Co-existence Between Broadband Wireless and the Fixed-Satellite Service in the U.S. 3700-4200 MHz Band: A Case Study

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Purpose

- Create a framework to understand the extent to which fixed or mobile broadband wireless systems could co-exist with existing fixed-satellite service receive-only earth stations in the 3700-4200 MHz band, using a specific geographic area as a case study

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General Method

- Establish an area of interest for the study
- Determine the actual locations of FSS earth stations within a potential impact zone in and around the area of interest
- Compute point-to-point propagation loss measurements from each of the FSS sites to each of the points within the analysis area
- Use the results to quantify the maximum omnidirectional or directional EIRP at each point in the analysis grid to understand the extent to which mobile or fixed broadband systems could be deployed without causing harmful interference to any of the FSS sites

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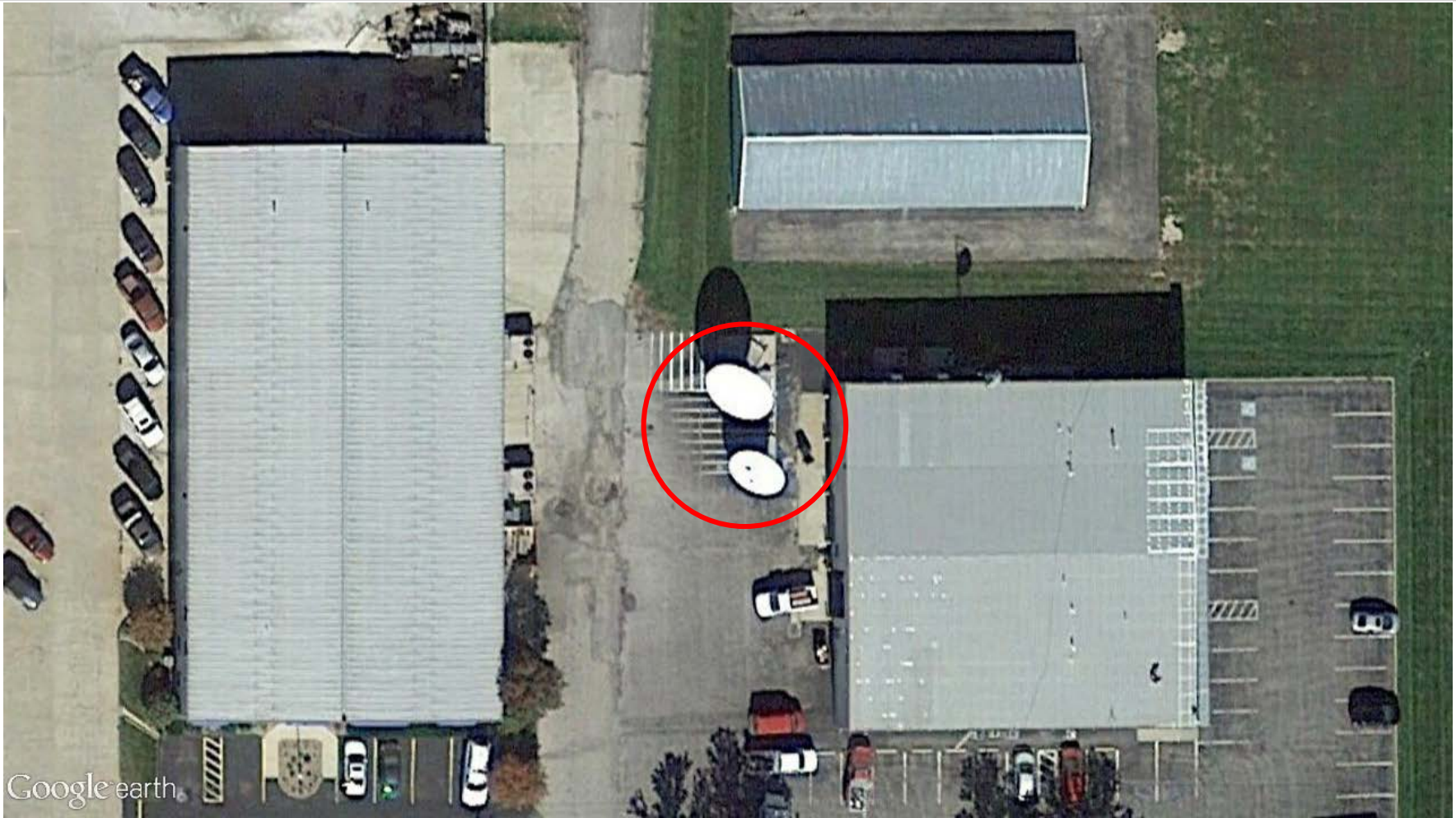
Characteristics of the Fixed-Satellite Service in 3700-4200 MHz

