.0	23.0	30.0		
-107.90	7.1	10.1	17.1	24.1		
-105.19	4.4	7.4	14.4	21.4		
-102.74	1.9	4.9	11.9	18.9		
-101.35	0.5	3.6	10.6	17.6		
-94.17	-6.6	-3.6	3.4	10.4		
-88.50	-12.3	-9.3	-2.3	4.7		
	17	14	7	0		dB
Aggregated Power Increase						



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West Los Angeles D/U Tables

BPL Dipole Power	Desired Field Strength =				38	dBu
	Equivalent Received Power =				-73.8	dBm
-123.30	32.5	35.5	42.5	49.5		
-119.74	28.9	31.9	38.9	45.9		
-117.95	27.2	30.2	37.2	44.2		
-114.94	24.1	27.1	34.1	41.1		
-114.40	23.6	26.6	33.6	40.6		
-113.76	23.0	26.0	33.0	40.0		
-107.90	17.1	20.1	27.1	34.1		
-105.19	14.4	17.4	24.4	31.4		
-102.74	11.9	14.9	21.9	28.9		
-101.35	10.6	13.6	20.6	27.6		
-94.17	3.4	6.4	13.4	20.4		
-88.50	-2.3	0.7	7.7	14.7		
	17	14	7	0		dB
Aggregated Power Increase						



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West Los Angeles D/U Tables

	Desired Field Strength =			48	dBu
	Equivalent Received Power =			-63.8	dBm
BPL Dipole Power					
-123.30	42.5	45.5	52.5	59.5	
-119.74	38.9	41.9	48.9	55.9	
-117.95	37.2	40.2	47.2	54.2	
-114.94	34.1	37.1	44.1	51.1	
-114.40	33.6	36.6	43.6	50.6	
-113.76	33.0	36.0	43.0	50.0	
-107.90	27.1	30.1	37.1	44.1	
-105.19	24.4	27.4	34.4	41.4	
-102.74	21.9	24.9	31.9	38.9	
-101.35	20.6	23.6	30.6	37.6	
-94.17	13.4	16.4	23.4	30.4	
-88.50	7.7	10.7	17.7	24.7	
	17	14	7	0	dB
Aggregated Power Increase					



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Redondo Beach D/U Tables

	Desired Field Strength =			28	dBu
	Equivalent Received Power =			-83.8	dBm
BPL Dipole Power					
-111.75	11.0	14.0	21.0	28.0	
-103.86	3.1	6.1	13.1	20.1	
-103.16	2.4	5.4	12.4	19.4	
-101.14	0.3	3.3	10.3	17.3	
-94.79	-6.0	-3.0	4.0	11.0	
-92.86	-7.9	-4.9	2.1	9.1	
-92.07	-8.7	-5.7	1.3	8.3	
-89.92	-10.9	-7.9	-0.9	6.1	
-89.92	-10.9	-7.9	-0.9	6.1	
-88.44	-12.4	-9.4	-2.4	4.6	
-87.29	-13.5	-10.5	-3.5	3.5	
-85.19	-15.6	-12.6	-5.6	1.4	
	17	14	7	0	dB
Aggregated Power Increase					



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Redondo Beach D/U Tables

	Desired Field Strength =			38	dBu
	Equivalent Received Power =			-73.8	dBm
BPL Dipole Power					
-111.75	21.0	24.0	31.0	38.0	
-103.86	13.1	16.1	23.1	30.1	
-103.16	12.4	15.4	22.4	29.4	
-101.14	10.3	13.3	20.3	27.3	
-94.79	4.0	7.0	14.0	21.0	
-92.86	2.1	5.1	12.1	19.1	
-92.07	1.3	4.3	11.3	18.3	
-89.92	-0.9	2.1	9.1	16.1	
-89.92	-0.9	2.1	9.1	16.1	
-88.44	-2.4	0.6	7.6	14.6	
-87.29	-3.5	-0.5	6.5	13.5	
-85.19	-5.6	-2.6	4.4	11.4	
	17	14	7	0	dB
Aggregated Power Increase					



