FCC Rules Necessary for 8-VSB Distributed Transmission

A Technology Presentation for

Federal Communications Commission Staff

April 8, 2004

S. Merrill Weiss / Merrill Weiss Group

Consultants in Electronic Media Technology / Management

Dual Presentation

- ✓ Technology Familiarization
  - ✓ Overview of Technology at Non-Technical Level
  - ✓ Adequate to Support Decision-Making
  - ✓ Examples of Applications
- ✓ FCC Policy & Decisions
  - ✓ Benefits with respect to Standing FCC Spectrum Policy
  - ✓ Decisions Needed to Establish Rules
  - ✓ Broadcaster Support

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Agenda

- ✓ Distributed Transmission (DTx) Systems
- ✓ Benefits of Distributed Transmission
- ✓ Prerequisites for DTx Operation
- ✓ System Design Examples
- ✓ Enabling FCC Rules
- ✓ Interference Analysis Methods
- ✓ Conclusions

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Distributed Transmission Systems

- ✓ Multiple Transmitters Covering an Area (SFN)
  - ✓ On-Channel Repeaters (successor to "Boosters")
  - ✓ Distributed Transmission
- ✓ Variety of Purposes
  - ✓ Gap Fillers (Filling in Shadows)
  - ✓ Service Maximization (Extending Service)
  - ✓ Creating Signal Hot Spots
  - ✓ Transmitter Diversity

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Benefits of Distributed Xmsn

- ✓ Spectrum Efficiency
  - ✓ Like Translators, But Without Another Channel
- ✓ Stronger Signals, Less Interference
  - ✓ Shorter Distances Need Less Fade Margin
  - ✓ Greatest Power Needed for "Last Mile"
  - ✓ Shorter Interference Zones
  - ✓ More Uniform Signal Levels

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Benefits of Distributed Xmsn (2)

- ✓ Tests Show More Signal Power Is Needed
  - ✓ NAB / MSTV
  - ✓ Especially for Set Top Reception
- ✓ Transmitter Diversity
  - ✓ Fills Holes in Difficult Propagation Channels
  - ✓ Helps Set Top Reception
  - ✓ Helps Pedestrian & Mobile Reception
- ✓ But, More Difficult for Receiver Equalizers
  - ✓ Similar to Difficult Reception Locations Using Single Xmtrs
  - ✓ DTx Offers Possibility to Overcome Many Such Difficulties

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Prerequisites for DTx Operation

- ✓ Transmitter Outputs Must Be Synchronized
  - ✓ Same Emitted Symbols for Same Data Input
  - ✓ Precise Frequency Control of Transmitters
  - ✓ Allows Treating Alternate Signals as Echoes
  - ✓ Allows Controlled Network Output Timing
- ✓ Capable Receiver Adaptive Equalizers
  - ✓ Must Treat Alternate Signals as "Echoes"
  - ✓ Must Handle Strong Leading Echoes
  - ✓ Wide Equalization Range (Pre- & Post-Cursor)

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System Design Example #1

- ✓ WPSX, Clearfield, PA (Penn State University)
- ✓ "V" Moving to "U"
  - ✓ NTSC Channel 3, DTV Channel 15
  - ✓ Maximized Facility (810 kW at 413 meters HAAT)
- ✓ Mountainous Terrain
- ✓ All Major Population Centers Obstructed
- ✓ Unable to Move Transmitter
  - ✓ FAA Restrictions
  - ✓ Loss of Service to Rural Areas
  - ✓ Population Centers Obstructed from One Another

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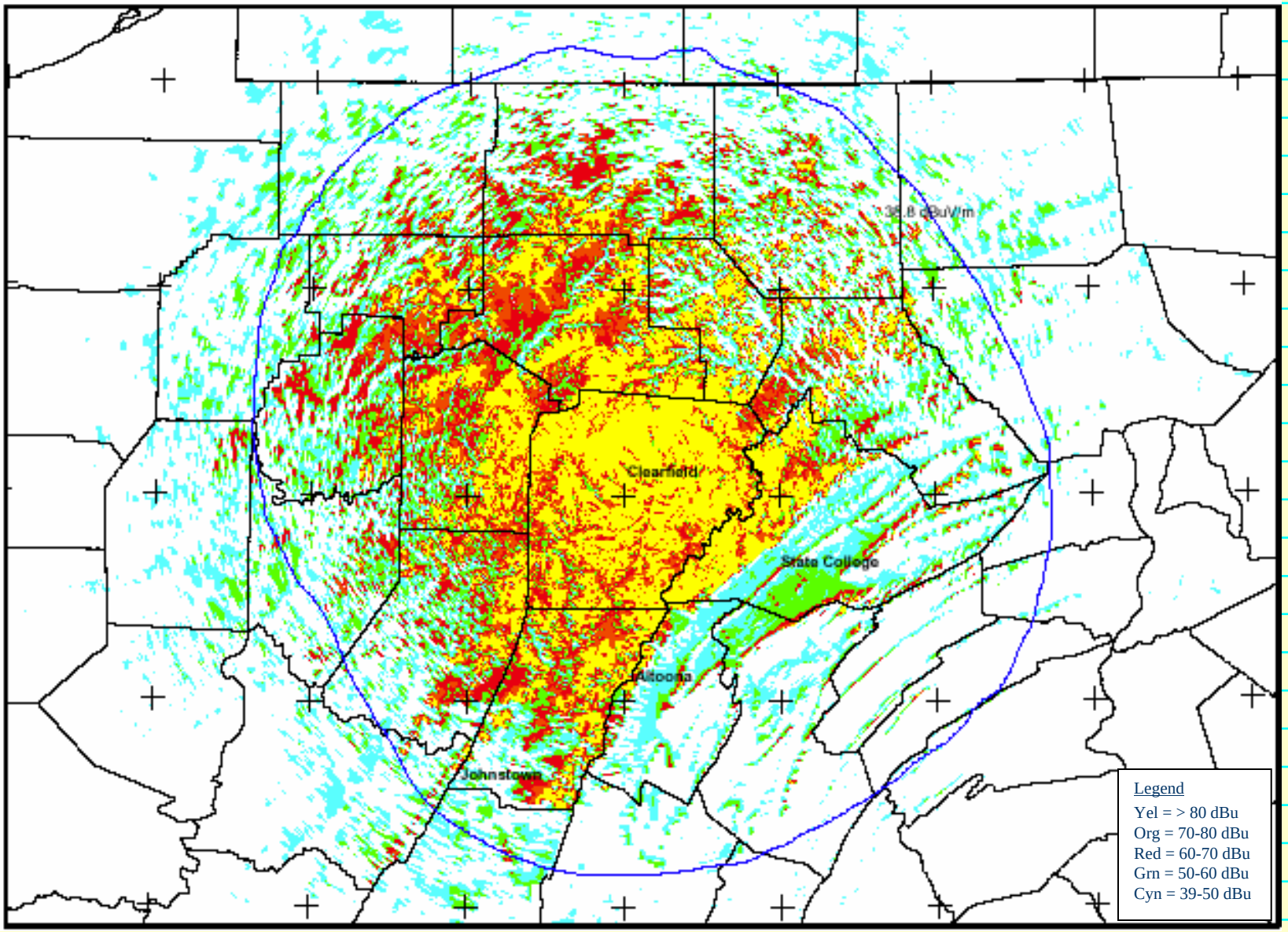
Terrain-Obstructed w/Single Xmtr



