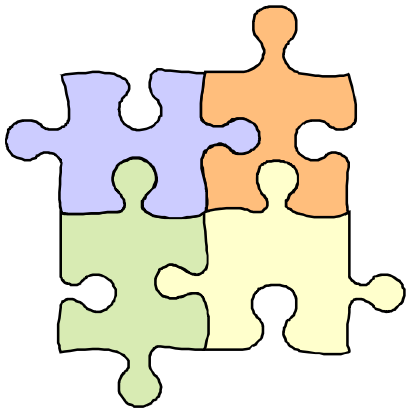
Syracuse Research Corporation

Wave 4 Rebanding Detail

Canadian Regions 2 and 7

Presented at:

Wave 4 Rebanding Summit
Cleveland OH
June 7, 2007



Prepared by:

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Syracuse Research Corporation

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This Will Be Complex

- For Regions 2, 3, and 7, New York State – Statewide Wireless Network (SWN) has offered to facilitate, and if necessary, execute the frequency reassignments in order to complete Wave 4 Rebanding
- NYS/SWN has the capabilities to handle this task
  - Has developed some very powerful spectrum engineering tools
  - Able to not only handle massive and complex frequency optimization problems, but able to auto-document all results in an easy to navigate fashion
    - Self creation Google Earth overlay files
    - Self creation of fully formatted DOC, XLS and PPT files
    - Self creation of complex, fully linked active html/java web entities

First things first…

- What assignments would we be generating?
- Existing Licenses and “Freeze STAs” for:
  1. Region 2
     - NPSPAC Assignments
     - PS “Old Block” Assignments
  2. Region 7 below Region 2
     - NPSPAC Assignments
     - Some if not all PS “Old Block” Assignments
  3. Region 3
     - NPSPAC Assignments? – possible if necessary
     - PS “Old Block” Assignments? – possible if necessary
  4. Region 7 below Region 3
     - NPSPAC Assignments? – possible if necessary
     - Some if not all PS “Old Block” Assignments? – possible if necessary

Need to do all of the above in make this all work

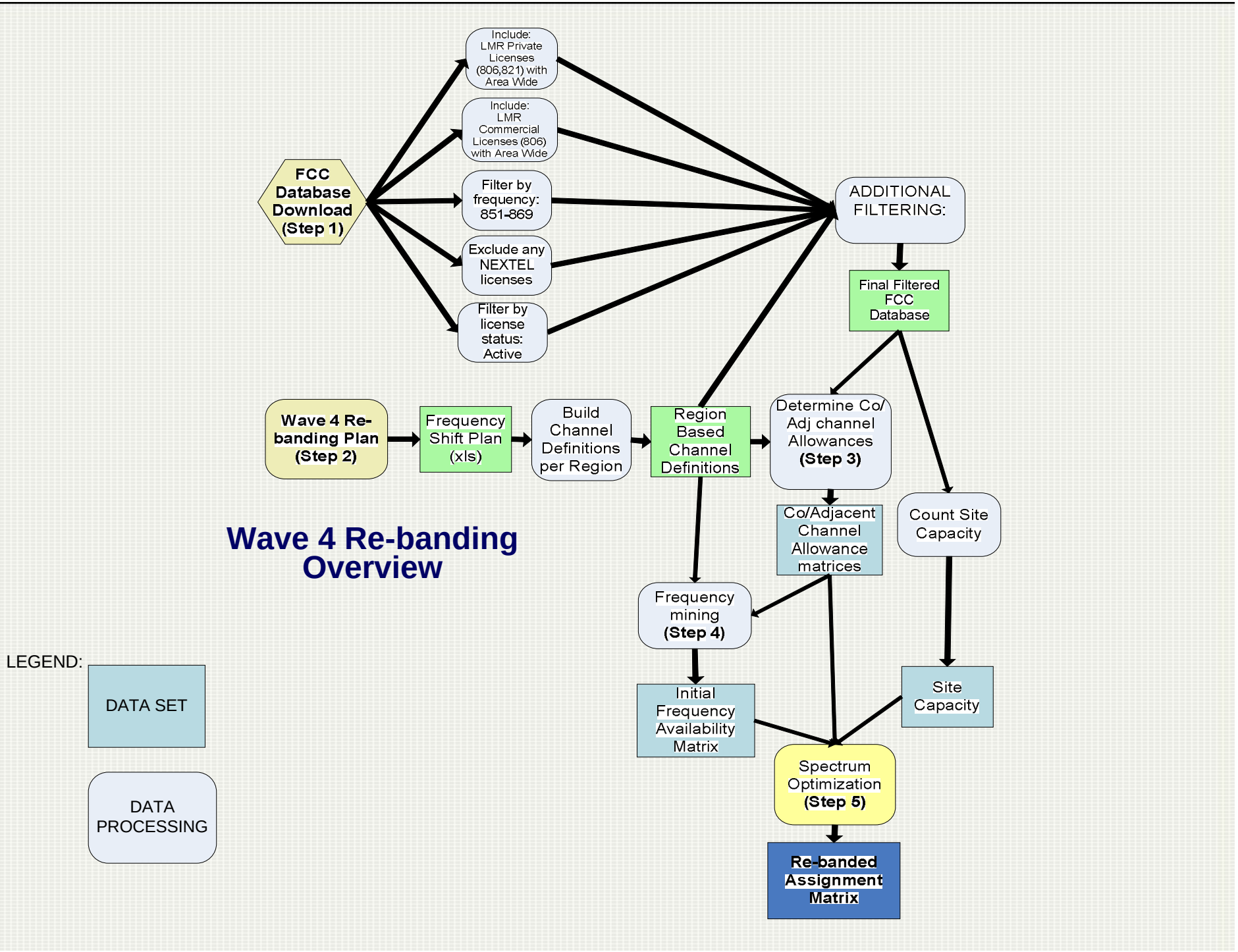
First things first…

- Before generating assignments we need:
  1. Incumbents or Constraints
     - What needs to be "worked around"
     - Outside Assignments: sites > 140+ km from border
     - IMPLICATION: Wave 1 Needs to Be Wrapped Up (or assignments defined)
     - Possibly…Canadian Region 3 Assignments
  2. "Targets" for Reassignment (non-incumbents)
     - Licenses and "Freeze STAs"
     - All border area sites will retain same number of channels
  3. Co/Adjacent Channel Compatibilities
     - Contour intersections
     - Existing relationships
  4. Initial frequency availability for "Targets"
     - Based upon (3), as well as actual spectrum utilization of incumbents
- Then we can use optimization tools (genetic algorithm) to generate the rebanding channel assignments.

Overview

1. Details of the Wave 4 re-banding strategy for Regions 2, 3, and 7.
   - Database download
   - Channel Definitions
   - Co-channel / Adjacent channel allowances
   - Initial channel availability
   - Find optimized channel assignments
2. Define rules guiding the re-banding process.
   - Dual Allocation Channels
   - Area Licenses
   - ITAC / Low Power

Wave 4 Re-banding Overview



Step 1: Build a transmitter database

FCC Database Download

FCC Federal Communications Commission

SMET Spectrum Management Engineering Tools

1. Transmitter information is downloaded from the FCC (and possibly other data sources).

   - LMR Commercial/Private Licenses (including area wide)
     - Old Block and NPSPAC
     - Only active licenses and STA's

   - Sprint / NEXTEL licenses are being excluded from re-assignment, and consideration as incumbents.

2. Some Additional Filtering

   - Limiting ourselves to bounding region (approx 1 million sq km):

     Longitude: (84W, 71W) Latitude: (39N, 46N)

     This includes: Border Regions 2, 3, and 7 (below 2 and 3)

Step 2: Define Post Re-banding Channel Structure

Wave 4 Re-banding Plan

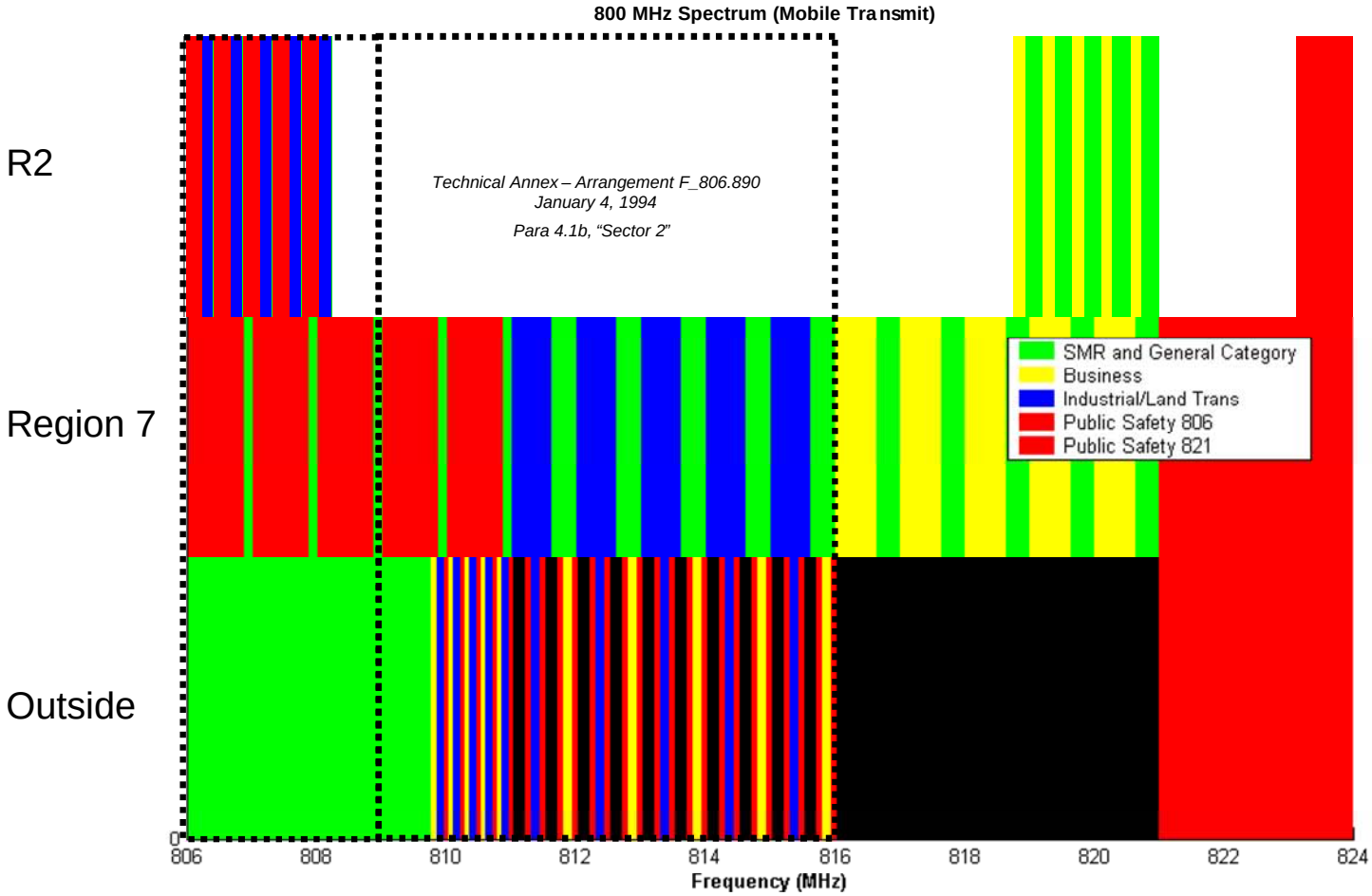
1. New Channel Assignments are based on the post re-banding plan structure for Regions 2, 3, and 7.