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Redondo Beach D/U Tables

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-111.75	31.0	34.0	41.0	48.0	
-103.86	23.1	26.1	33.1	40.1	
-103.16	22.4	25.4	32.4	39.4	
-101.14	20.3	23.3	30.3	37.3	
-94.79	14.0	17.0	24.0	31.0	
-92.86	12.1	15.1	22.1	29.1	
-92.07	11.3	14.3	21.3	28.3	
-89.92	9.1	12.1	19.1	26.1	
-89.92	9.1	12.1	19.1	26.1	
-88.44	7.6	10.6	17.6	24.6	
-87.29	6.5	9.5	16.5	23.5	
-85.19	4.4	7.4	14.4	21.4	
	17	14	7	0	dB
Aggregated Power Increase					



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Summary of BPL

- BPL signals on low-VHF frequencies have the very real capability of making television reception impossible.
- Rules for BPL compliance does not assure low-VHF protection from interference.
- The potential for interference increases as the number of BPL carriers increases.
- The potential for interference increases as the number of power line phases excited increases.



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Broadcast Spectrum Under Attack

Ultra-Wideband

Charles W. Einolf, Jr.

Consultant - CBS

Ultra-Wideband

- What is Ultra-Wideband (UWB)?
- What are UWB proponents claiming?
- Why is UWB a threat to Broadcasters?
- How has NABA countered the threat?
- What remains to be done?
 - At home?
 - Internationally?



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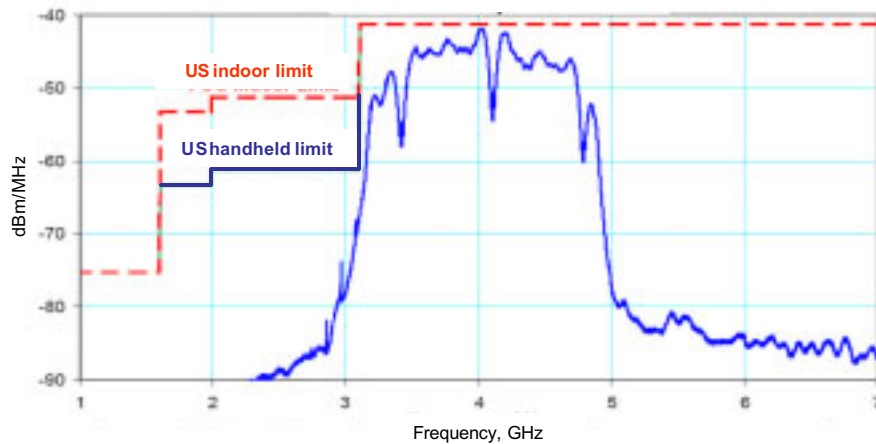
Ultra-Wideband: What is it?

- Ultra-Wideband (UWB)
 - Unlicensed technology
 - Included under the FCC Part 15 rules
 - Technology for short-range radiocommunication
 - RF energy that spreads over a very large frequency range
 - Bandwidth **at least** 500 MHz
 - Overlaps several frequency bands allocated to radiocommunication services



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UWB: What is it?



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UWB: What is being said?

BusinessWeek online

MARCH 16, 2000

NEWS ANALYSIS

- Ultrawideband: Gold in the "Garbage Frequency"



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UWB: Why a threat?

- UWB extends the Part 15 “Garbage” frequency spectrum from “DC to daylight”
- 500 MHz of spectrum easily covers entire blocks of allocated licensed spectrum
- Ultra-Wideband is global pollution of the electro-magnetic ocean - the RF spectrum broadcasters depend upon



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UWB: Threat to Broadcasting

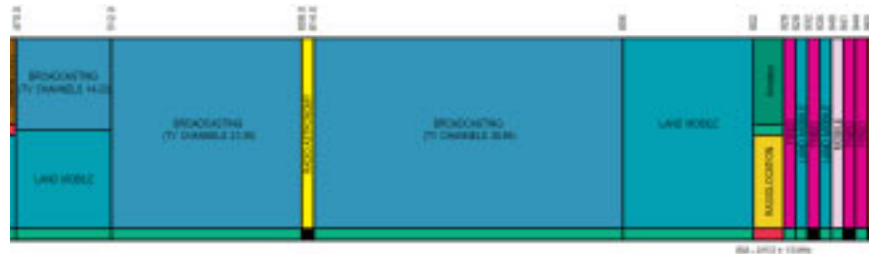
- Intentional raising of the radio noise floor
- Directly affects noise limited radio-communication services including broadcasting
- It's your spectrum as a Primary Service under the ITU Radio Regulations