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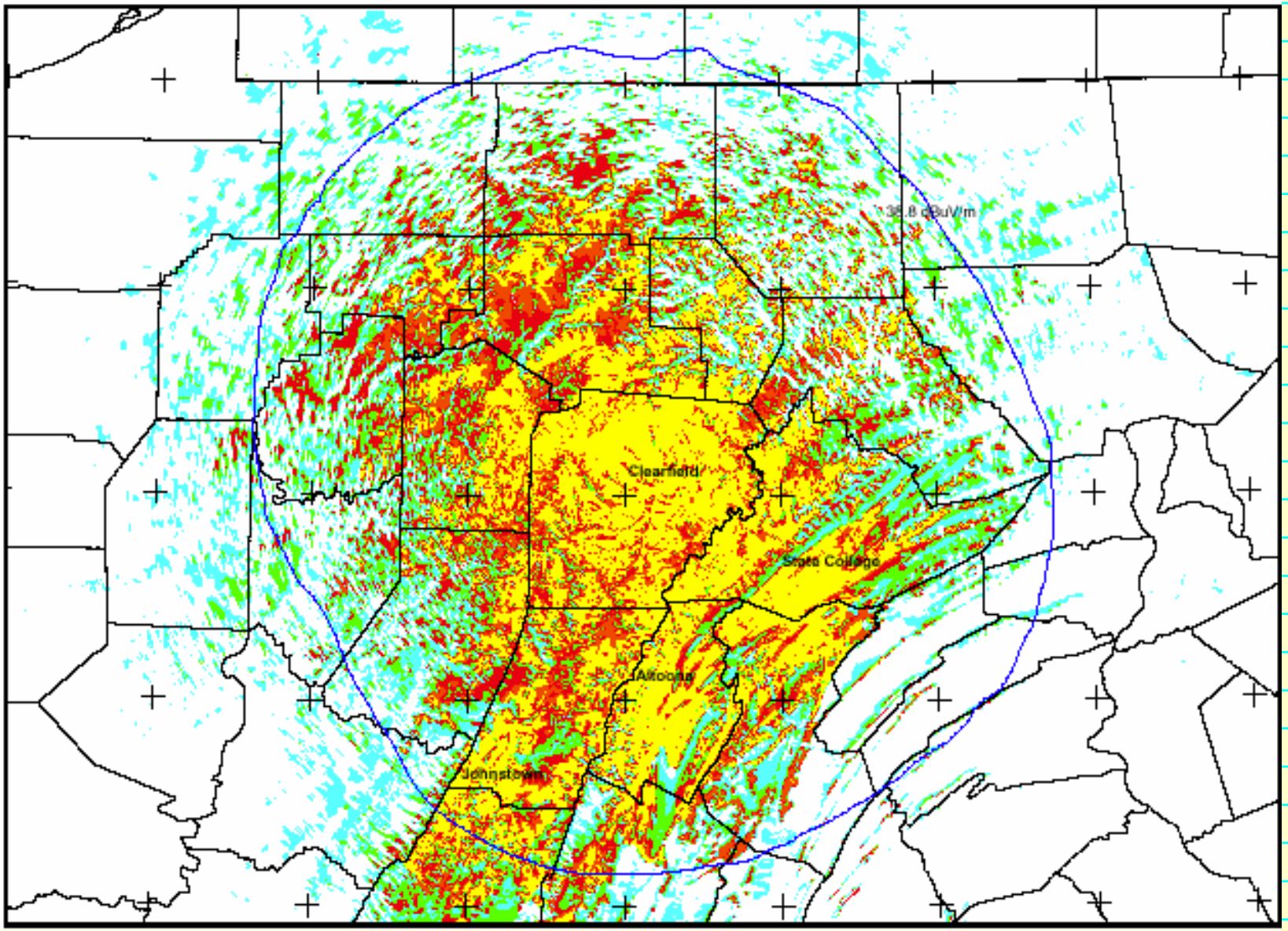
Distributed Transmitters Added



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Population Reached

Transmitter	>80 dBu	>70 dBu	>60 dBu	>50 dBu	>39 dBu
Clearfield (810 kW)	109,075	158,833	242,365	416,410	797,388
State College (50 kW)	83,293	96,432	119,847	152,266	243,474
Altoona (25 kW)	111,278	134,750	165,535	259,954	441,834
Johnstown (25 kW)	87,216	107,980	135,005	184,972	264,632
Combined	384,853	471,945	598,655	750,777	1,044,701

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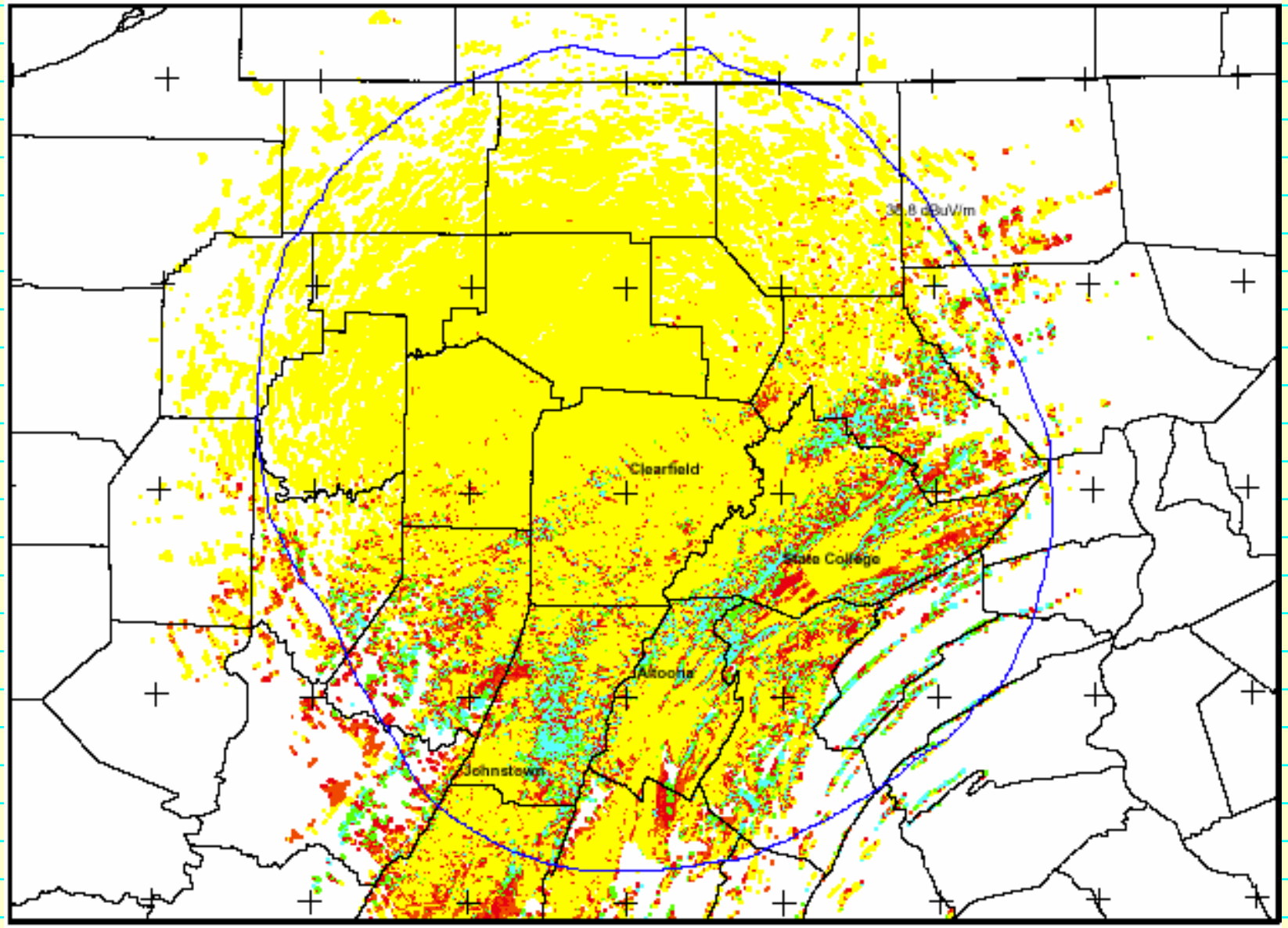
Managing Signals from Multiple Xmtrs