   – "Outside Region" transmitters are treated as incumbents.
     - NPSPAC will be shifted down 15 MHz.
     - Exact re-banding move for old block incumbents still not completely defined

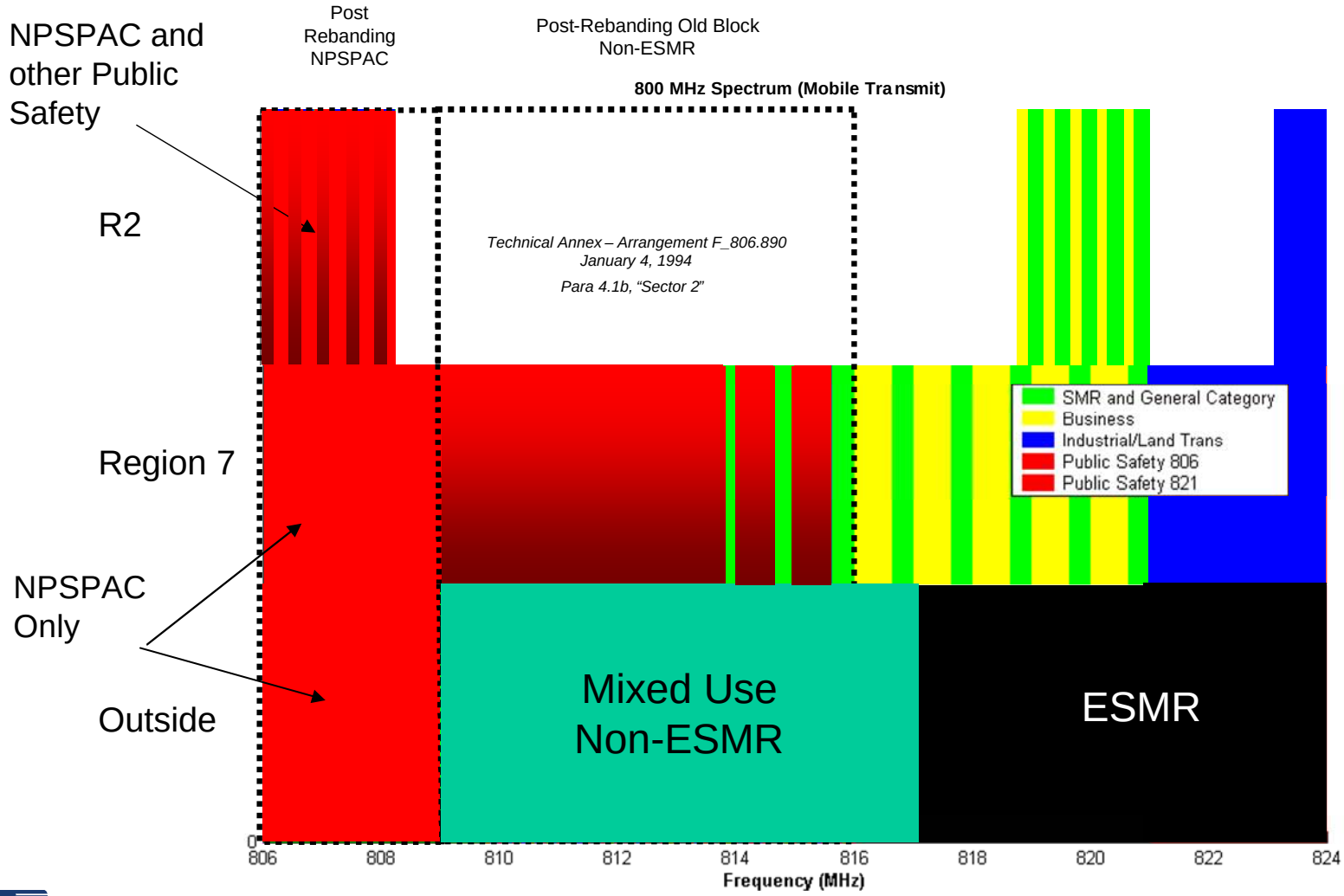
   – Mutual Aid and Low Power channels are treated as incumbents in all regions.
     - These channels will also be shifted down 15 MHz.

   – All other channels will be assigned based on optimization algorithm (genetic algorithm).

Current Regional Alignment: Border Region 2, Border Buffer Region 7, and Non-Border Areas



Proposed Regional Alignment: Border Region 2, Border Buffer Region 7, and Non-Border Areas



Existing Co-Channel Rules/Protections

Victim

Interferer

Channel Type	Old Block	NPSPAC
Old Block	DHAAT (§90.621)	None
NPSPAC	None	Contours (Regional Plans)

Existing Adj-Channel Rules/Protections

Victim

Interferer

Channel Type	Old Block	NPSPAC
Old Block	None Required	None
NPSPAC	None	Contours (Regional Plans)

Step 3: Determine Co / Adj Channel Allowances

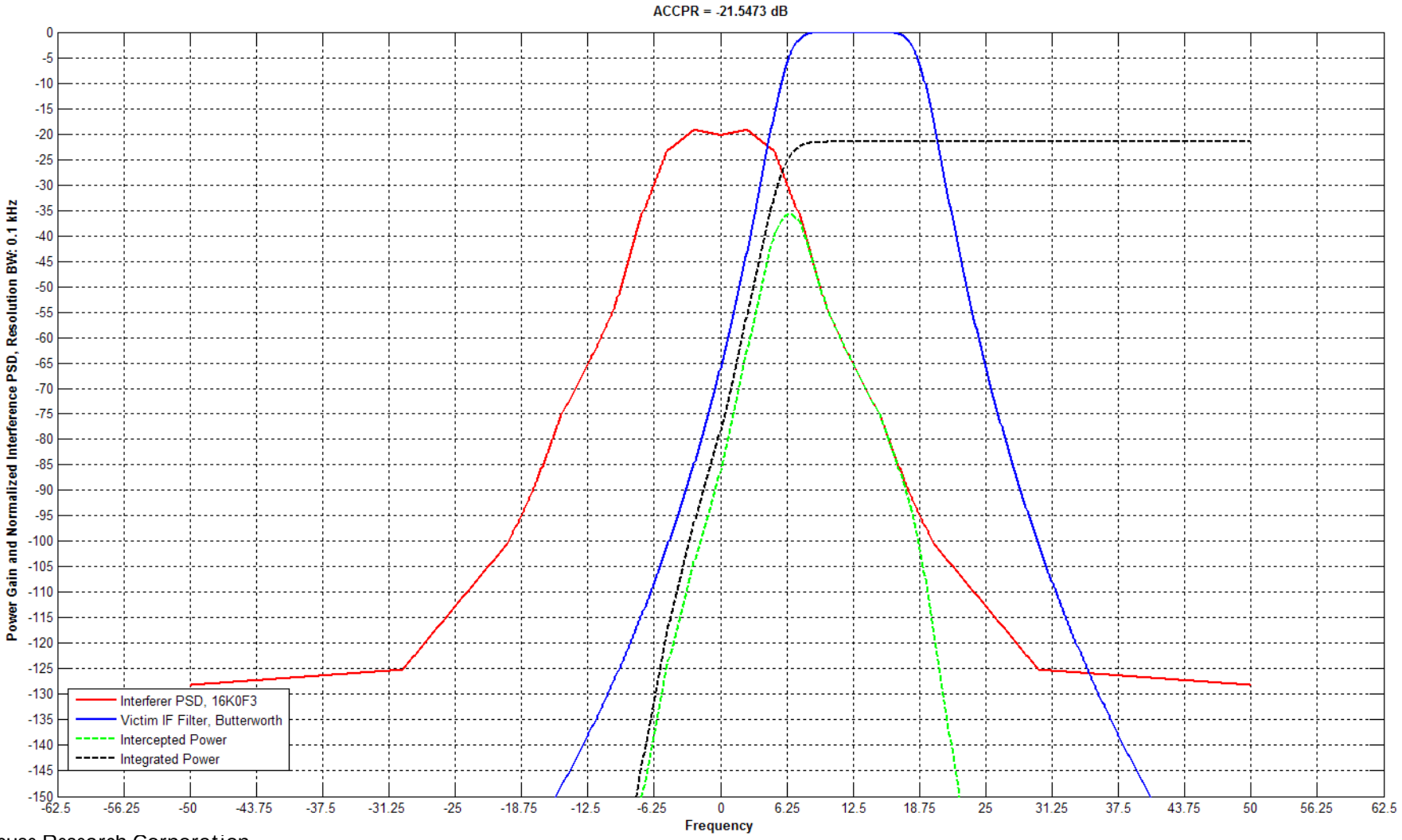
Determine Co-channel /Adj channel Allowances

- Contour Intersections are used to determine both co-channel and adjacent channel allowances.
  - Old Block contours calculated using FCC R6602 contours (can also use DHAAT tables for if desired)
    - F(50,50) at 40 dBu (service contour)
    - F(50,10) at 42 dBu (adjacent channel interference contour) *
    - F(50,10) at 22 dBu (co-channel interference contour)
  - NPSPAC contours are calculated using Okumura Suburban model
    - 40 dBu, 25 dBu, 5 dBu contours

* An adjacent channel interference contour is being used for Old Block in order to compare the Old Block to NPSPAC adjacent channel interactions. An ACCPR of 20 dB is utilized)