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UWB: Threat to TV Broadcasting

- US Frequency Allocation (470MHz - 1GHz)
- Includes all UHF TV channels



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UWB: Threat to TV Broadcasting

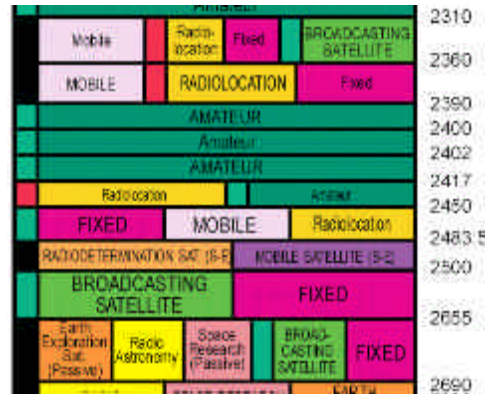
- Interference from UWB devices used for ground penetrating radar and wall imaging systems in the 470 to 960 MHz TV bands



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UWB: Threat to Broadcast Satellite

- Satellite digital audio radio service (SDARS) systems
- 2,320-2,345 MHz band



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UWB: Threat to Broadcast Satellite

- Interference from UWB devices used for surveillance systems between 1,990 MHz and 10,600 MHz



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UWB: Threat to Broadcast Satellite

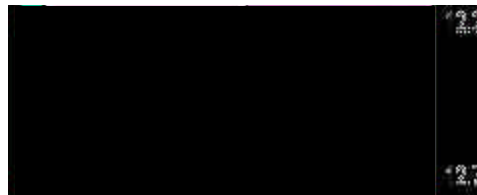
- Direct Broadcast Satellite
- Allocated 500 MHz in the 12,200 MHz to 12,700 MHz band



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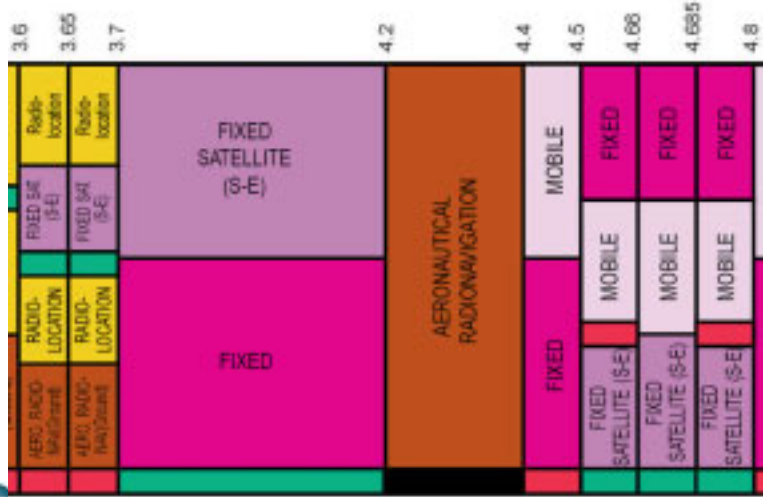
UWB: Threat to Broadcast Satellite

- UWB devices operating in the Direct Broadcast Satellite band in the vicinity of the receive antenna will interfere with reception



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UWB: Threat to Fixed Satellite




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UWB: Threat to Fixed Satellite



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UWB: NABA's Activities



INTERNATIONAL TELECOMMUNICATION
UNION
RADIOCOMMUNICATION
STUDY GROUPS

Document 1/02-E
Document 1-8/263-E
18 April 2005
English only

Source: Document 6/188

Study Group 6

LIAISON STATEMENT TO STUDY GROUP 1 AND
TASK GROUP 1/8 ON ULTRA-WIDEBAND DEVICES

- Established interference criterion of $I/N = -20$ dB for broadcast applications



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UWB: NABA's Activities

- International Telecommunications Union
 - Followed-up on the San Diego work with 18 contributions at the TG 1/8 meeting in October 2005
 - Contributions provided studies and protection requirements
 - Digital Television
 - Analog Television
 - Broadcast Satellite Service
 - Fixed Satellite Service
 - FM and TV receivers identified as UWB victims
 - UWB measurement techniques