- The band 3700-4200 MHz is allocated to the fixed-satellite service (FSS) for space-to-Earth (downlink) transmissions
- FSS earth stations receive satellite transmissions in this band
  - All earth stations in this band are receive-only
  - Satellites with downlinks in this band are geostationary, so the earth station dishes remain pointed toward a specific direction in the sky when receiving
- A typical earth station site consists of one or more dishes, 3-10 m in diameter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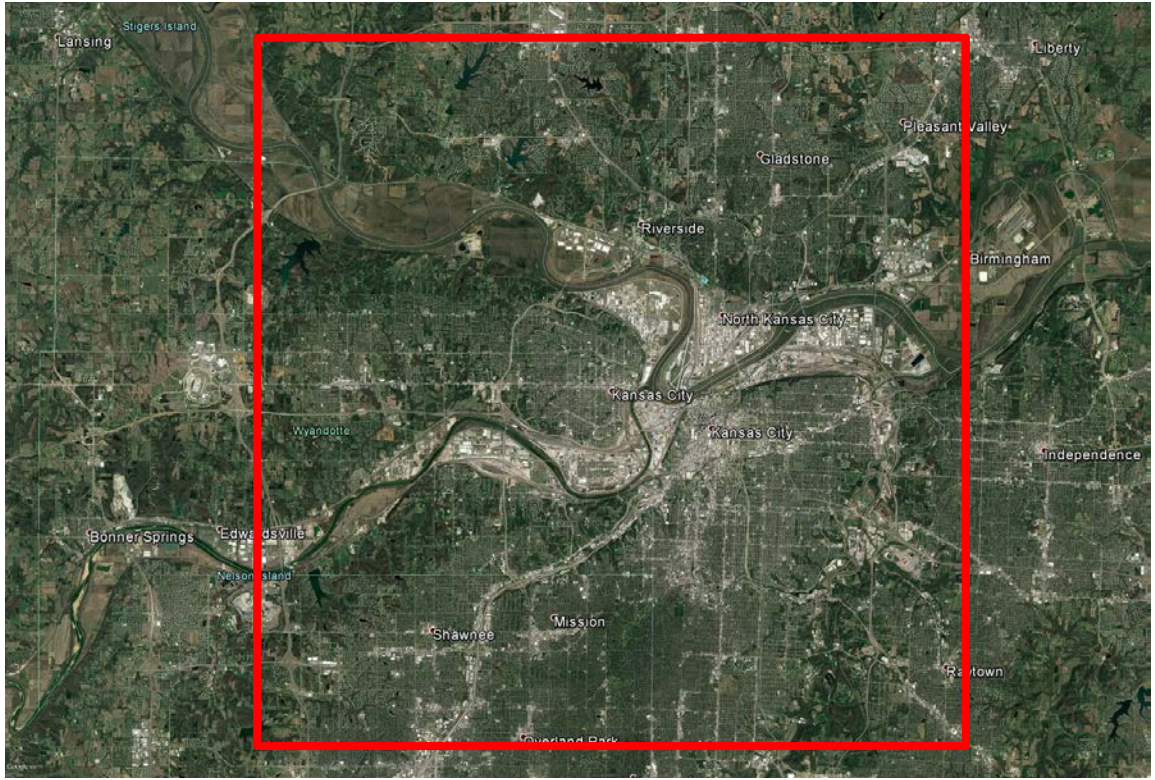
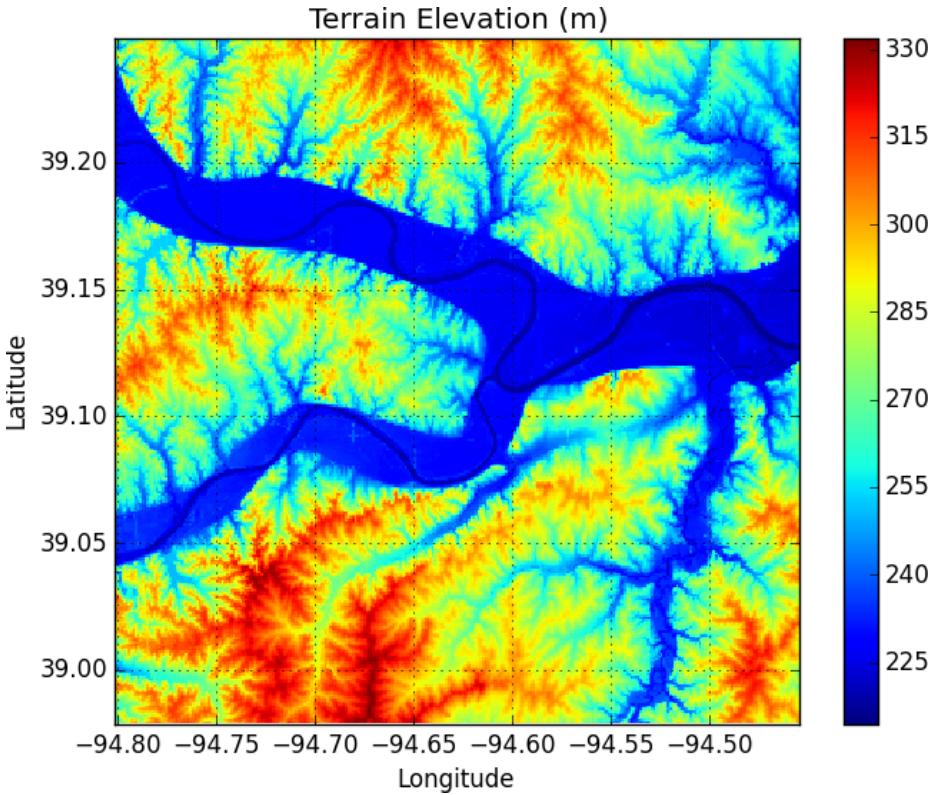
Analysis Area

