Risk Analysis in Spectrum Policy

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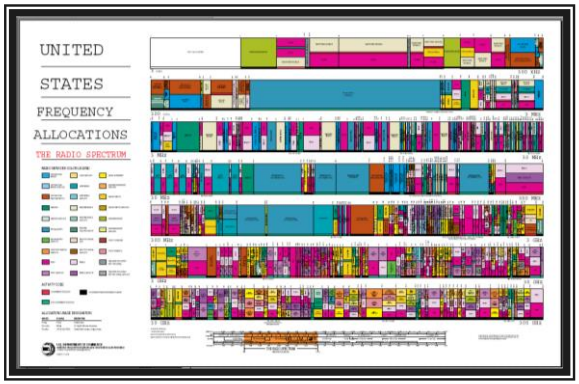
Note: The views expressed in this presentation are those of the author and may not necessarily represent the views of the Federal Communications Commission

Spectrum Policy: A 2-Minute Primer

Spectrum Allocations



- Each radio service is allocated spectrum - - a range of frequencies on the airwaves
- New or growing services often need additional allocations
- Carefully organized to avoid "harmful interference"

Harmful Interference

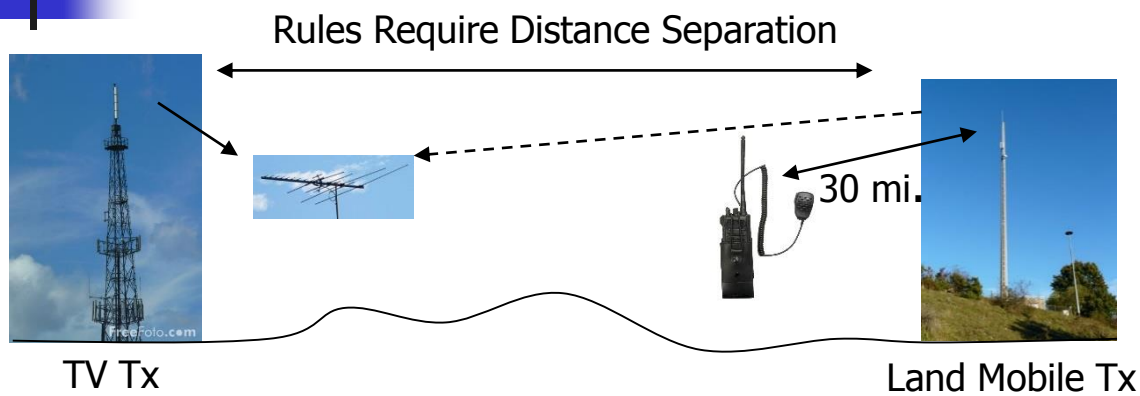
- Interference which endangers the function of safety services or seriously degrades, obstructs, or repeatedly interrupts a radio service
- Ix debates often arise in considering allocations for new radio services
- What is Ix:

Noisy of No Picture

Slowed data

Garbled Voice

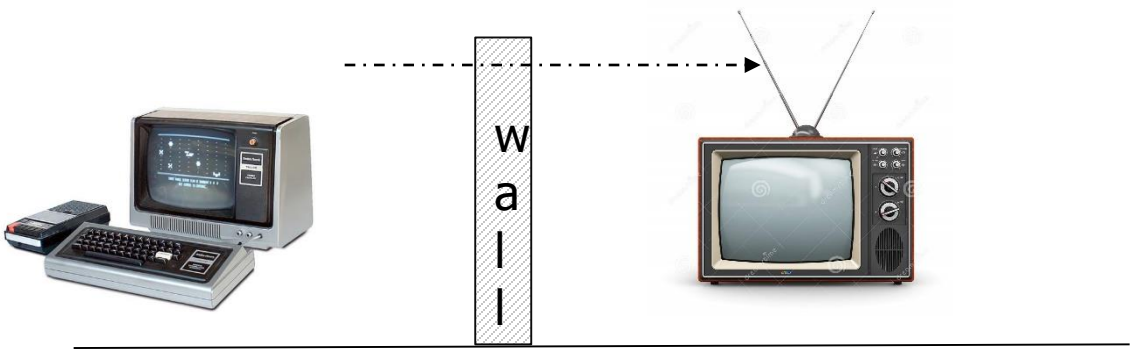
Case Studies of Two Landmark Interference Analyses



1970 Land Mobile Sharing Docket 18261

Assumptions

- TV Protected Contour
- TV Antenna Characteristics
- Path Loss w/ terrain
- LM Operating Area
- LN Antenna



1979 Part 15 Digital Device Emissions Limits Docket 20780

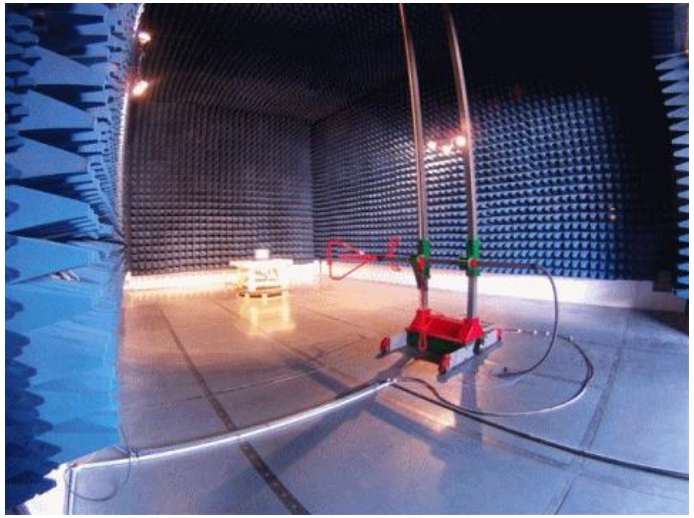
Assumptions

- TV Protected Contour
- Separation Distance (3/10 m)
- Wall attenuation
- Ability to meet limits