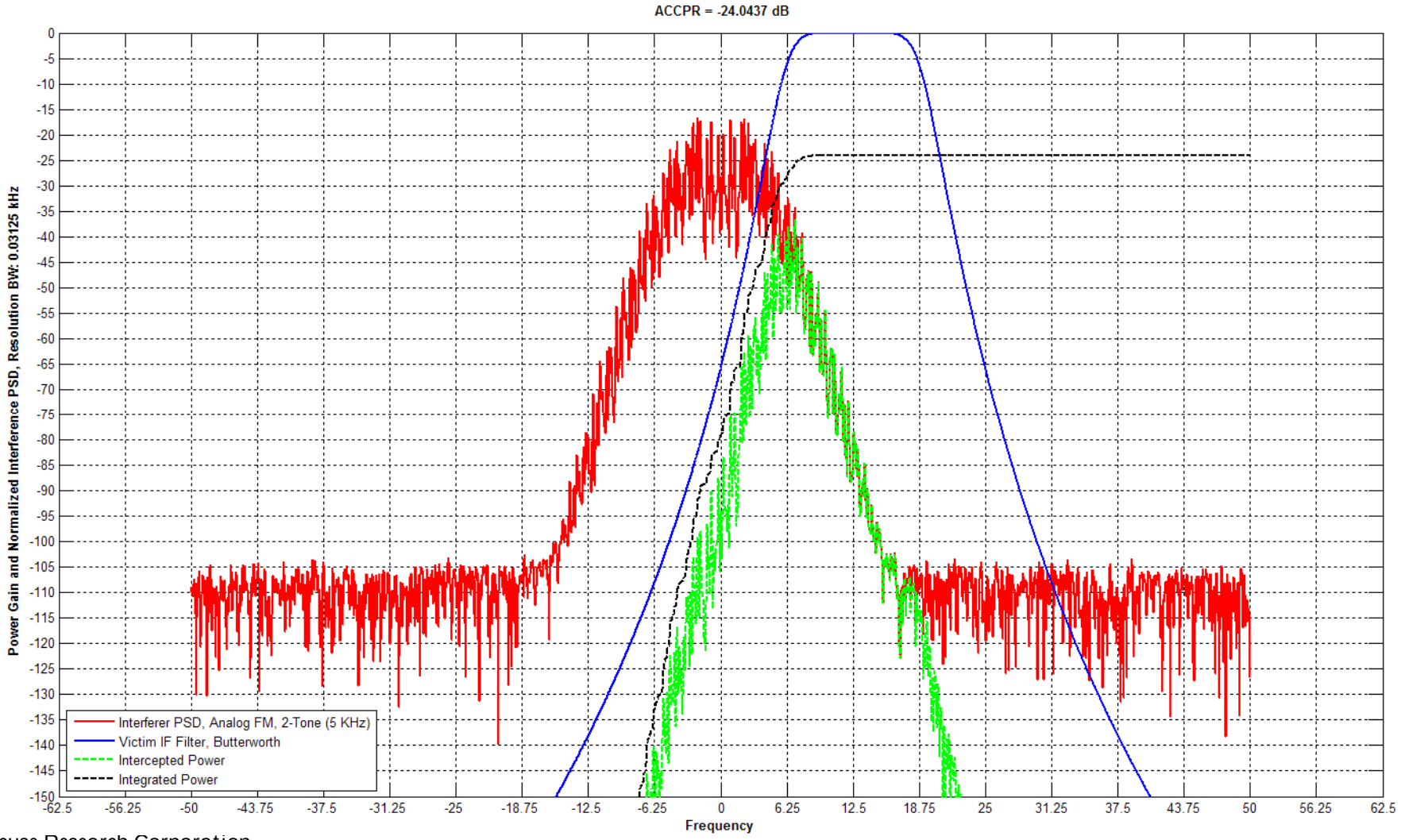
Adjacent NPSPAC/Old Block

16K0F3 to NPSPAC 12.5 kHz Offset: ~21 dB ACCPR



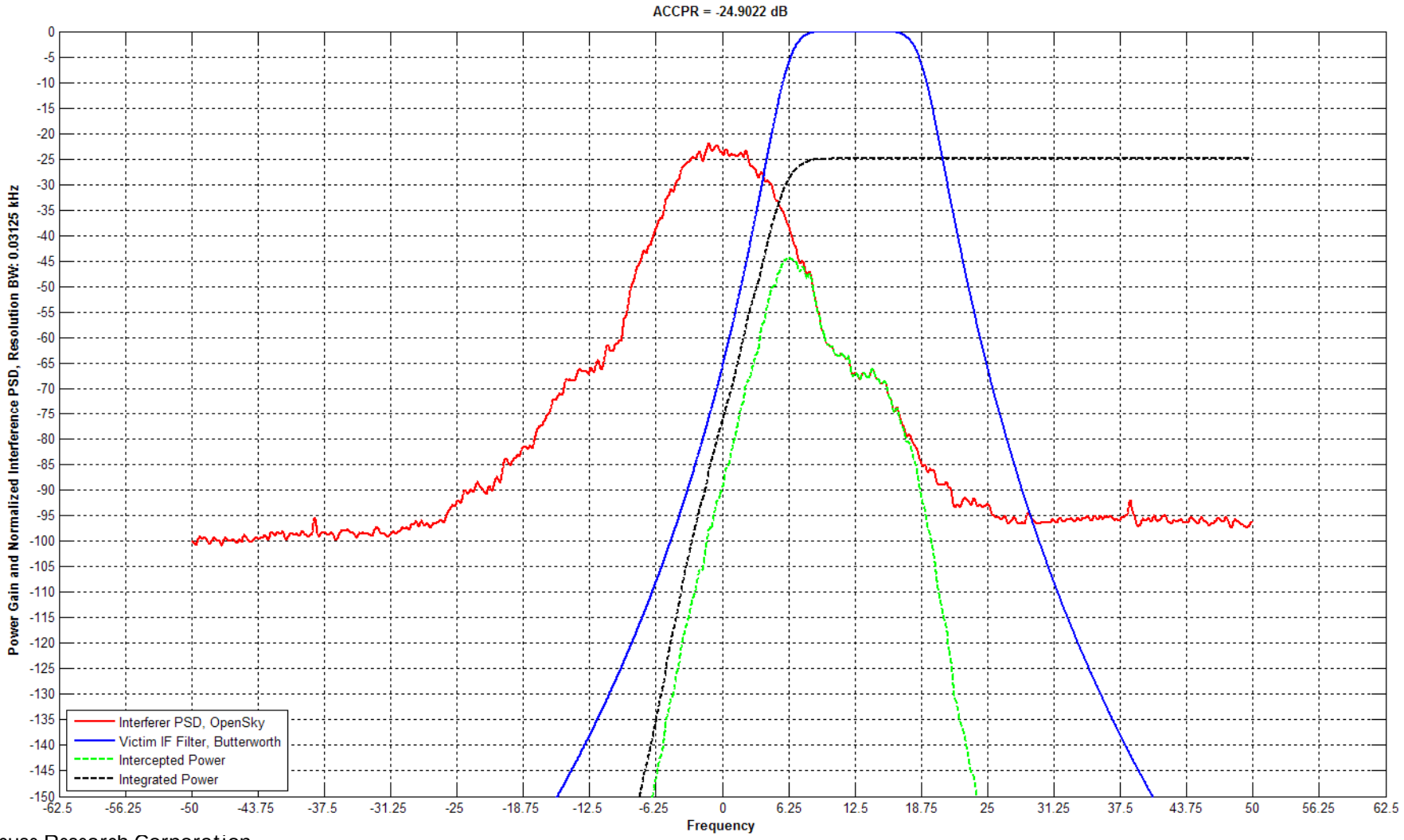
Adjacent NPSPAC/Old Block

Analog 5 kHz to NPSPAC 12.5 kHz Offset: ~24 dB ACCPR



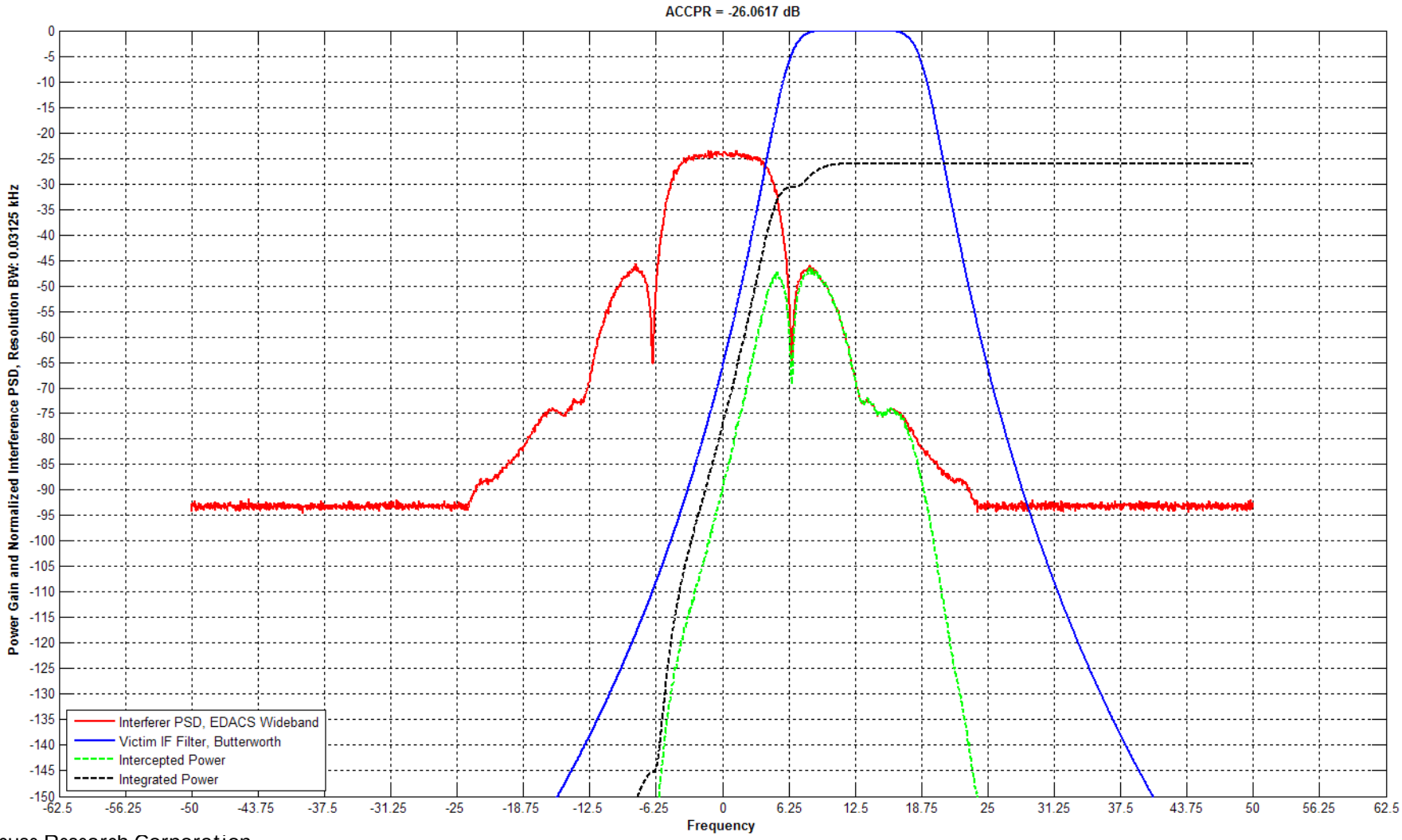
Adjacent NPSPAC/Old Block

OpenSky to NPSPAC 12.5 kHz Offset: ~25 dB ACCPR



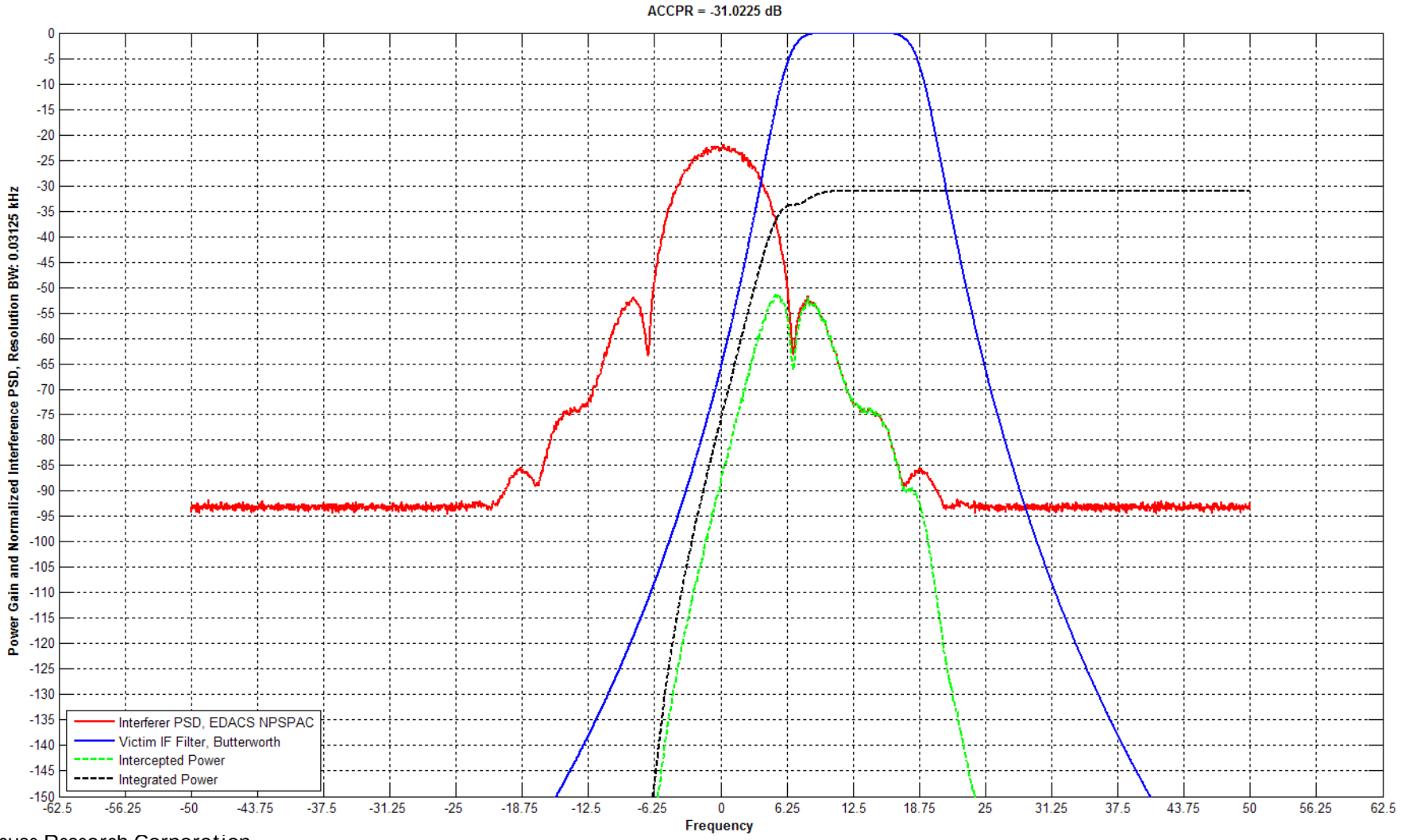
Adjacent NPSPAC/Old Block

EDACS Wideband to NPSPAC 12.5 kHz Offset: ~26 dB ACCPR