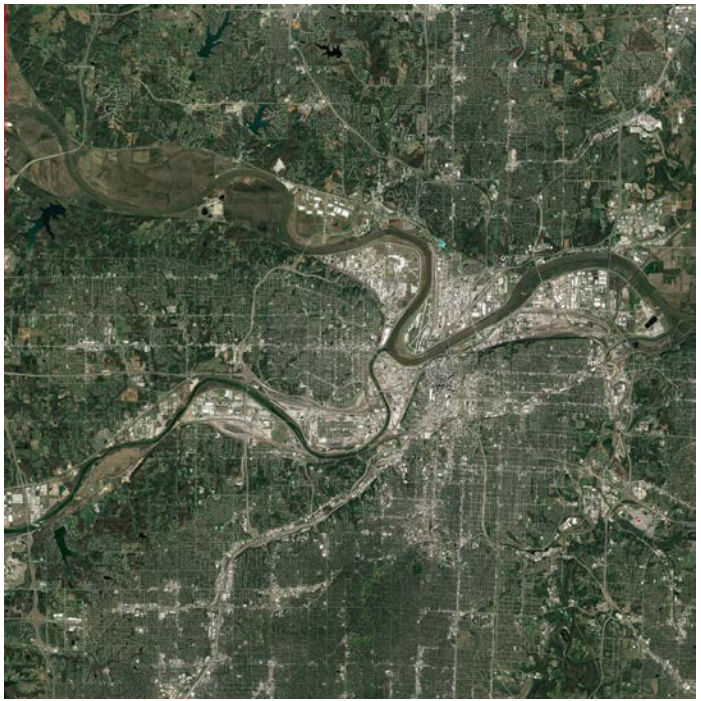
Kansas City, KS

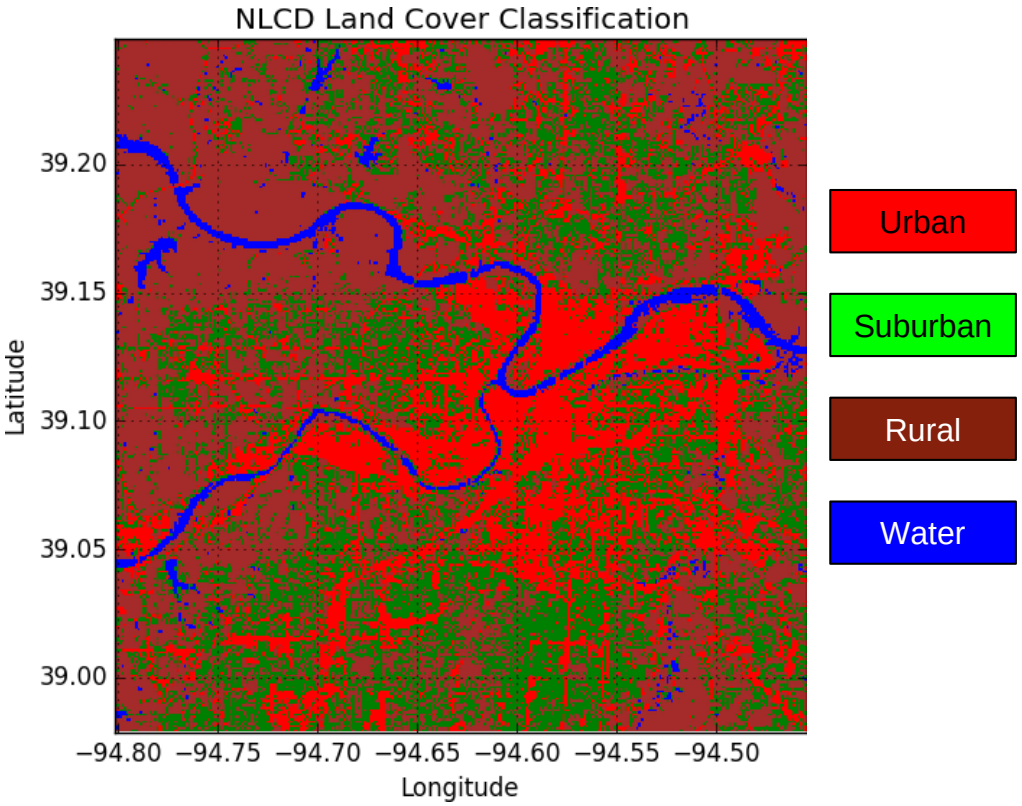
- 30 km x 30 km square
- Centered on N 39.114053, W 94.627467
- Coordinate extent:
  38.978854 - 39.249252 N
  94.454375 - 94.801717 W
- Analysis conducted on a grid of points spaced approximately 100 m apart
  - 301 N/S x 301 E/W
  - 90,300 points