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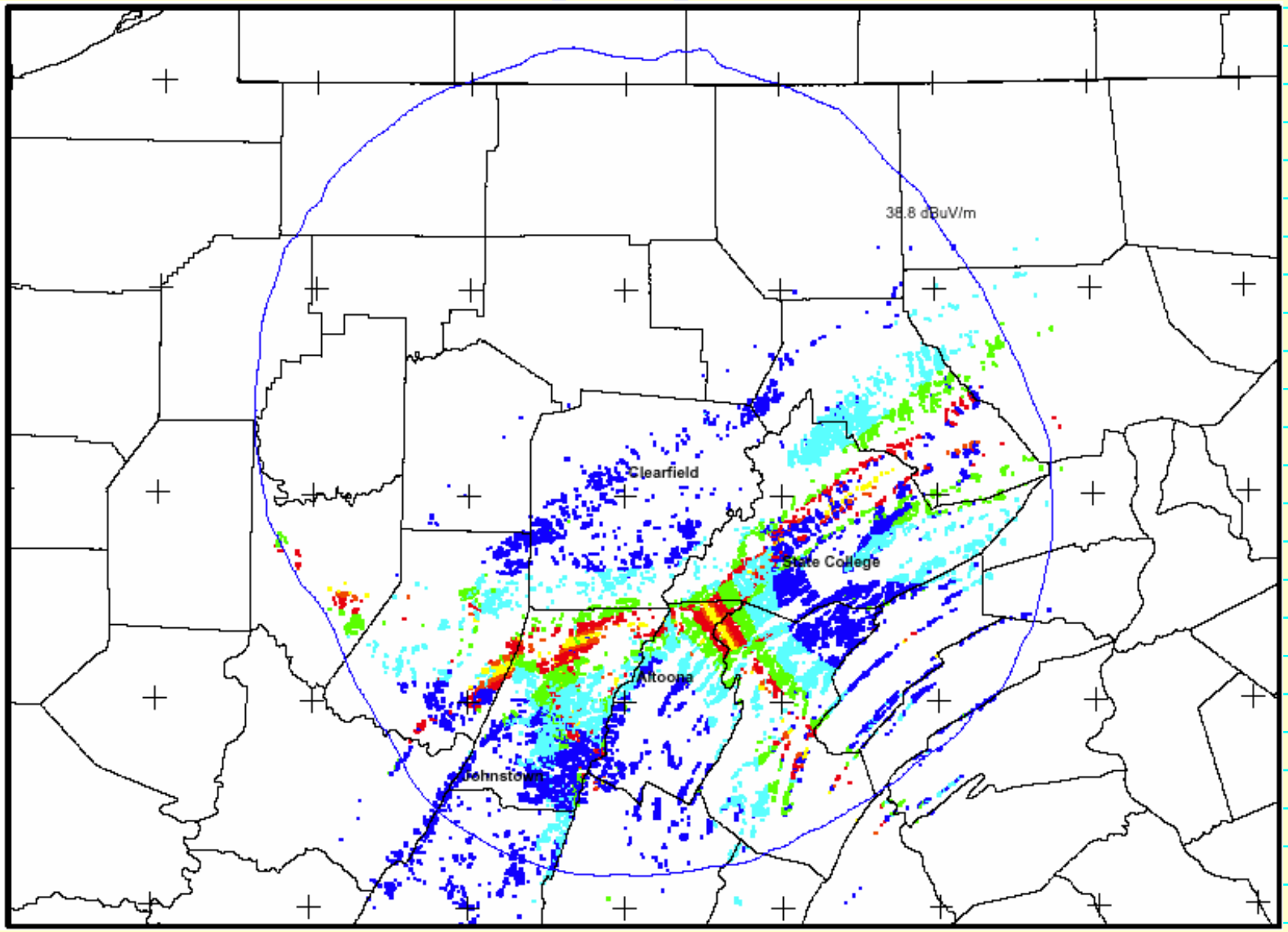
Timing Adjustment



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System Design Example #2

- ✓ Indianapolis Metropolitan Area Network
- ✓ Existing UHF Stations Under Common Ownership on 2 Channels
- ✓ Flat Terrain Example
  - ✓ Little Terrain Shielding to Reduce Interference within Network
- ✓ Existing DTV Stations Unable to Reach Market Center
- ✓ Ungranted Maximized Facility in Center of Market on File w/FCC
  - ✓ Would reduce service to outlying rural areas of each principal community
  - ✓ Would not provide City Grade service to both principal communities
  - ✓ Would require significant tower reconstruction

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System Design Example #2 cont'd.

- ✓ Distributed Transmission Network Offers Benefits
  - ✓ Cover center & outlying rural areas with stronger signals
  - ✓ Avoid major reconstruction of tower in center
  - ✓ Reduce capital costs

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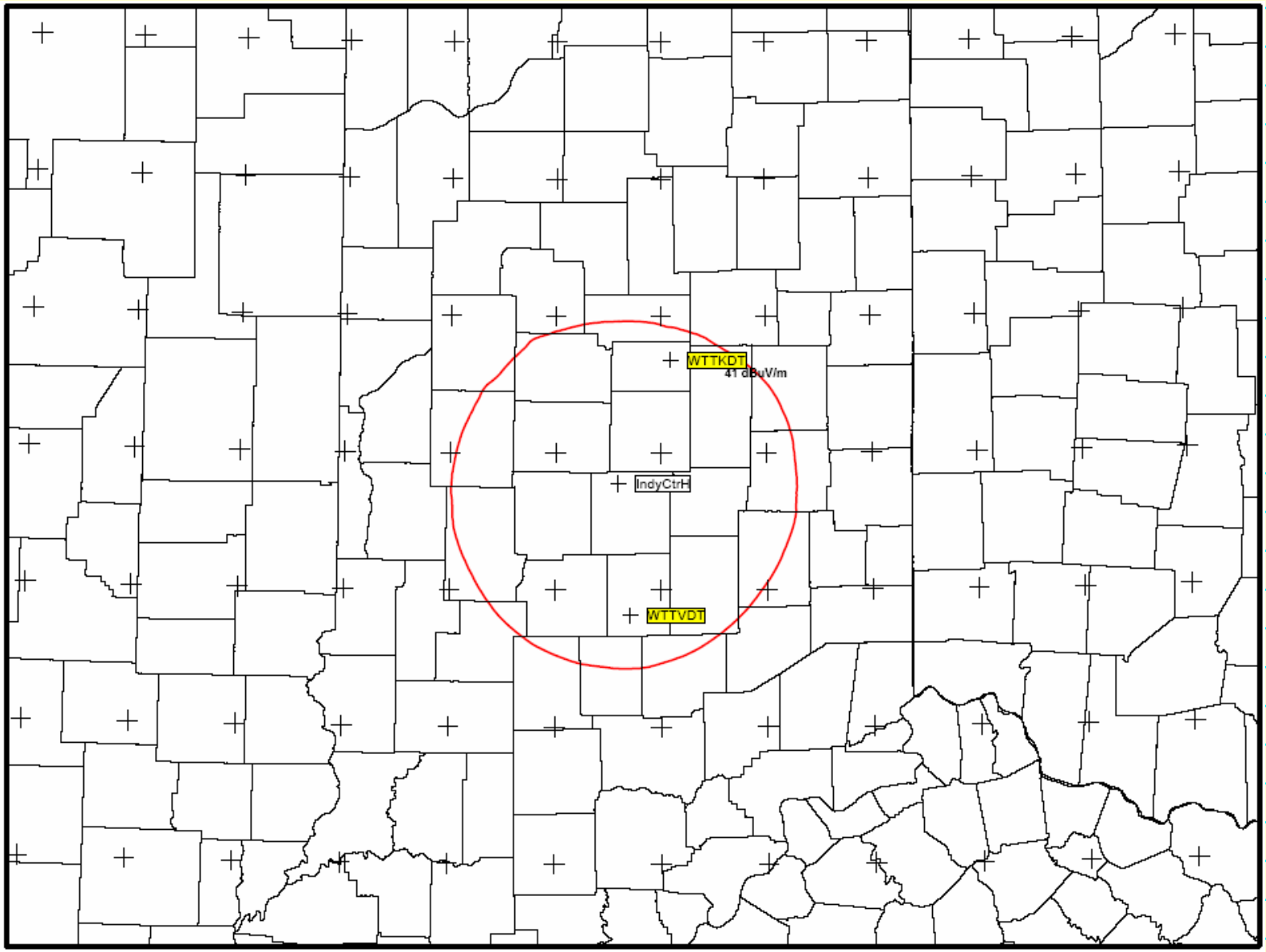
Coverage of 1 MW Transmitter