Produced Field Strength limits

Additional Factors Reduce Likelihood of Interference

- Compliance based on maximum transmitter power but power reduced in operation to prolong batter life
- Certain elements often not considered such as body loss for handheld devices
- Part 15 compliance tests are based on maximizing emissions from the device:
  - Device settings & accessories adjusted to maximize emissions
  - Device rotated to maximize measured level
  - Measurement antenna height adjusted to maximize direct & ground reflected
- Usually only a few emissions, if any, are close to the limits
- Devices often have a self-interest in reducing emissions (GPS)
- Emissions from multiple devices are not necessarily coherent - - different frequencies & directionality



Notable Interference Debates

TV White Space

Ultra-wideband

Progeny

Northpoint

WCS/SDARs

3.5 Ghz

5 GHz

GPS

Fireworks!

M2Z

AWS-3

Observations

- Interference analyses were generally based on worst case:
  - Interferer at max power
  - Protected device receiving weak signal
  - Separation distances debated
  - In some cases there are statistical elements - propagation models, clutter, Monte Carlo analyses, assumptions about activity factors, etc.
- Parties often described risk in extremes:
  - Public safety
  - Lost TV reception – emergency alerts; disasters
  - Dropped 911 calls
  - Lost satellite service
  - Dramatic degradation of performance

Today's Systems Are More Complex

- Analog vs Digital:
  - Analog: Noisy picture/garbled voice
  - Digital: Video cliff effect/bit error rate
- Systems Are Dynamic:
  - Interference coping mechanisms
  - Adjust modulation/data rate
  - Switch to best available resource
- More Variables:
  - Separation distance
  - Antennas: MiMo, steered beams
  - Aggregation from multiple devices
  - Allowance for noise from other sources

1.3 CONFIGURATION DESCRIPTION

Configuration Code	Carrier(s)	Configuration Description
W-SC	1C	WCDMA Single Antenna, Single Carrier
W-MC	2C	WCDMA Single Antenna, Multi Carrier x2
W-MIMO-SC	1C	WCDMA MIMO, Single Carrier
W-MIMO-MC	2C	WCDMA MIMO, Multi Carrier x2
L-MIMO-SC	1C	LTE MIMO, Single Carrier
L-MIMO-MC 1	2C	LTE MIMO, Multi Carrier x2
L-MIMO-MC 2	3C	LTE MIMO, Multi Carrier x3
W+L-MC 1	1W+1L	WCDMA+LTE Single Antenna, One Tx, 1WCDMA+1LTE
W+L-MC 2	2W+3L	WCDMA+LTE Single Antenna, One Tx, 2WCDMA+3LTE
W+L-MIMO-MC 1	1W+1L	WCDMA+LTE MIMO, 1WCDMA+1LTE
W+L-MIMO-MC 2	2W+3L	WCDMA+LTE MIMO, 2WCDMA+3LTE
W+L-MIMO-MC 3	2W+1L	WCDMA+LTE MIMO, 2WCDMA+1LTE

The settings below were deemed representative for all traffic scenarios when settings with different modulations, channel bandwidths, number for carriers and RF configurations have been tested to find the worst case setting. The settings below were used for all measurements unless otherwise noted:

WCDMA:
Non-MIMO:
Single carrier TM1: 64 DPCHs at 30ksps (SF=128)
Multi carrier TM1 (x2): 32 DPCHs at 30ksps (SF=128) in each carrier

MIMO:
Single carrier TM5: 30 DPCHs at 30ksps (SF=128) and 8 HS-PDSCHs at 240 ksps (SF16)
Multi carrier TM5 (x2): 30 DPCHs at 30ksps (SF=128) and 8 HS-PDSCHs at 240 ksps (SF16)

MIMO:
Single carrier TM6: 30 DPCHs at 30ksps (SF=128) and 8 HS-PDSCHs at 240 ksps (SF16)
Multi carrier TM6 (x2): 30 DPCHs at 30ksps (SF=128) and 8 HS-PDSCHs at 240 ksps (SF16)

Channel Bandwidth: 5.0MHz and 4.2MHz

LTE:
MIMO mode sigle carrier: E-TM1.1
MIMO mode multi carrier (x2): E-TM1.1
MIMO mode multi carrier (x3): E-TM1.1

MIMO mode sigle carrier: E-TM3.2
MIMO mode multi carrier (x2): E-TM3.2
MIMO mode multi carrier (x3): E-TM3.2

MIMO mode sigle carrier: E-TM3.1
MIMO mode multi carrier (x2): E-TM3.1
MIMO mode multi carrier (x3): E-TM3.1

Equipment Authorization Tests
Reflect Complexity of Technologies

Difficult to Evaluate Real-World Impact & Harmful Ix

A Way Forward

Interference Analyses

- Statistics are beginning to enter into analyses
- Work needed to obtain underlying data:
  - Distribution of received signal levels
  - Distribution of transmitted power levels
  - How to treat aggregation
  - Etc.
- Need to develop better statistical models
- Change will not happen overnight - start "small"

Risk Assessment

- Need to better understand baseline performance of systems & consequence of interference in assessing
- Note that other federal agencies conduct risk assessments, including safety
- Assess the risks of harms against the benefits of creating opportunities for new services & innovation

Why It Matters

Underprotect:

Harms incumbent services and potentially increases costs

Overprotect:

Jeopardizes viability of new service and discourages innovation

SMART BALANCE®

Conclusion

Discussion