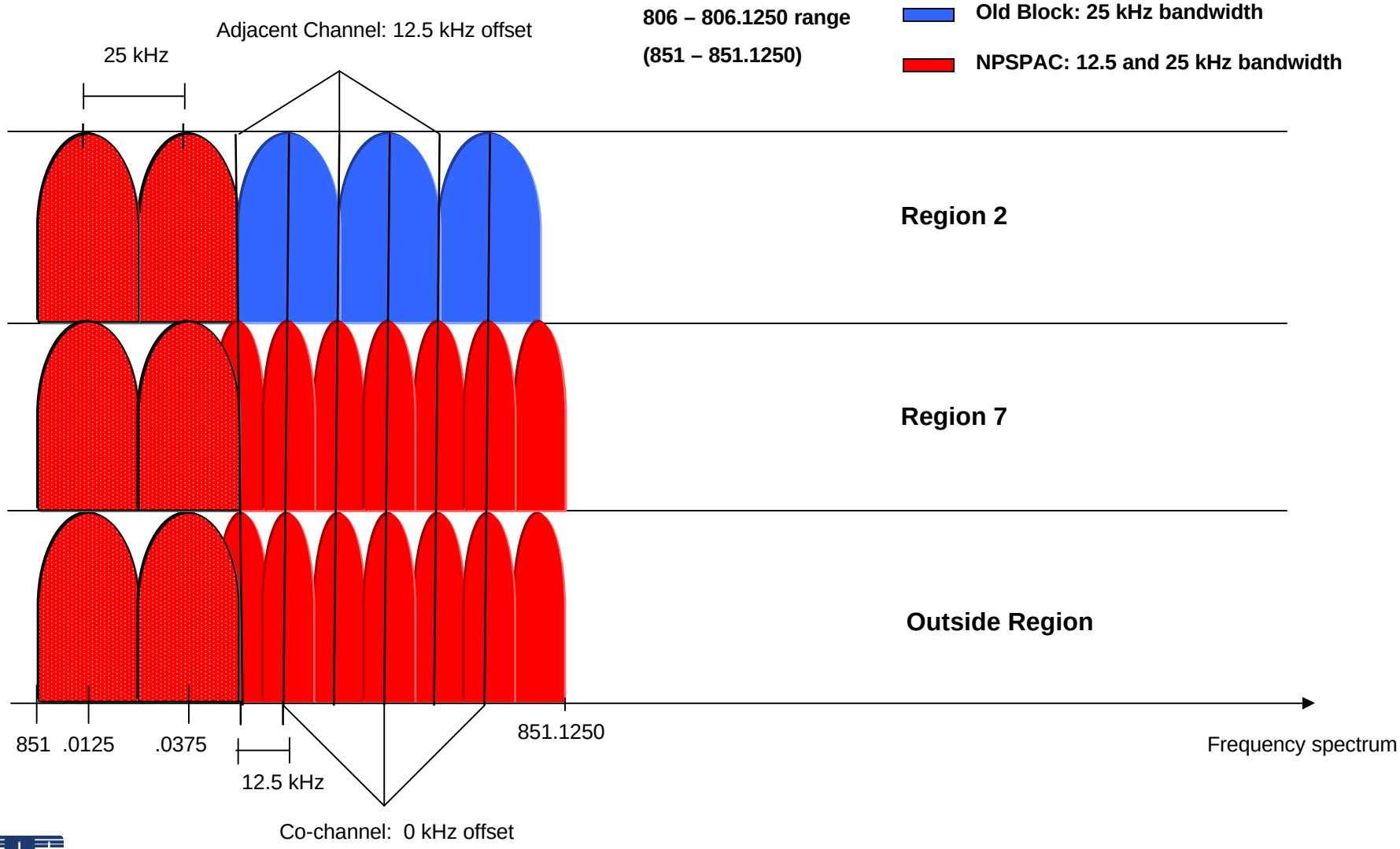


Adjacent NPSPAC/Old Block

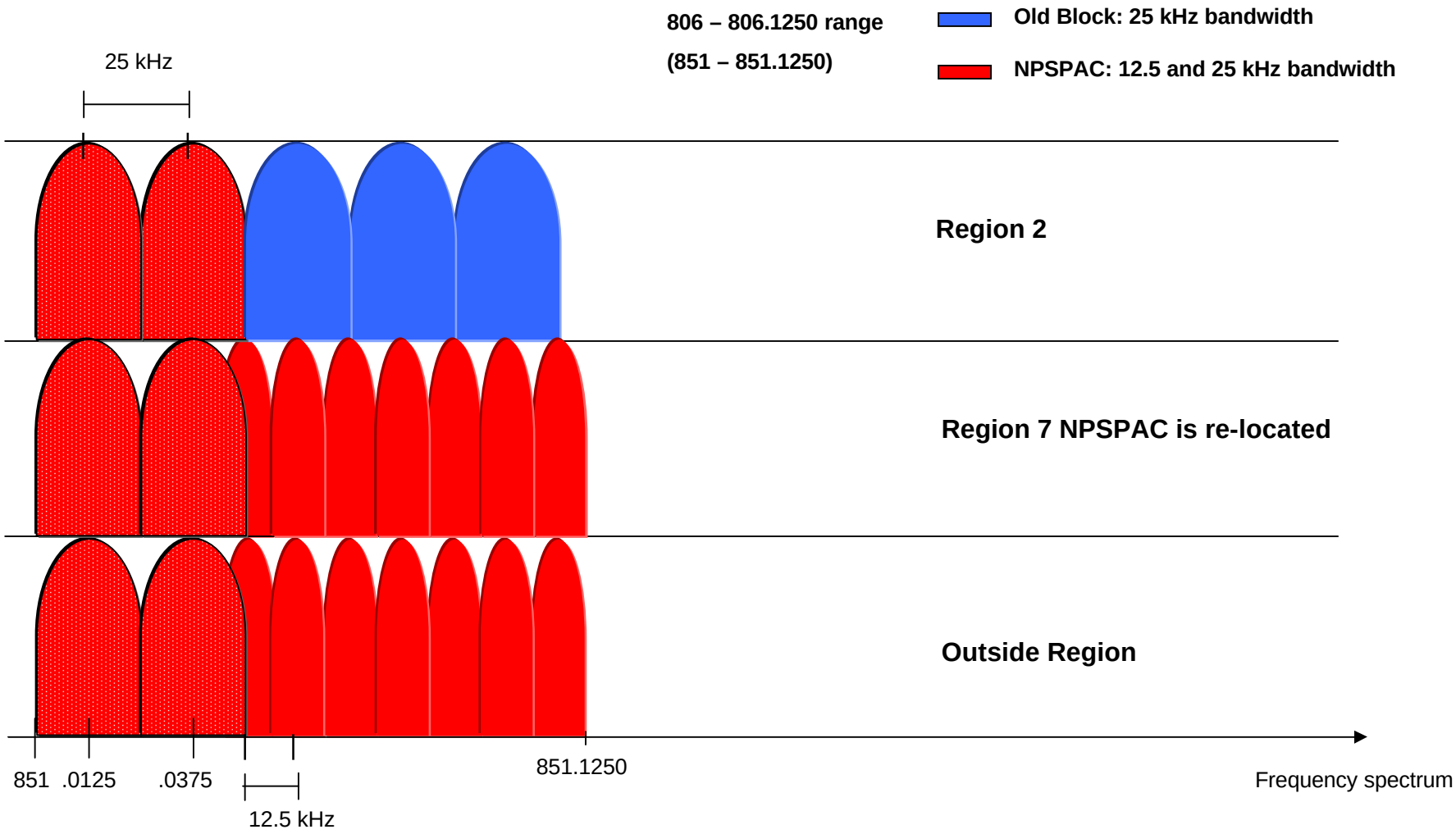
EDACS NPSPAC to NPSPAC 12.5 kHz Offset: ~31 dB ACCPR



Frequency Offsets between NPSPAC and Old Block after Re-banding



Frequency Offsets between NPSPAC and Old Block after Re-banding



Frequency Offsets between NPSPAC and Old Block after Re-banding

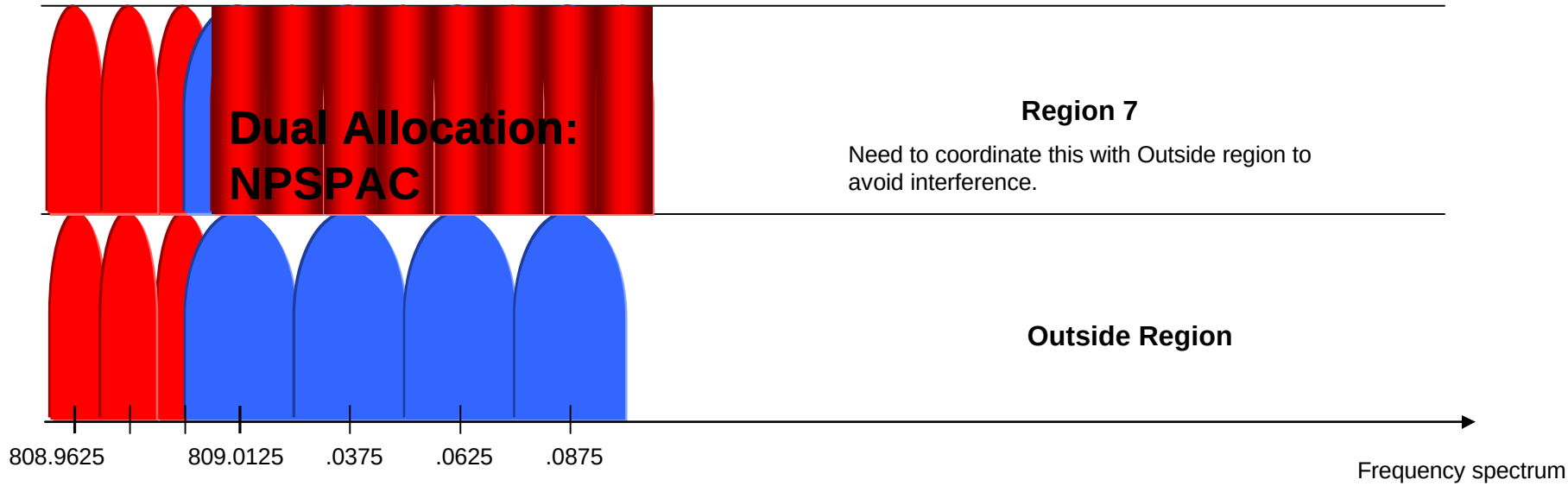
808.9625 –809.0875

(853.9625 –854.0875)