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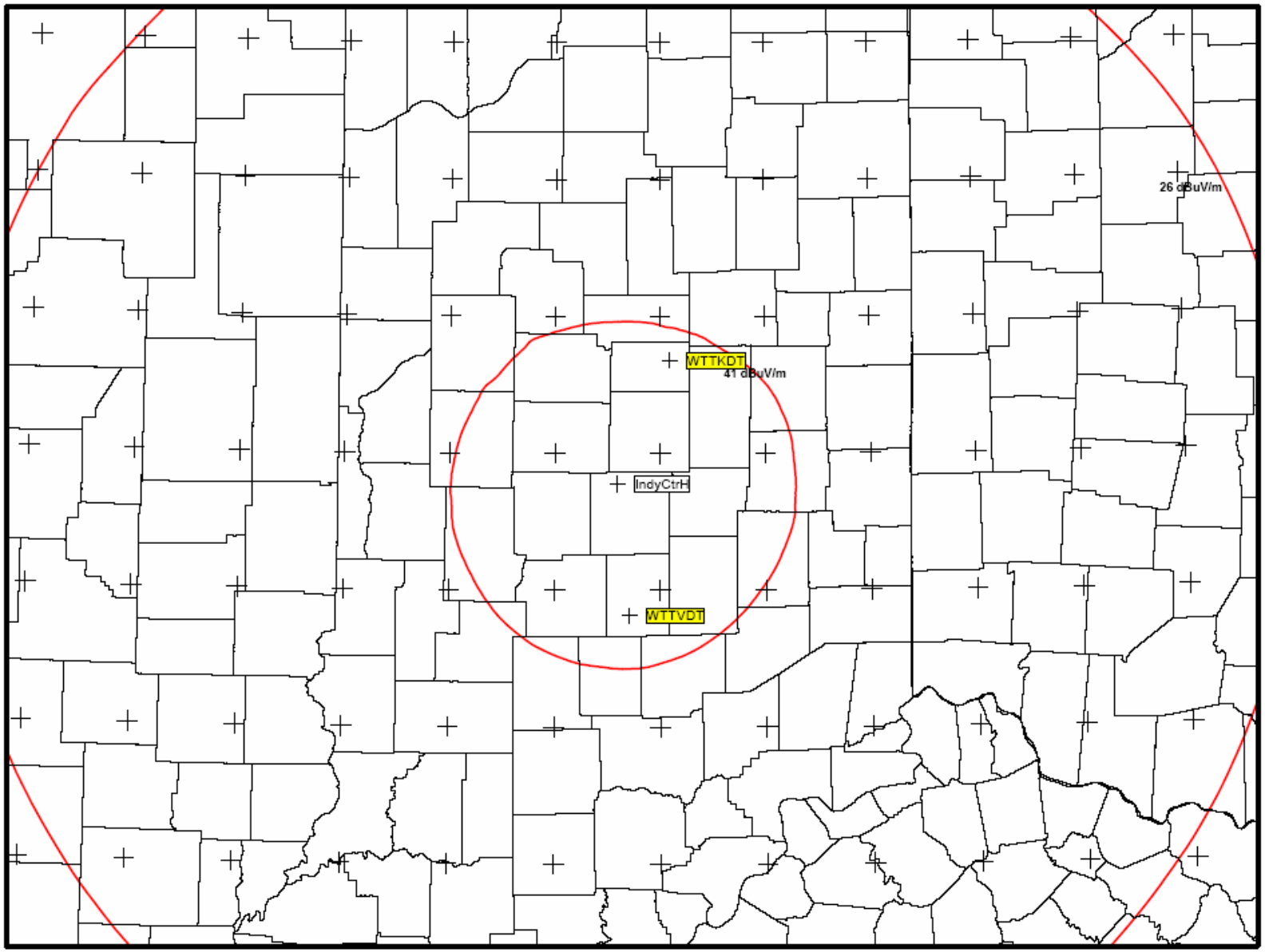
Interference from 1 MW Transmitter



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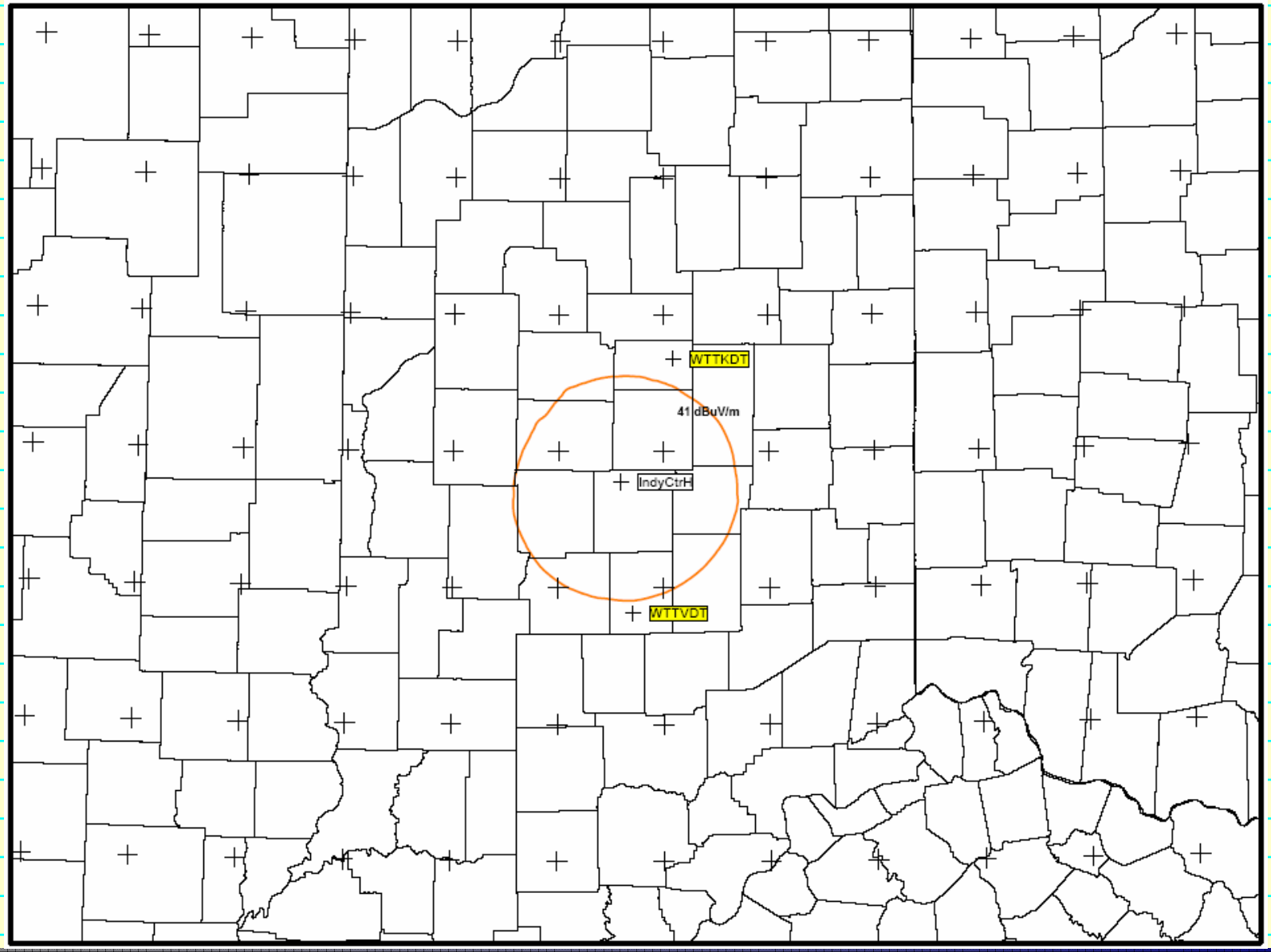
Coverage of 40 kW Transmitter