Aerial Image





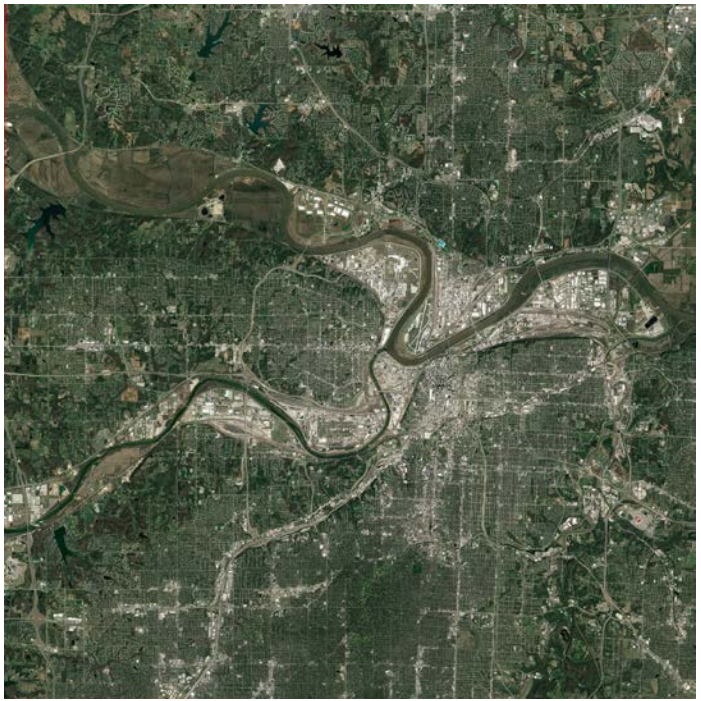
Urban

Suburban

Rural

Water

Aerial Image



Step 1: Query all FSS Sites within 150 km of Analysis Area

- Extract all current 3700-4200 MHz FSS earth station licenses from the FCC's International Bureau Filing System (IBFS) database
  - 150 km is the maximum interference coordination distance established for co-channel operation with FSS in FCC rules for adjacent band
    - Part 96 for 3550-3700 MHz Citizens Broadband Radio Service [47 CFR 96.17(a)(2)]
    - Part 90 for Wireless Broadband Services in 3650-3700 MHz [47 CFR 90.1331(a)]

Step 2: Validate and Correct the IBFS Data

- The IBFS data are sometimes inaccurate or outdated
- For each site extracted from IBFS, Google Earth, Google Earth historical imagery, and Google Street View were used to verify or correct the IBFS data
  - If dishes could be found at or near the listed coordinates, the coordinates were corrected to reflect the actual current location of the earth station if necessary. Such sites were considered “existent.” The actual operating status of the site could not be confirmed.
  - If no dishes could be found within approximately 1 mile of the listed coordinates, the historical imagery feature was used to ascertain if the dishes had existed in the past but have since been removed. These sites were considered “removed.”
  - If no dishes were found in current or historical imagery, the sites were considered “nonexistent.”
  - The apparent height of the dish above ground level was ascertained using Google Street View, and the height listed in the license record was corrected as necessary to reflect the actual height.
- Some records in IBFS are geographically coincident with other registered sites (i.e., different call signs, same coordinates). These instances were treated as one site.

Site Statistics based on a Scrub of the IBFS Data

Category	Number	Fraction of Total
Existent	40	74%
Removed (9) or Nonexistent (5)	14	26%
TOTAL IBFS SITES	**54**	**100%**

After scrubbing the IBFS data, the 40 existent FSS sites were used in the analysis.