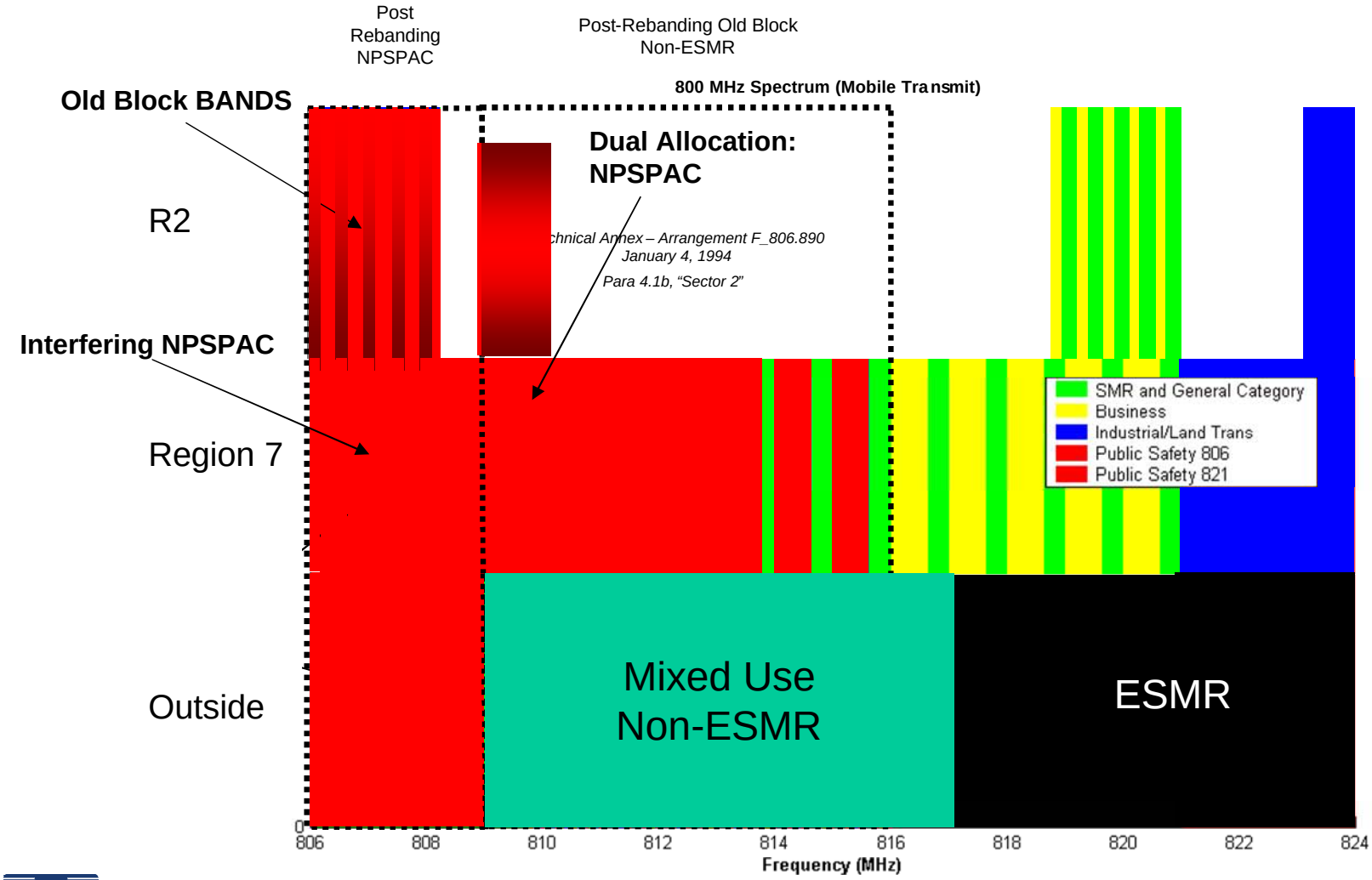
Old Block: 25 kHz bandwidth

NPSPAC: 12.5 and 25 kHz bandwidth

Region 2: No Public Safety in this range



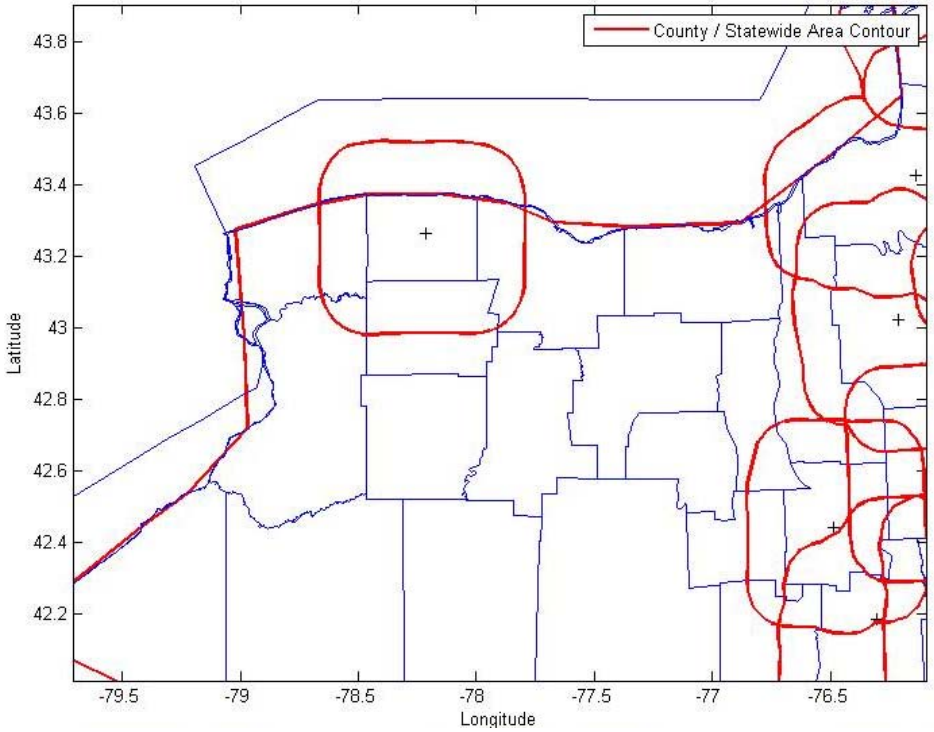
NPSPAC in Region 7 will not be co-channel to OB in region 2 (or 3)



Other cases

- Antenna heights less than 10 m are given 20 km contours
  - TSB-88.3-C doesn't define contours for this case.
  - Sites must be protected

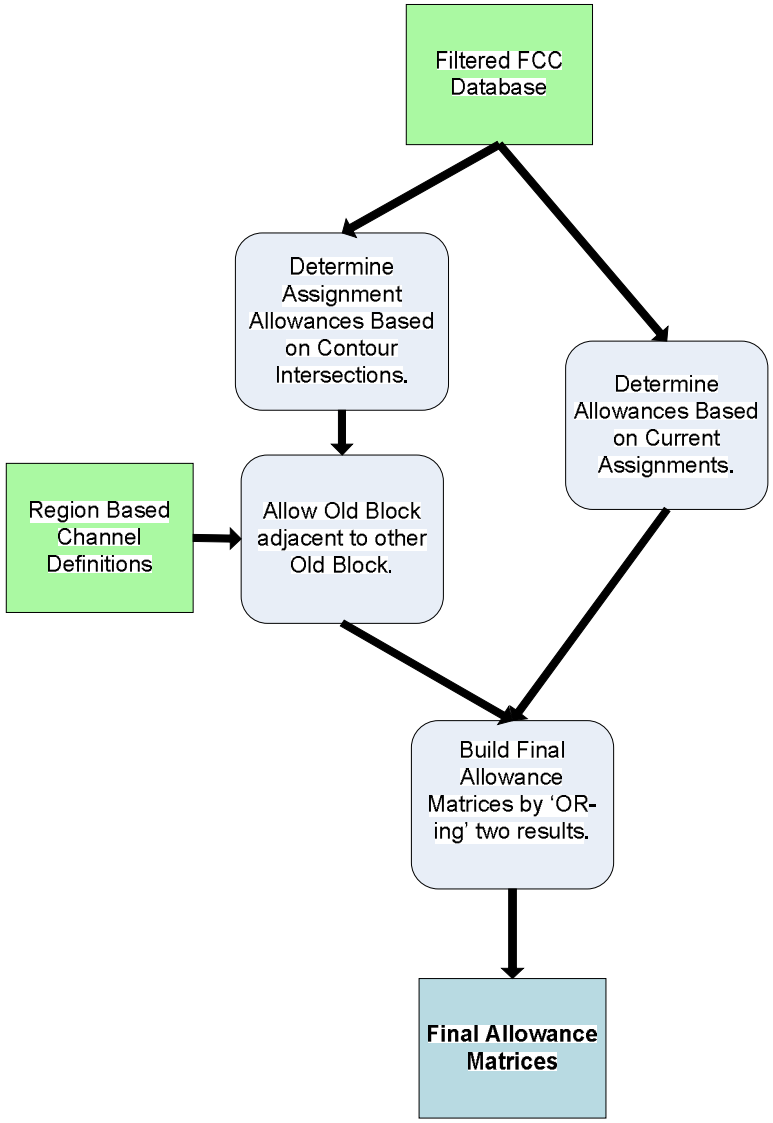
- Area wide licenses are given county/state wide contours with 5mi buffer



Build Co/Adj Channel Matrices

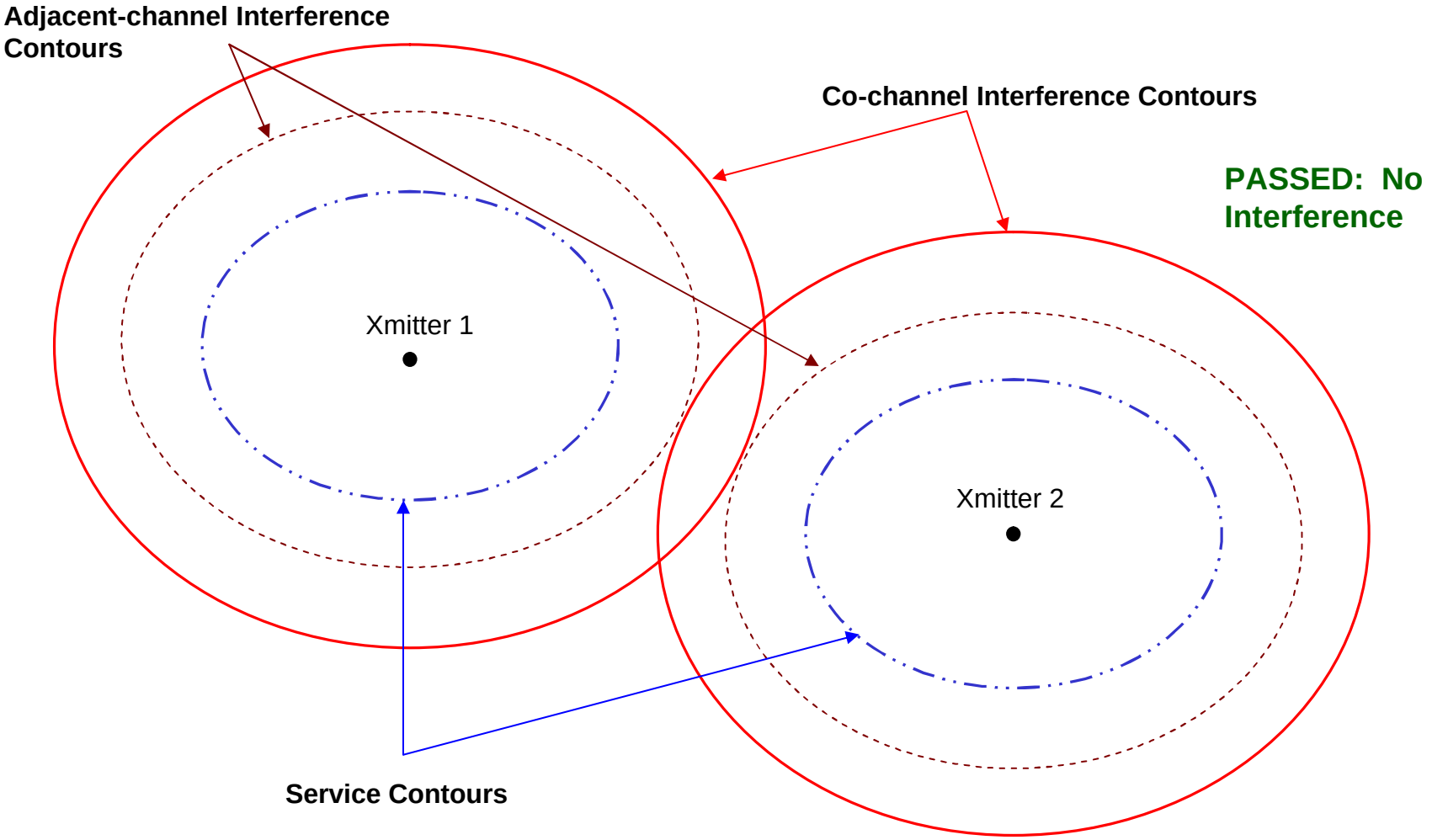
Determine Co-channel /Adj channel Allowances

1. Build compatibility matrices based on contours.
2. Build compatibility matrices based on current assignments.
3. Construct final compatibility matrices by ‘OR-ing’ these two sets.



Build Co/Adj Channel Matrices Using Contours:

No Interference



Build Co/Adj Channel Matrices Using Tile based methods

- Normally, we handle large scale problems using tile based propagation modeling and reliability degradation techniques
- A fuzzy logic variable (reliability degradation) corresponds to a channel sharing allowance between the two corresponding transmitters.
- Gives the best results, maximum capacity, and better interference prediction
- For this process, we are trying to go what with most folks are comfortable with

Co-channel Allowances

Transmitters \ Transmitters			
	0.99	0.78	0
	1	0.25	0
	0	0	0.10

Adjacent-channel Allowances

Transmitters \ Transmitters			
	0.49	0.38	0
	1	0.05	0
	0	0	0

Build Co/Adj Channel Matrices Using Contours

•In the non-fuzzy approach, a logical ‘1’ corresponds to a co or adjacent channel sharing allowance between the two corresponding transmitters (corresponding to contour intersections)

Co-channel Allowances

Transmitters

Transmitters

$$\begin{pmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Adjacent-channel Allowances