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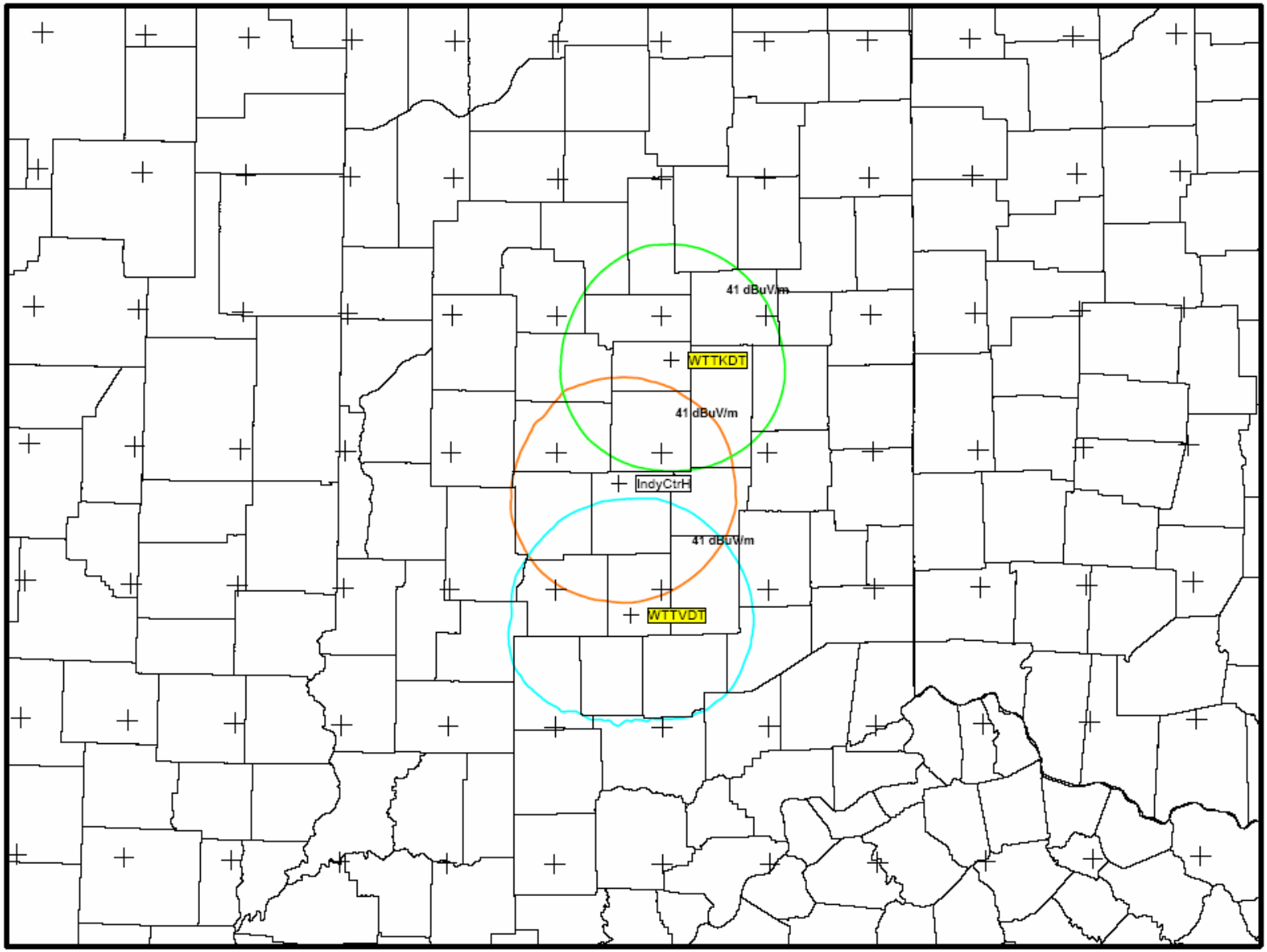
Coverage of 3x 40 kW Transmitters



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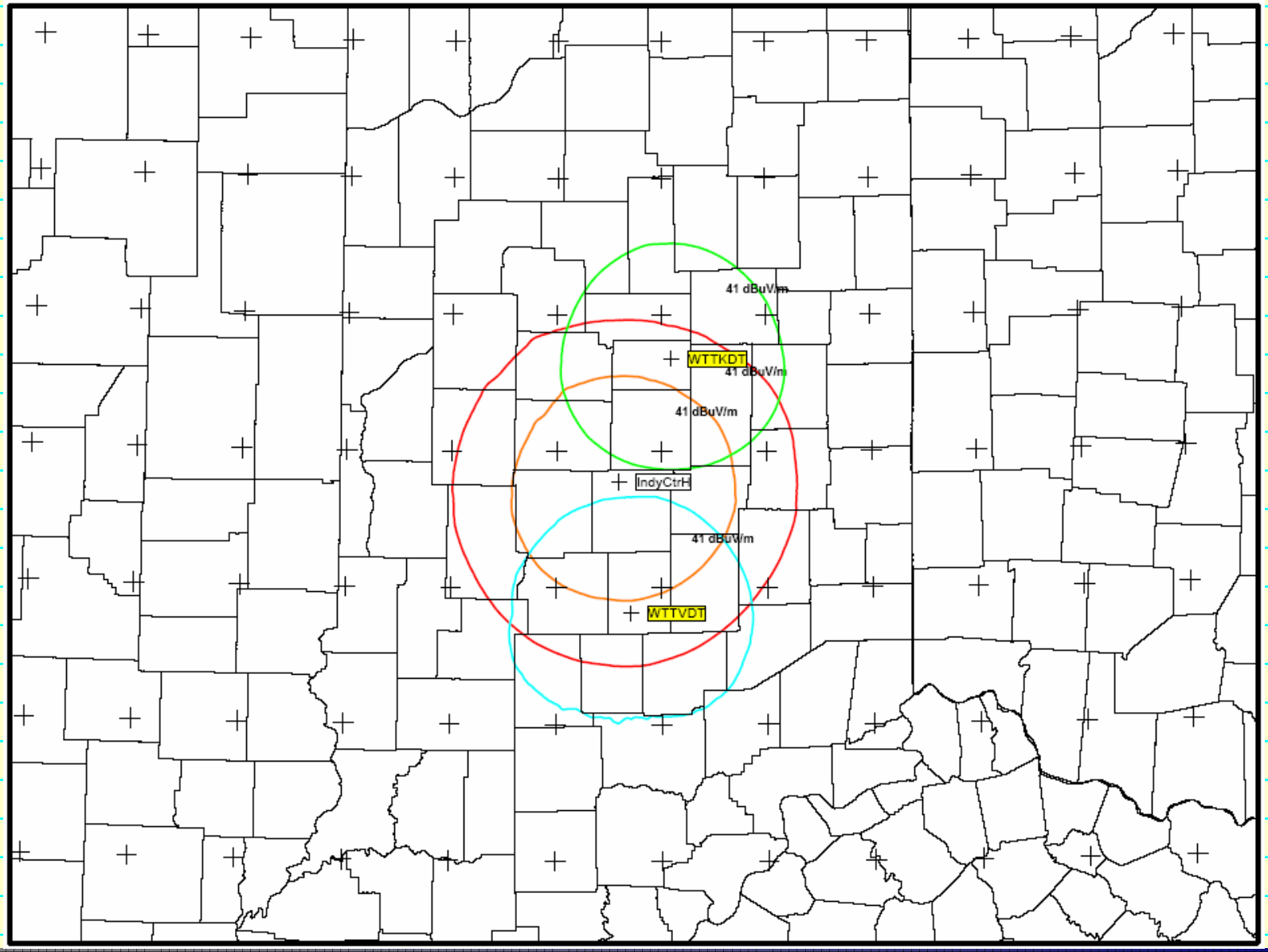
Coverage of 3x 40 kW Xmtrs vs 1 MW Xmtr