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UWB Impact on DTV

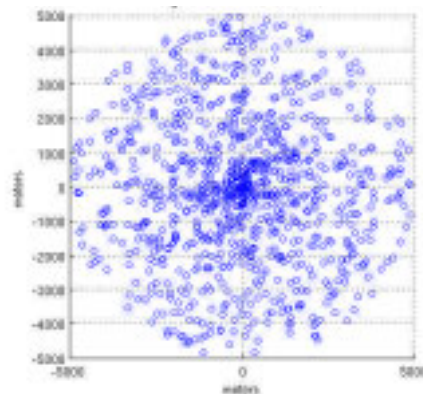
- Investigated single and aggregate UWB devices interfering with DTV reception
- Aggregate
 - Distribution of UWB devices
 - Ranges: 1,000m and 5,000m
- Single
 - Indoor: 0.5 meter separation
 - Outdoor: 3 meters separation



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UWB Impact on DTV

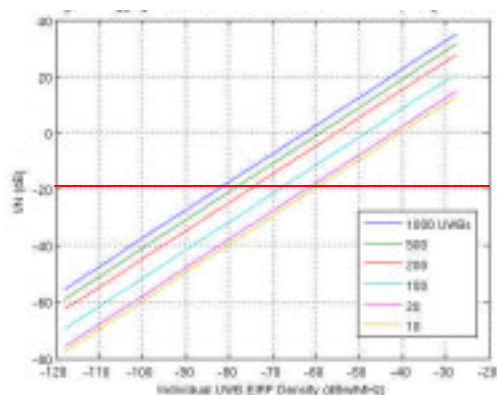
- Uniform distribution
 - also normal and inverse normal
- 5,000 meter range
 - also 1,000 meter
- 10 to 1,000 UWB devices
- VHF and UHF



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UWB Impact on DTV

- Protection criterion (I/N) as a function of power output of each individual UWB device in an aggregate



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UWB Impact on DTV

- Aggregate interference to DTV reception
- Lower UWB power levels are required to prevent interference

Band	UWB EIRP Density Limits (dBm/MHz)	
	I/N = -20 dB	FCC
Low VHF	-91	-65.3
High VHF	-84	-65.3
UHF	-78	-65.3



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UWB Impact on DTV

- Single UWB device interference to DTV reception
- 50cm indoors, 3m outdoors
- Significantly lower UWB power levels are required

Band	UWB EIRP Density Limits (dBm/MHz)	
	I/N = -20 dB	FCC
Low VHF	-122	-65.3
High VHF	-113	-65.3
UHF	-106	-65.3



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UWB: What remains to be done?

- At home?
 - USA
 - Spectrum Management Advisory Committee
 - Canada
 - UWB Consultation
 - Mexico



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UWB: What remains to be done?

- Internationally?
 - ITU
 - Recommendation limiting interference to Broadcast Satellite Services
 - Demand administration approval
 - Promote approval world-wide
 - Initiate similar recommendation for terrestrial broadcasting
 - Continue efforts to protect and secure spectrum used for TV and radio production



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Broadcast Spectrum Under Attack



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Broadcast Spectrum Under Attack

Impact of Interference

Paul Bush
VP Corporate Development
Telesat Canada

Impact of Interference

- Radio spectrum is the raw material of the broadcast signal transport infrastructure
- The broadcast industry has driven the development of technologies to use this spectrum
- Broadcast spectrum has become “beach front property”



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Impact of Interference

- Unlicensed wireless technologies
 - Introduced on a “non-interference basis” into broadcast bands
 - Created interference by raising the noise floor
 - Cannot be controlled due to ubiquitous nature
 - Will impact broadcast service quality



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Impact of Interference

- Defensive Actions
 - Monitor wireless initiatives
 - Continue to undertake technical studies
 - Develop contributions to be submitted to the international forum (ITU) and actively participate to these fora
 - Establish and promote unified NABA position with North American regulators



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Impact of Interference



• Questions?

SO, UM, WHAT CAN I DO FOR YOU?
WE ARE TAKING OVER YOUR WORLD.
YOU ARE?? WHAT FOR??
EARTH IS PRIVATE REAL ESTATE.
LOCATION, LOCATION, LOCATION.
I GUESS I'D NEVER THOUGHT ABOUT THAT.
EARTH, ATMOSPHERE, QUIET GALAXY...
ACTUALLY THE ATMOSPHERE NEEDS CLEANING.
A GOOD FLOOR LIPPER.



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North American Broadcasters Association

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