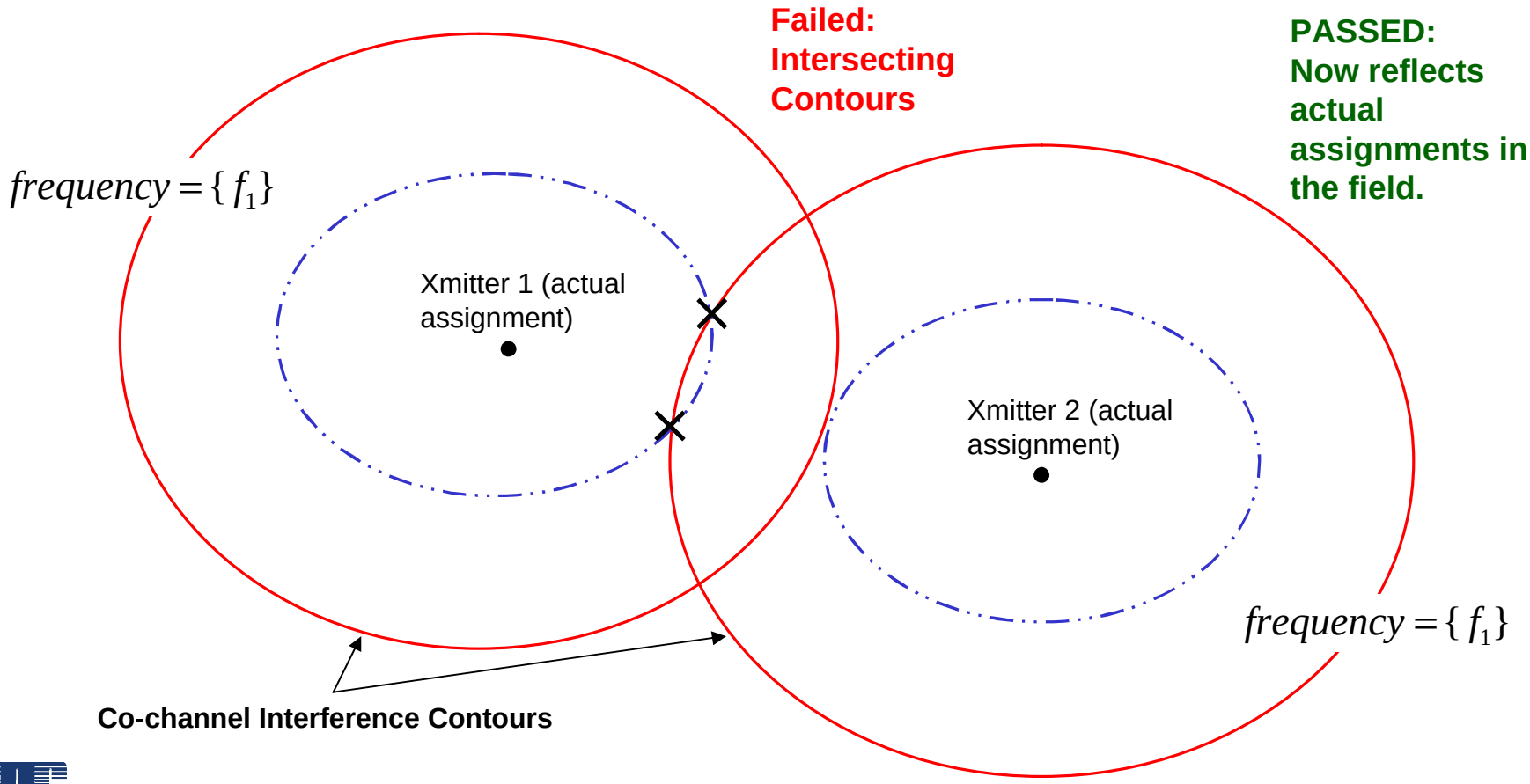
Transmitters

Transmitters

$$\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{pmatrix}$$

Build Co/Adj Channel Matrices Using Real Assignments

- Contours are deemed secondary in favor of what is actually assigned/deployed.
- Here both transmitters are co-channel in real life even if they have intersections



Determine Co / Adj Channel Allowances

EXAMPLE

- Using a logical ‘OR’ operator to combine the two results:

Co-channel: Contours

$$\begin{pmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{pmatrix}$$

Final Allowance Matrix

$$\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \end{pmatrix}$$

Transmitters

Co-channel: Field Assignments

$$\begin{pmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

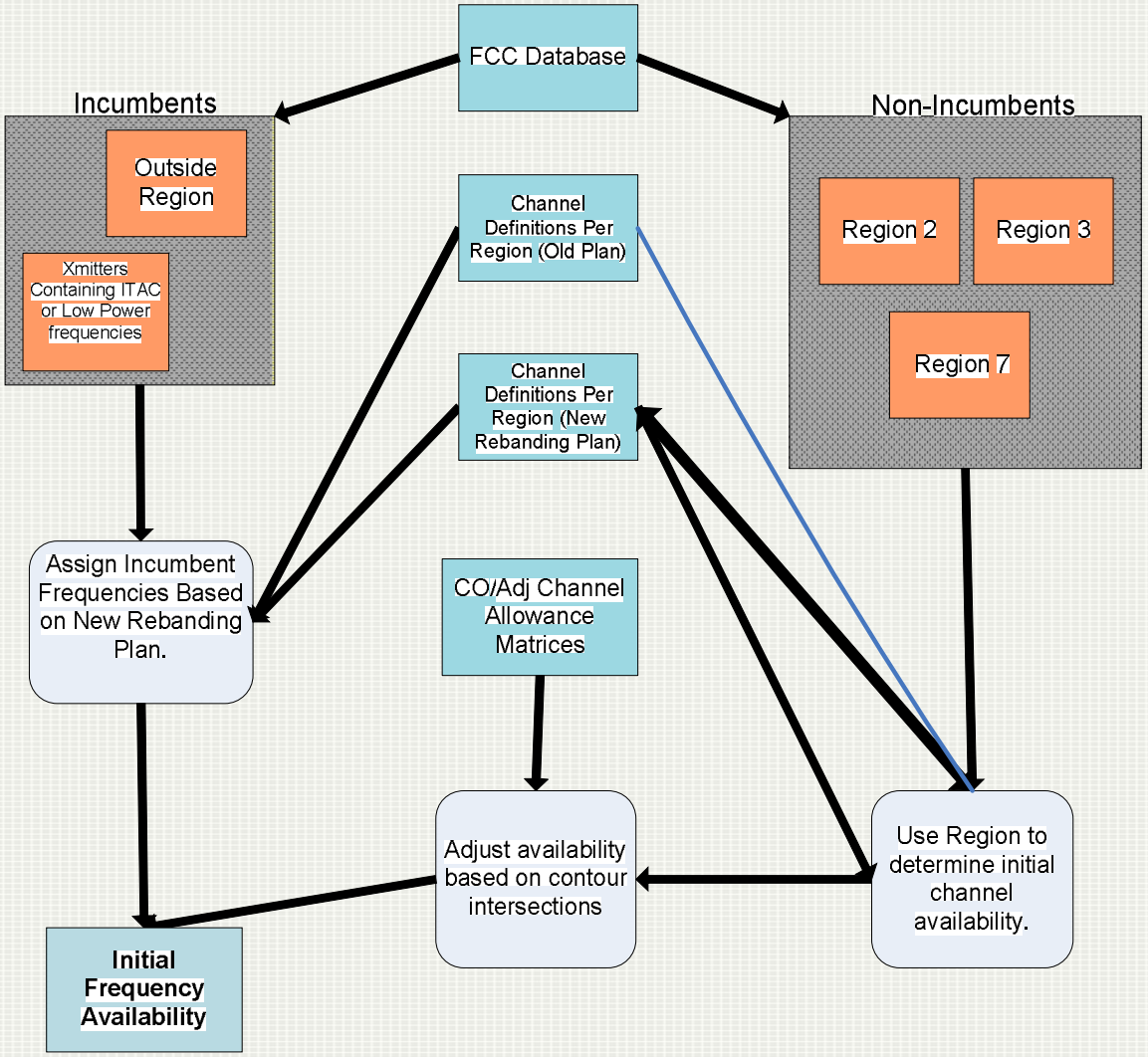
Note: There will be two final allowance matrices (one for co-channel and one for adjacent channel).

Equivalent Logical Operation:

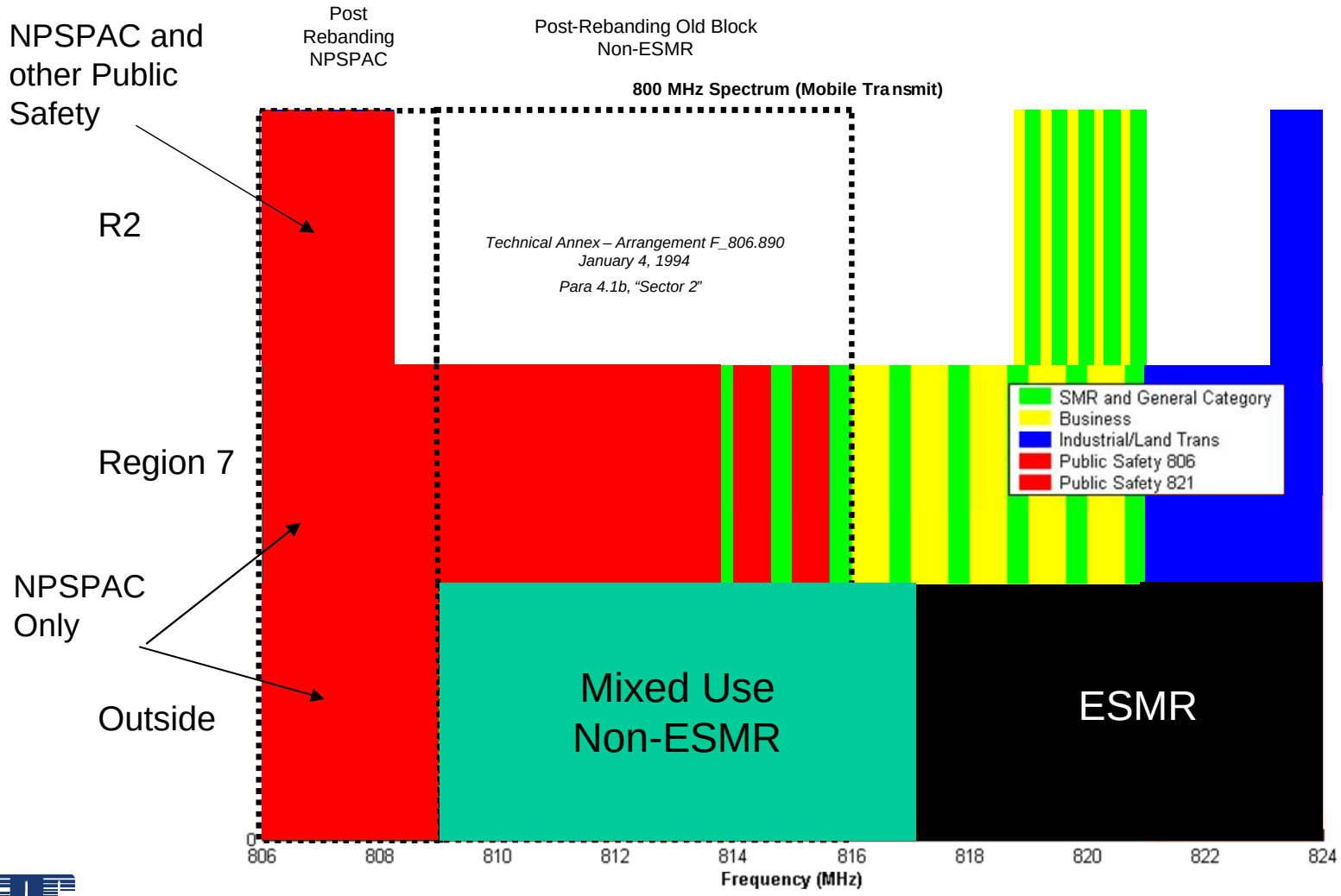
$$1 \vee 1 \equiv 1$$
$$1 \vee 0 \equiv 1$$
$$0 \vee 1 \equiv 1$$
$$0 \vee 0 \equiv 0$$

Step 4: Compatibility Determination

INITIAL FREQUENCY AVAILABILITY



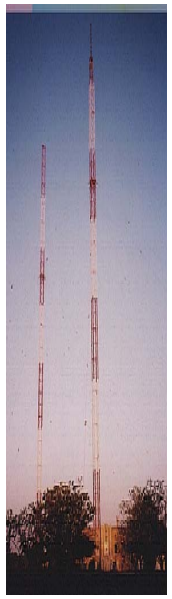
Step 4: Compatibility Determination



Step 4: Determine Initial Channel Availability for Non-incumbents

Incumbent Tower

Co-channel Interference



Border Region Tower

Incumbent

1	1	1
1	1	0
1	0	1

Non-Incumbent

Co-channel Allowances

$$Incumbent = \{ f_1 \}$$

$$Border\_\mathrm{Re}gion = \{ f_1, f_2, f_3 \}$$

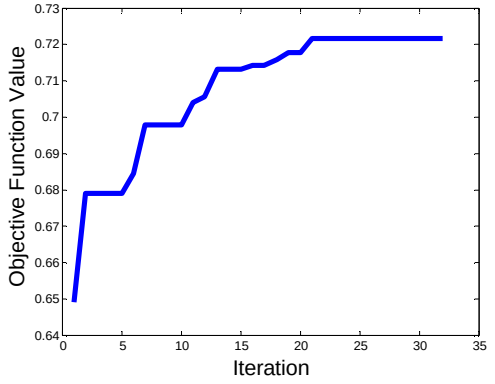
Initial pool of available frequencies for the Canadian Border Region this tower is located in.