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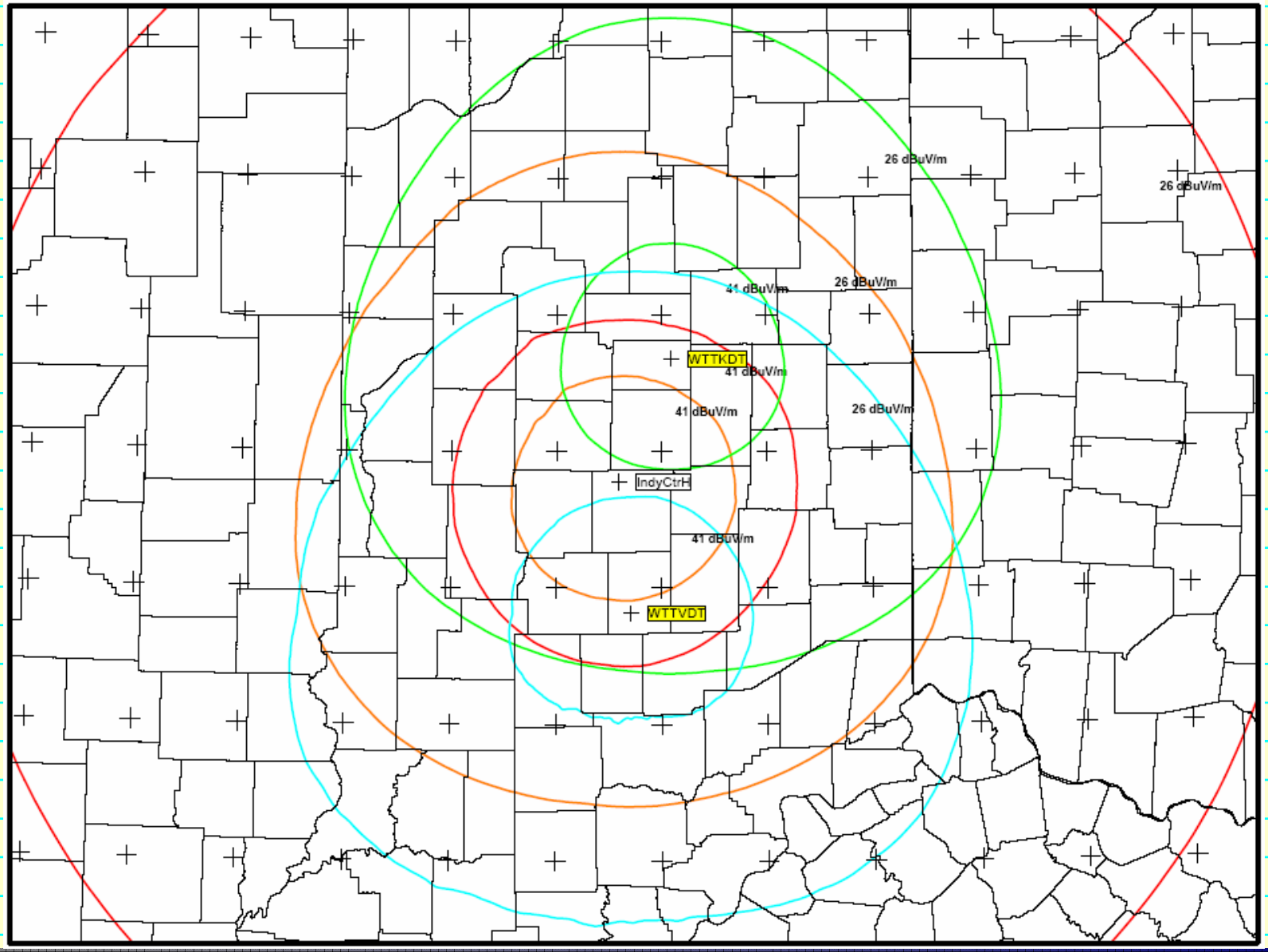
Interference from 3x 40 kW vs 1 MW Xmtrs



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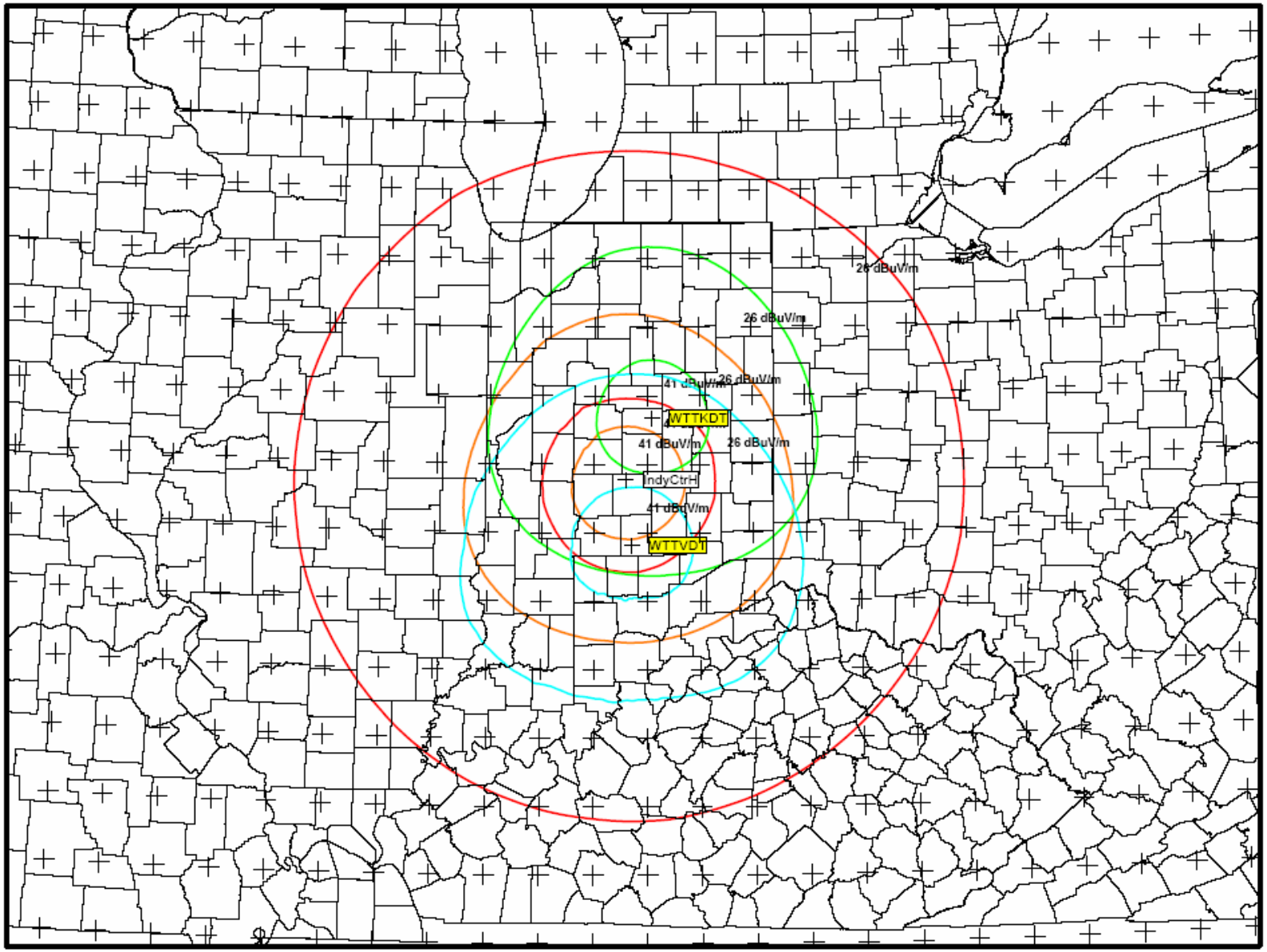
Comparisons of Coverage & Interference