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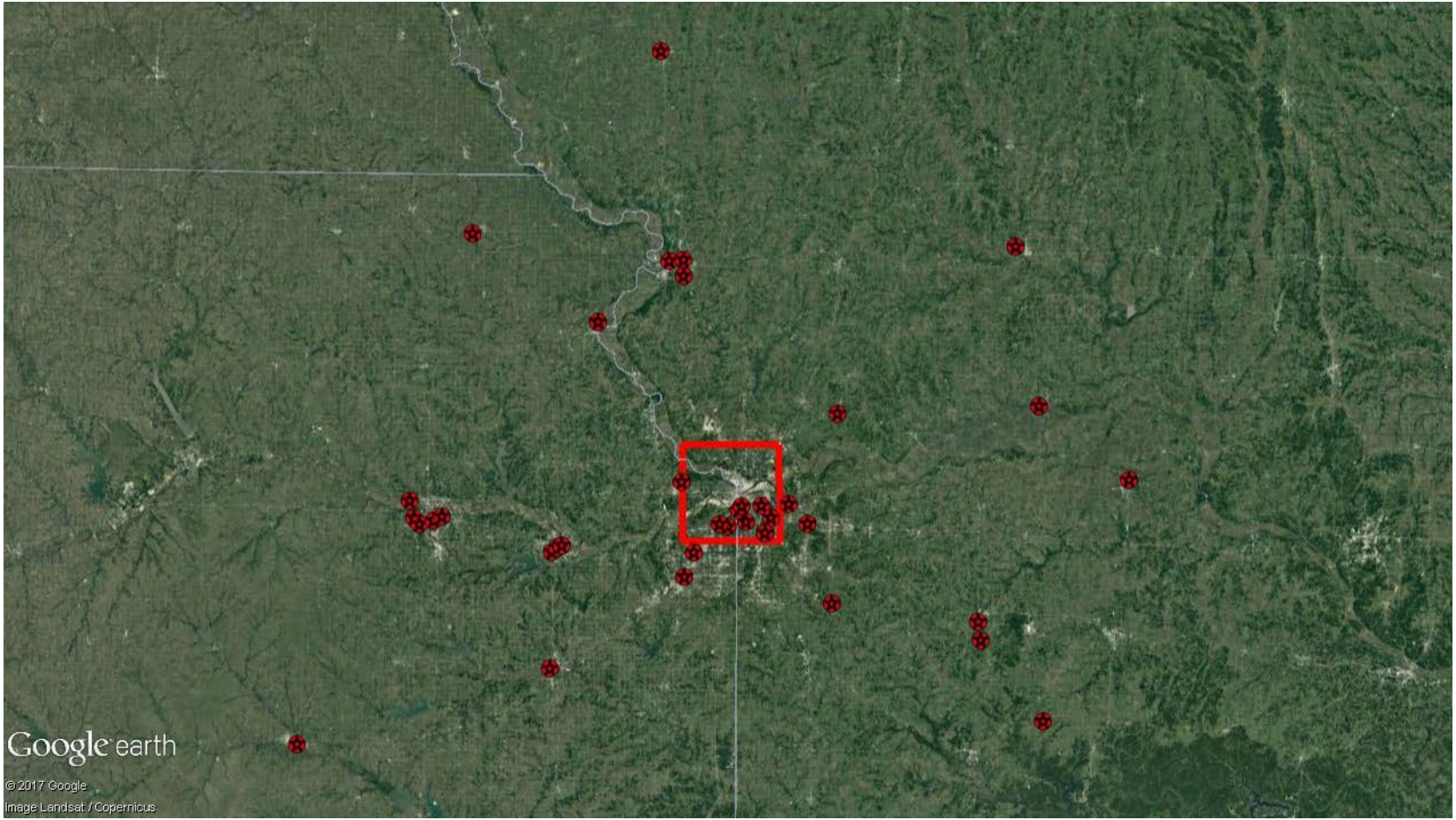
Position Errors (Actual FSS Location compared to IBFS Coordinates)