Step 5: Genetic Algorithm

Spectrum Optimization (Genetic Algorithm)

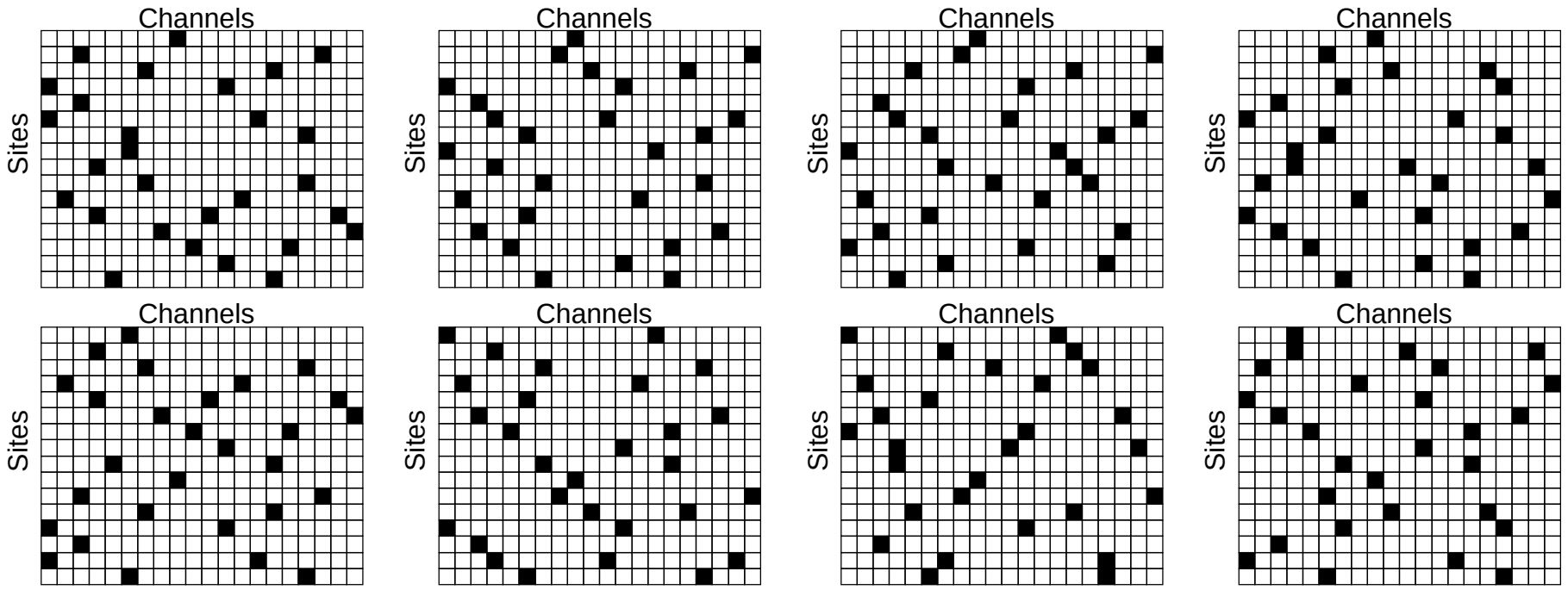
- An optimization algorithm (genetic) is used to find optimal channel assignments for the non-incumbent transmitters.

1. Need to optimally assign remaining channels and meet site capacity requirements.
2. Need to avoid co/adj channel interference with other border sites while doing so.
3. Algorithm will run until objective function levels off (optimal solution has been reached).