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Current NTSC Rules — Boosters

- ✓ Boosters Are Secondary
  - ✓ Subject to Displacement, Even Inside Grade B
- ✓ Contours Must Be Inside Grade B Contours
  - ✓ Maintains Control of Signals
  - ✓ Administrative Solution to Technical Problem
- ✓ Many Rules Specific to NTSC Transmission
  - ✓ Related to Use of Multiple Carriers in NTSC
  - ✓ 11 Waivers Needed in 1st DTV Booster App.

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Current DTV Situation

- ✓ Terrain-Based Interference Determination
  - ✓ Longley-Rice Propagation Model
  - ✓ Small "Cells" Evaluated for D/U Ratios
  - ✓ Contours Only Provide Limitation on Studies
- ✓ FCC Included DTx In 2nd DTV Periodic Review
  - ✓ Originally to be Handled w/LPTV, Translators, Boosters
    - ✓ Response to 1st Biennial Review Comments
  - ✓ Most Comments Received Positive About DTx

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Required/Proposed Rule Changes

- ✓ Primary Treatment of Distributed Transmitters
  - ✓ Inclusion in Part 73 vs Part 74 in most instances
    - ✓ No Additional Spectrum Allotment Required
  - ✓ Protect Dist Xmtr Service Area Same as Main Service
  - ✓ When Distributed Xmtrs Provide Part of Main Service
    - ✓ Filling Gaps in Coverage, Creating Hot Spots
    - ✓ Maximizing Service Area and Population
- ✓ Permit DTV Coverage Area Extensions
  - ✓ More Effective Service Maximization
  - ✓ Proposal for 50% Extension In Each Direction
  - ✓ Distributed Xmtrs Located Within Reference Contours
  - ✓ Population Increase Limited Outside Licensee's DMA

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Required/Proposed Rule Changes (2)

- ✓ Limits for Main Stations Apply to Dist Xmtrs
  - ✓ Power
  - ✓ Antenna Height
  - ✓ Interference Analysis Serves as Constraint
- ✓ Eliminate Constraints of Analog Service Rules
- ✓ Interference Analysis Methods Extended
  - ✓ Modifications to Current Techniques / Software

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DTx Standards Development

- ✓ ATSC Candidate Standard CS/110A
  - ✓ Defines Synchronization Methods
  - ✓ Part of ATSC Enhanced VSB Initiative
  - ✓ Integrates with E-VSB Techniques / Standards
  - ✓ WPSX-DT Facility / Equipment Built to CS/110A
- ✓ ATSC SFN Recommended Practice Being Drafted
  - ✓ Covers Systems Using DTx Techniques
  - ✓ Addresses Issues of Receiver Technology / Sensitivities
  - ✓ Due for Consideration at T3 June Meeting

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Conclusions

- ✓ DTx Systems Provide Solutions to Significant Problems
- ✓ DTx Systems Provide Significantly Increased Spectrum Efficiency
- ✓ DTx Systems Allow Extension to Service
  - ✓ "Propagationally Challenged" Areas
  - ✓ Service Maximization
  - ✓ Extended Service Offerings
- ✓ Broadcasters Implementing DTV Now
- ✓ FCC Rules Needed Soon to Enable DTx Operation
- ✓ Ex Parte Letter to FCC Had Wide Support
  - ✓ Seeking Inclusion of Distributed Xmsn in NPRM

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Interference Analysis Methods

- ✓ Based on Current Techniques
  - ✓ Longley-Rice Propagation Model
  - ✓ OET Bulletin 69
  - ✓ *de minimis* Interference Thresholds
    - ✓ Embodied in the Rules – Whatever They May Become
- ✓ Must Protect Neighbors from DTx Systems
  - ✓ All Transmitters Taken Together
- ✓ Must Protect DTx Systems from Neighbors
  - ✓ Must Avoid Double Counting
- ✓ Modification of Current Software

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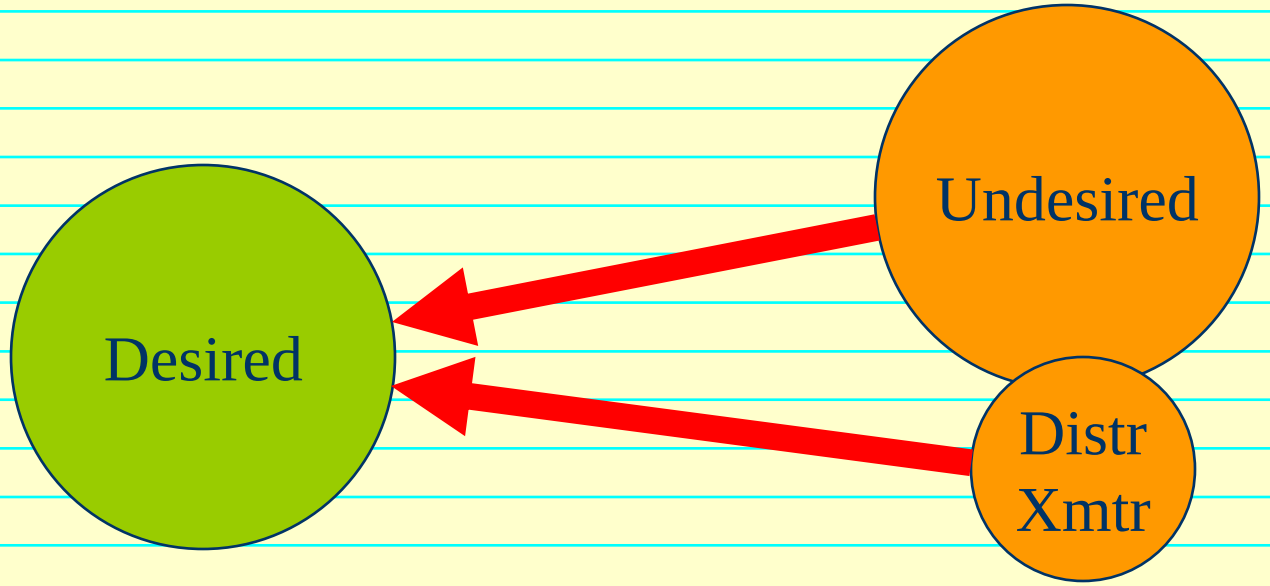
Interference FROM DTx System

- ✓ Current Interference Analysis Method
  - ✓ Main & Distr Xmtrs Treated Separately