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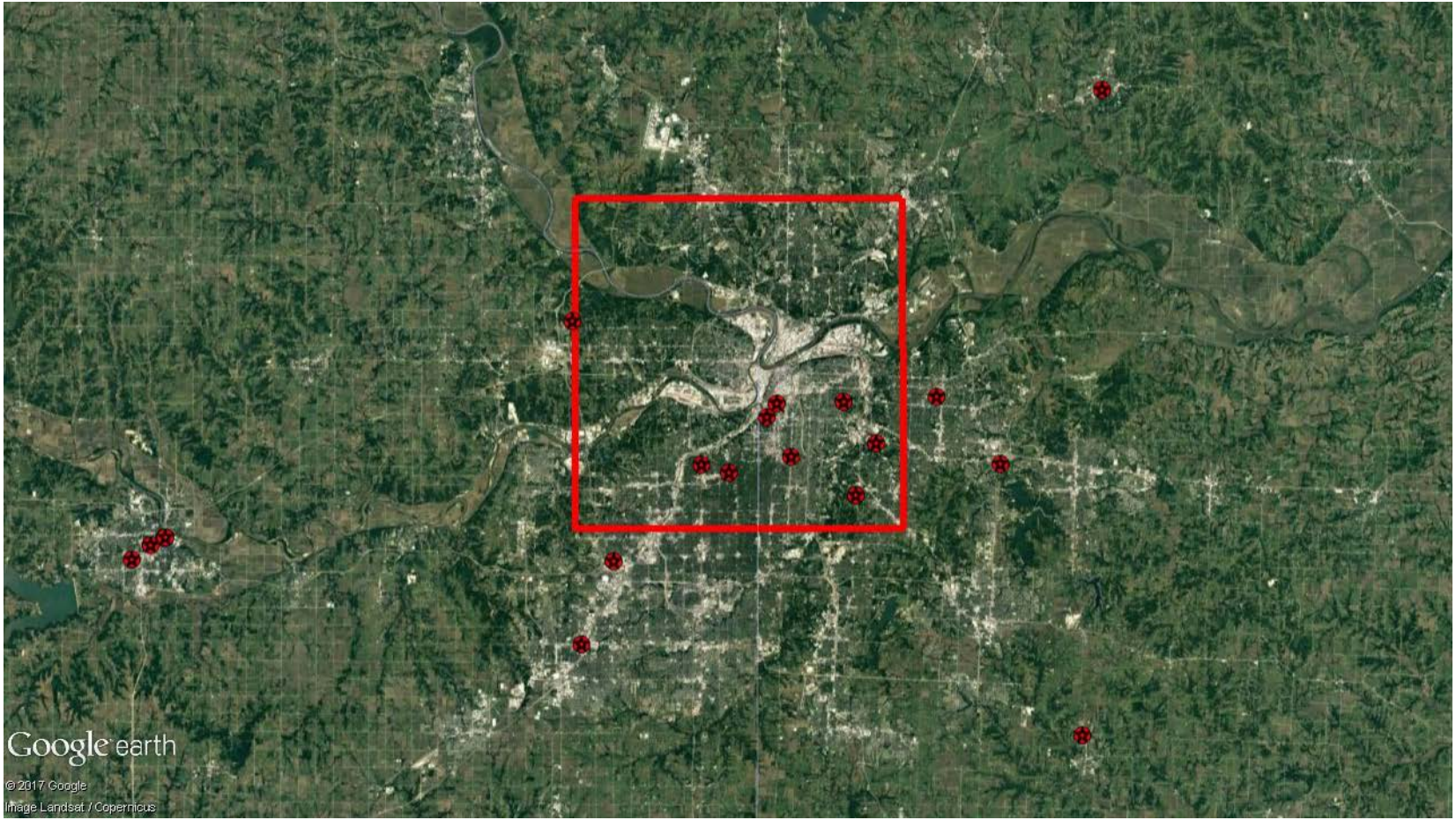
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FSS Sites Used in Analysis, with Validated/Corrected Coordinates