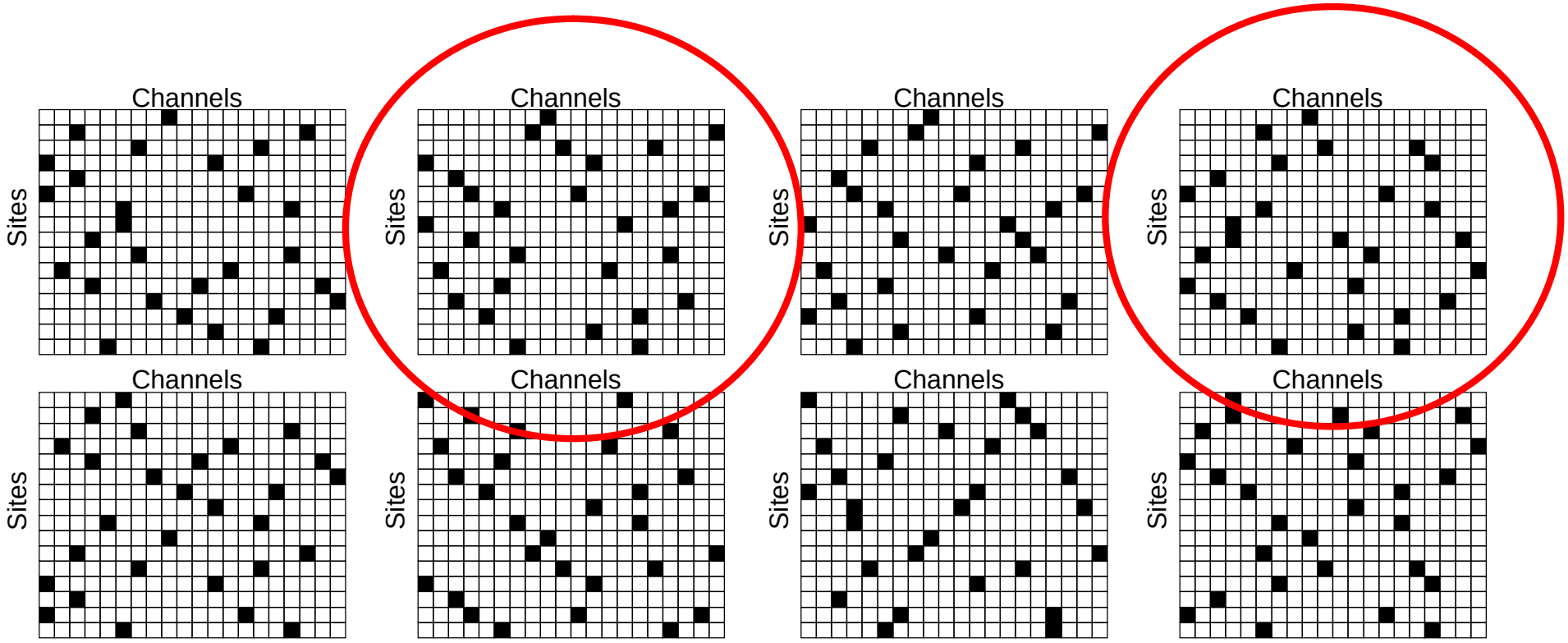
Step 5: Genetic Algorithm

Start with a number of quasi-randomly generated assignment matrices

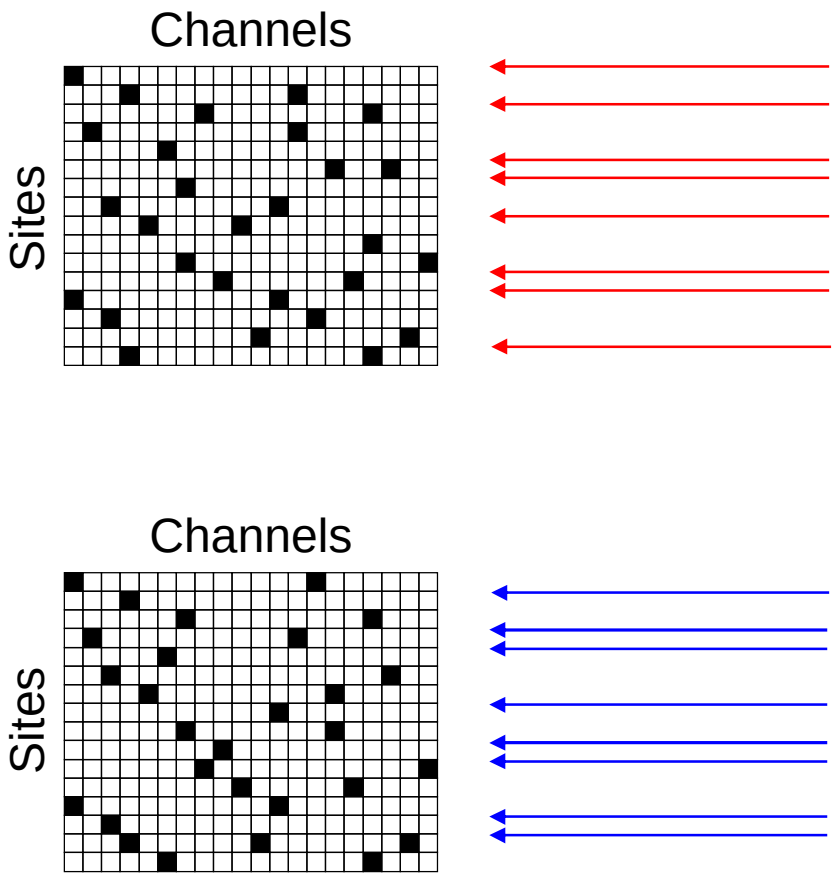


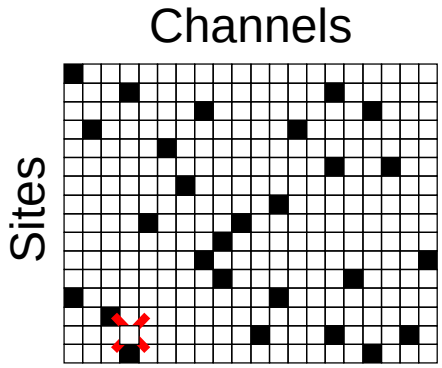
Step 5: Genetic Algorithm

Select two parent assignments (solution sets) at random



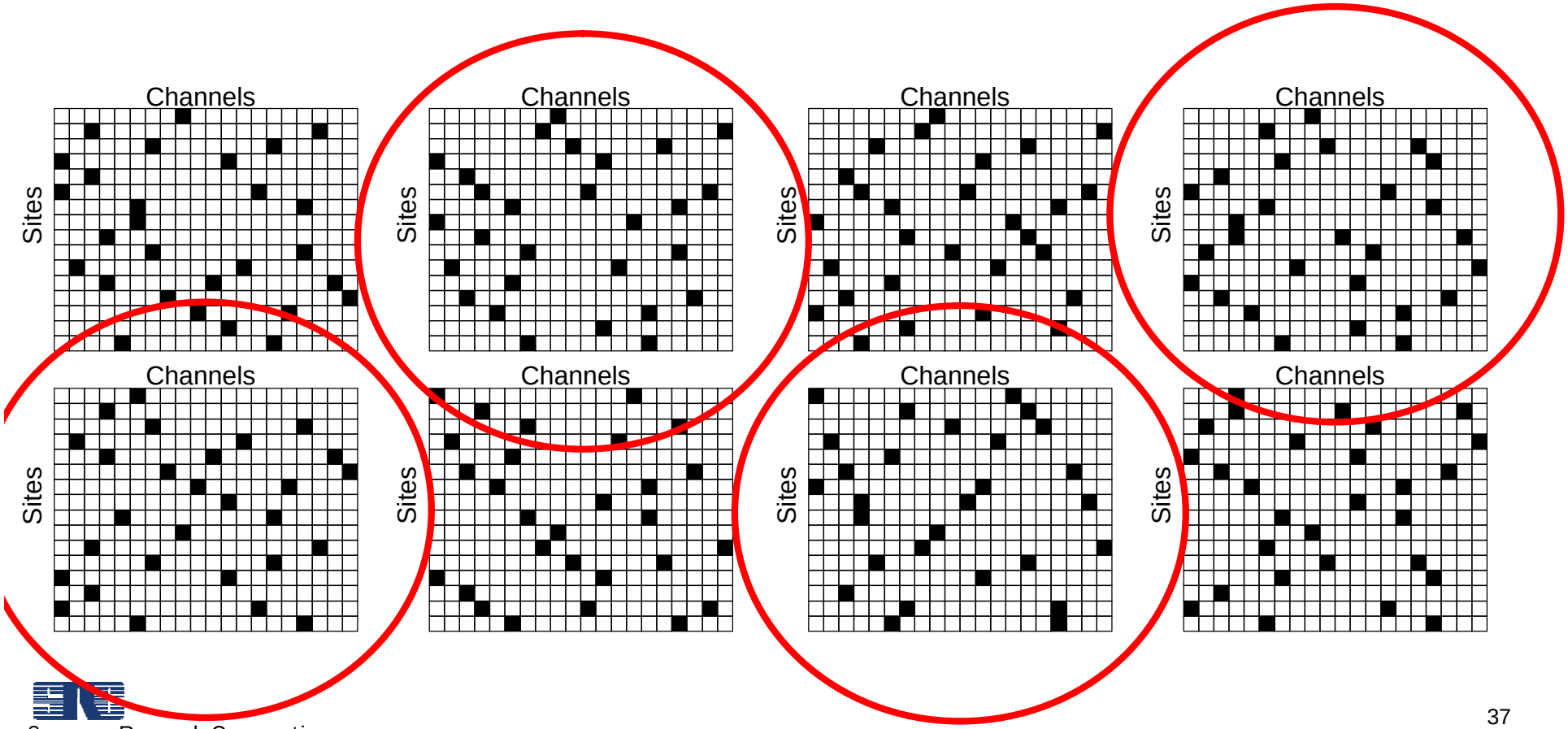
Step 5: Genetic Algorithm





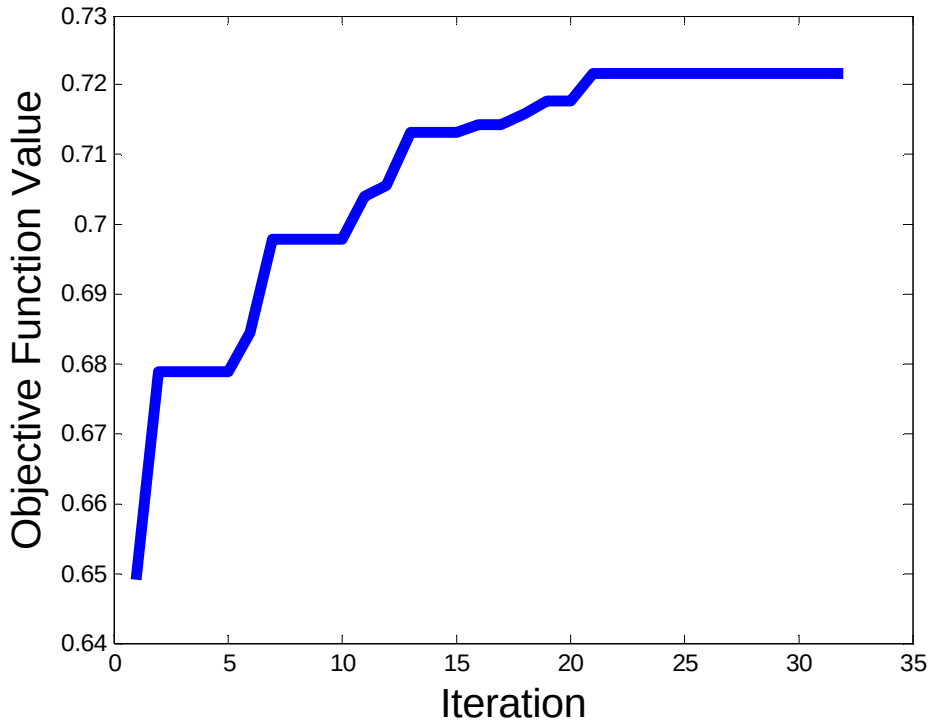
Step 5: Genetic Algorithm

Analyze the priority-weighted capacity achieved by each solution



Step 5: Genetic Algorithm

- The algorithm is run until the objective optimal assignments level off (no better assignments are possible).

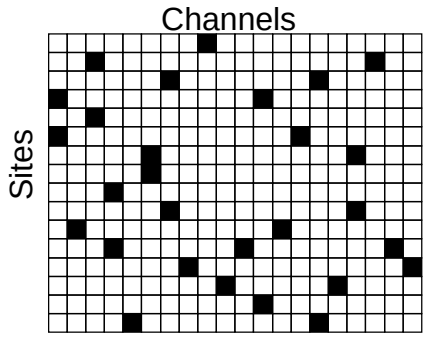


Output: Optimized Channel Assignments

Final Channel Assignment Matrix

Output from genetic algorithm represents optimal channel assignments for Canadian Border Regions.

Optimal Solution



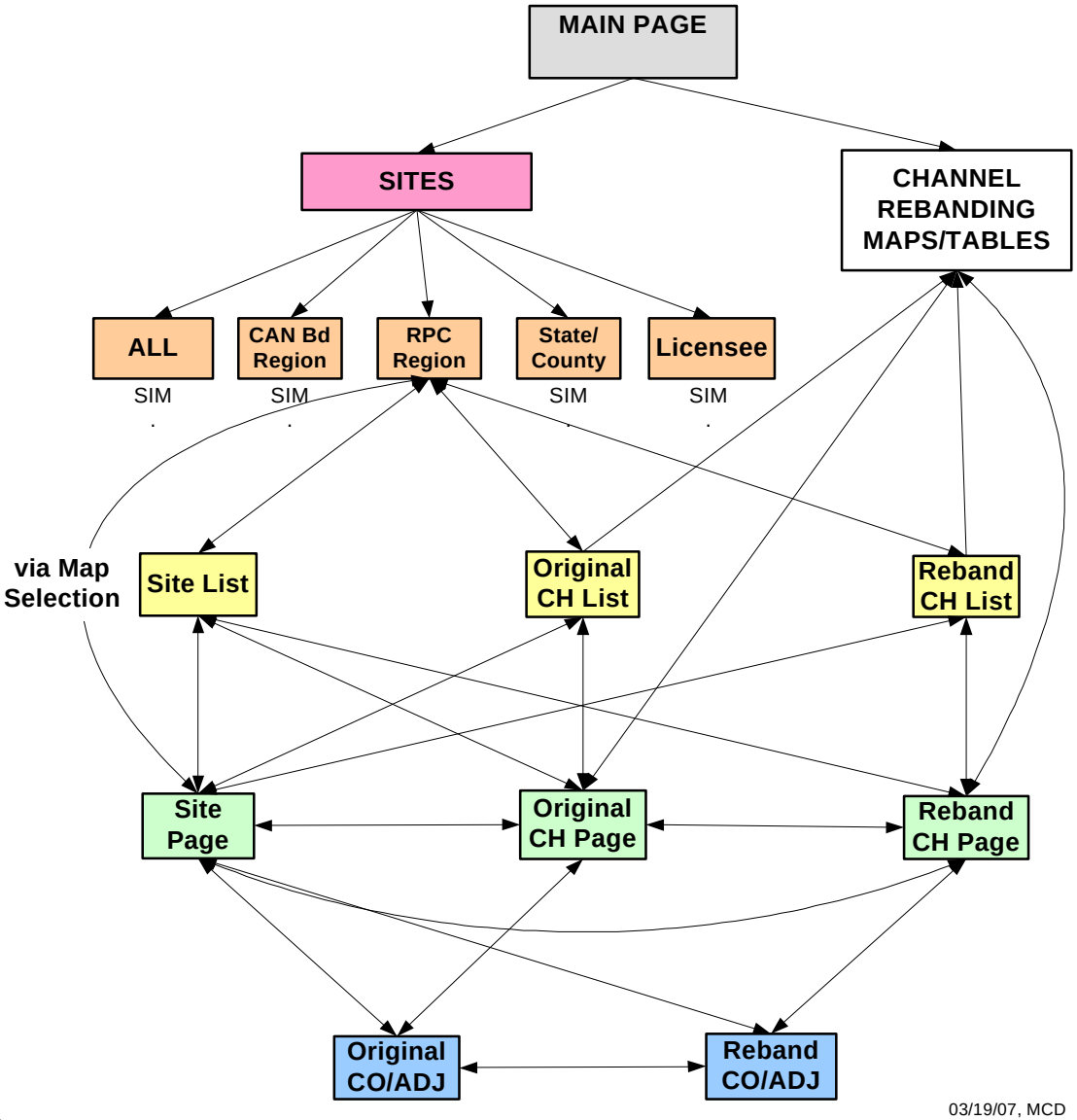
Process Summary

- Wave 4 Re-banding is being conducted in 5 steps:

1. Build a Canadian Border Transmitter Database
2. Define Post Re-banding Channel Structure
3. Determine Co-channel / Adjacent channel allowances between transmitters.
4. Determine initial channel availability for each transmitter
5. Find optimized channel assignments using genetic algorithm.

These Assignments will now need to be reviewed by the licensees and RPCs

Post Rebanding: HTML Documentation Hierarchy



HTML: Example

Before and After Information will be available for each site.

Site: CSCQ-V60

Site Parameters

Site ID	CSCQ-V60
Site Name	CSCQ-V60*
SWN Callsign(s)	WQFG703_1
Dist to Callsign(s)	0.56961 m
State	NY
Region	PRB
County	Chautauqua
Licensee	SWN PRB Itr4 (Nov2006 sites)
Status	Notional
Longitude (NAD83)	-79.44227 (79-26-32.2 W)
Latitude (NAD83)	42.10422 (42-6-15.2 N)
AMSL	499.0 m
HAAT	48.2 m
Antenna Height	24.1 m
ERP	85.1 W (49.3 dBm)
Frequency (MHz)	852.8375 (800_74)

TOWAIR Report

CO/ADJ Channel Report

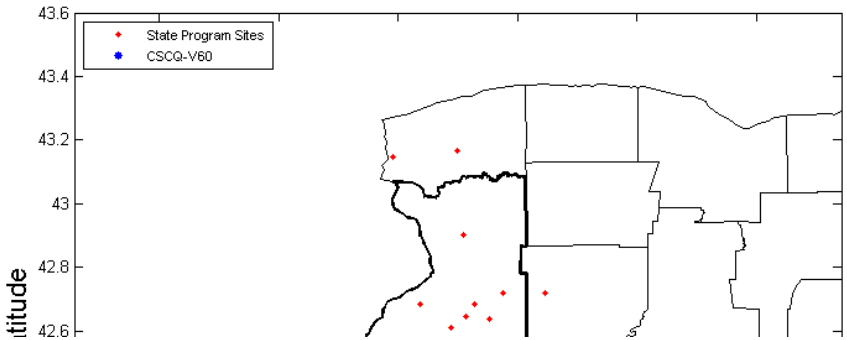
Site Propagation

Site Reliability

Site Coverage (95% Reliability)

Site MLS Area

Scroll down for more



HTML: Example

Before and After Information will be available for each site.

CO/ADJ Channel Impacts: CSCQ-V60

View Site Channel Compatabilty

Co-Channel Assignments

Site ID and Name	Location (NAD83)	Distance	Height	Freq (Chan)	ERP	Degradation to CSCQ-V60	Degradation to Co-Channel Site
PRB1013C Silver Creek T2	42-33-15.2 N 79-6-49.8 W 42.55422 N -79.11383 W	56.9 km 35.3 miles	68.6 m 225.0 feet	851.6875 (800_28) 852.8375 (800_74)	125.9W 51.0dBm	0.00%	0.00%

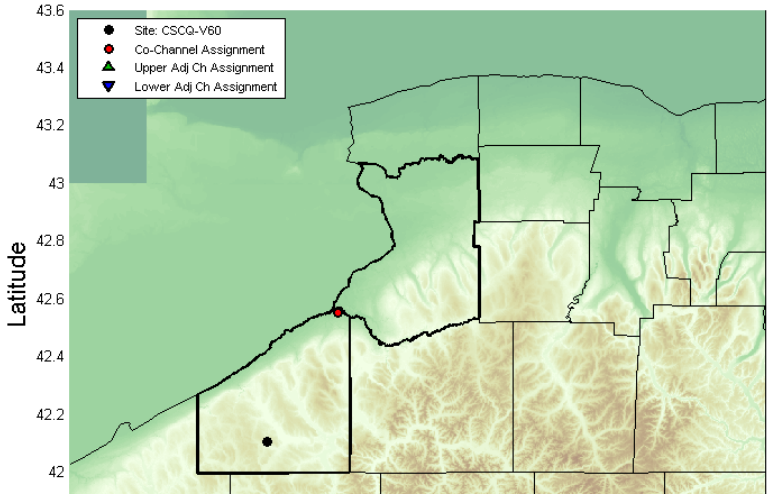
Upper Adjacent Channel Assignments

None

Lower Adjacent Channel Assignments

None

Co- and Adjacent Channel Assignments



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Some Outstanding Questions

- Area Licenses
  - How do we determine what border region area licenses belong to? This is necessary in order to determine what pool of post re-banding channels are available to an area license.
  - Public safety service code but with non-public safety frequencies in the mix.
    - Example: Callsign WNZB282
      Service Code: YF (PS Ntl Plan, 821-824 / 866-869 MHz)
      Assigned freqs = $\{856.8875, 857.8875, 858.8875, 859.8875, 860.8875\}$
      Yet these freqs are not public safety in any border region…
- Simulcast Systems
  - What is the best way to capture when a simulcast system is being used.
  - Want to keep assignments co channel than need to be co-channel