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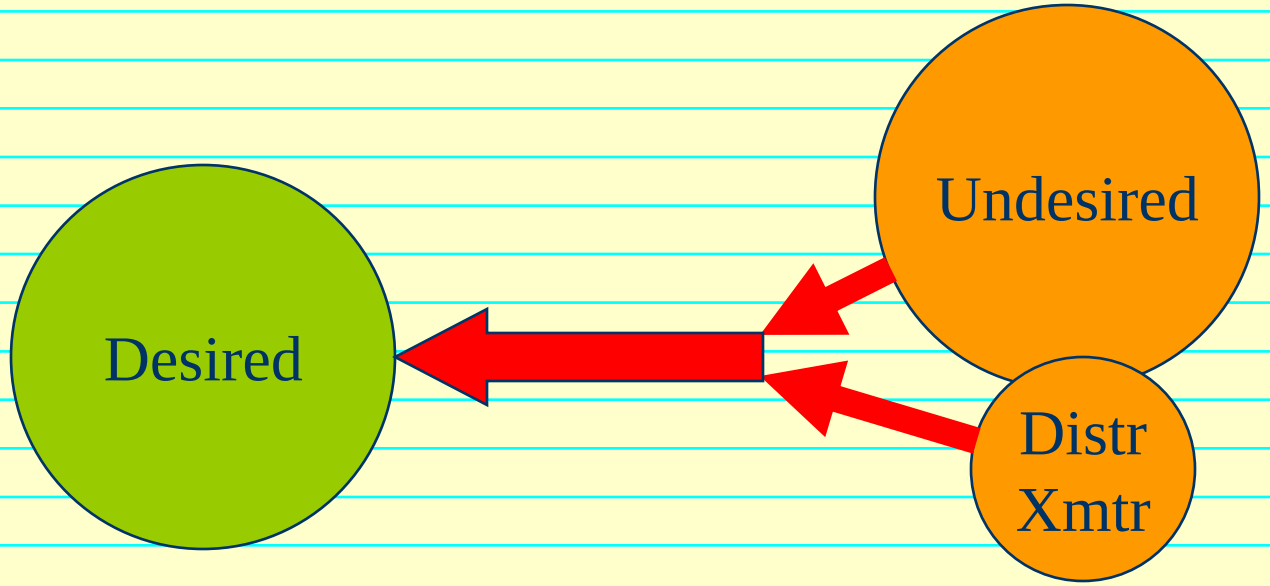
Interference FROM DTx System

- ✓ Proposed Interference Analysis Method
  - ✓ Main & Distr Xmtr Signals Aggregated



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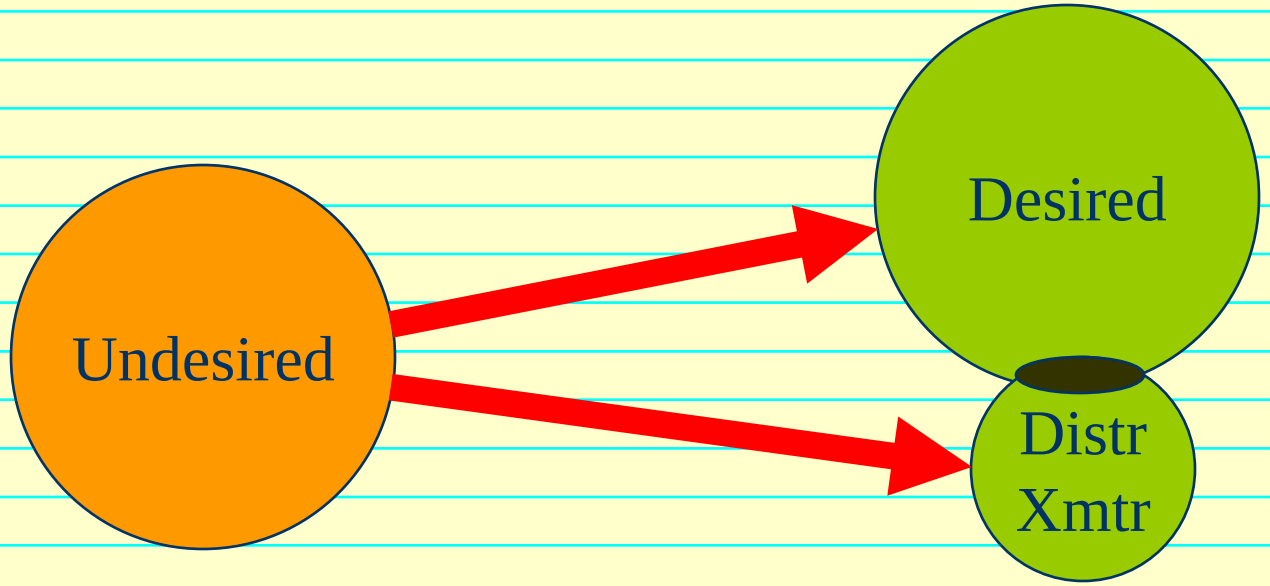
Interference TO DTx System

- ✓ Independent Interference Analysis Method
  - ✓ Overlap Leads to Double-Counting



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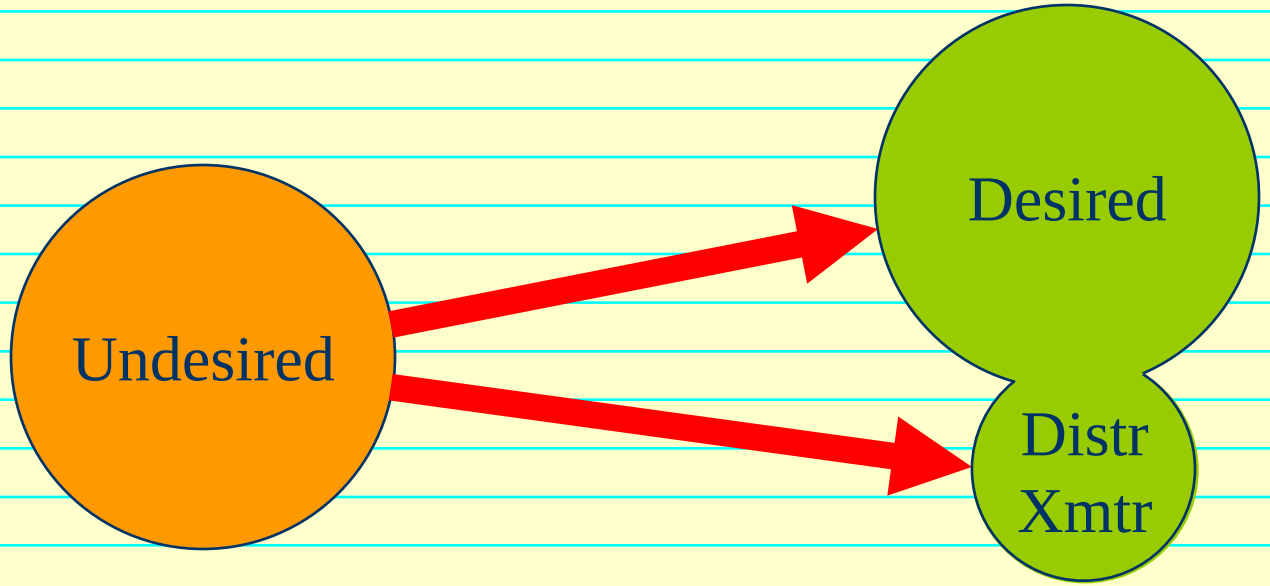
Interference TO DTx System

- ✓ Proposed Interference Analysis Method
  - ✓ No Double-Counting



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Software Modifications

- ✓ Interference FROM DTx System
  - ✓ Main & Distributed Xmtrs Analyzed Together
  - ✓ Can Be Done Manually — Turn On/Off Together
    - ✓ Method Used for Application Now On File with FCC
  - ✓ Link Distr Xmtrs to Main for Automated Analysis
- ✓ Interference TO DTx System
  - ✓ Treat Main & Distr Xmtrs As Single Service Area
  - ✓ Generate Analysis "Cells" from Single Reference Point
  - ✓ Analyze D/U Ratios Using Highest Signal Level as "D"
  - ✓ If D/U Below Threshold, Count Population from Cell
    - ✓ Avoids Double-Counting Population Losses to Interference

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