Call	Lat	Lon	Call	Lat	Lon	Call	Lat	Lon	Call	Lat	Lon
E000028	38.8101	-94.2646	E040298	40.3535	-94.8824	E150063	38.4743	-93.5083	E940178	38.7039	-93.7299
E000405	39.0719	-94.5975	E050031	39.0273	-95.7484	E170001	39.0077	-94.5036	E940245	38.9653	-95.2501
E020099	39.5958	-95.1074	E050211	39.0328	-94.6667	E170069	39.0842	-94.5162	E9470	39.0831	-94.5870
E020149	39.0442	-95.7680	E070103	38.9717	-95.2344	E2076	39.1458	-93.1872	E960124	39.0883	-94.4179
E020333	39.1504	-94.8035	E070155	39.7700	-94.7978	E5122	39.0496	-95.6672	E970151	39.0330	-94.3505
E030201	39.0392	-94.5720	E090042	39.0263	-94.6377	E5240	38.9716	-95.2352	E970337	38.8855	-94.7935
E030261	38.7558	-93.7388	E100155	39.0926	-95.7849	E5309	39.7662	-94.8499	KF41	39.0377	-95.6972
E040003	39.0503	-94.4819	E110027	38.9536	-94.7595	E6099	38.4045	-96.1817	KQ48	38.6279	-95.2748
E040017	39.0077	-94.5036	E130172	39.7247	-94.7973	E6494	38.9716	-95.2352	KQ95	39.8025	-93.5878
E040259	38.9534	-95.2699	E150020	39.8401	-95.5664	E930412	39.3397	-94.2407	KT41	39.3558	-93.5100

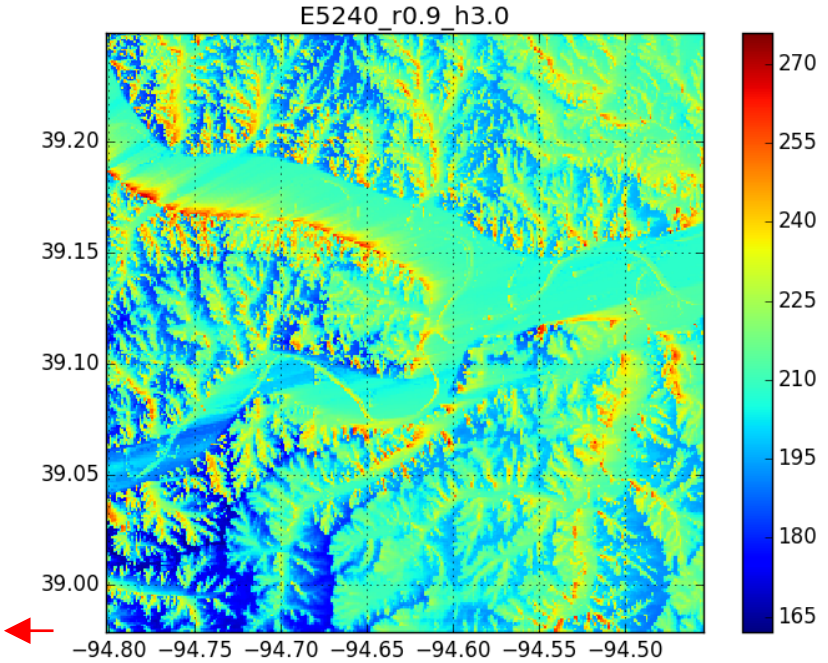
Step 3: Compute Propagation Loss

- For each existent FSS site, compute the propagation loss to each of the points within the analysis area
  - Used Longley-Rice ITM in the point-to-point mode
  - No explicit allowance for clutter was used in this step
- The FSS dish was the receive-end of the link, while the points in the analysis area were the transmit ends of the link
- The height of the tallest dish at each site was used for the receive height
- For the transmitter height, a variety of heights were used: 3, 10, 30 m

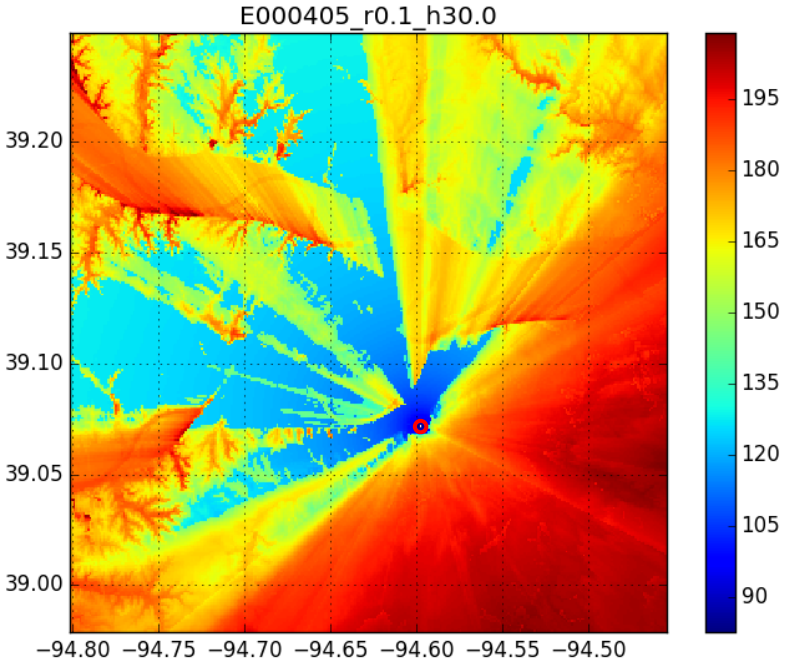
Propagation Model Inputs

- Frequency: 3700 MHz (lowest propagation loss across band)
- Dielectric constant: 25 (good soil)
- Conductivity: 0.02 S/m (good soil)
- Refractivity: 323.5 N-units (based on ITU refractivity map for KC area)
- Climate: 5 (continental temperate) (based on ITU map for KC area)
- L-R situational confidence: 50%
- Transmitter height: [3., 10., 30.] m
- L-R reliability: [1%, 10%, 50%, 90%, 99%]
- Polarization: [H, V]
- Terrain Data: USGS 1” 3D Elevation Program (3DEP1) data sampled every 30 m
- Total number of propagation loss predictions per FSS site computation: 93,000 x 30 propagation parameter combinations = 2,790,000
- Total number of predictions across all FSS sites = 40 x 2,790,000 = 111,600,000
- Result is a set of 30 maps of prop loss at each point in the analysis area from

Example Propagation Loss Maps for Individual FSS Sites



Propagation loss to FSS site E5240, approximately 37 km to the west of the southwest corner of the analysis area (arrow). Transmitter height is 3 m and the reliability factor is 90%.



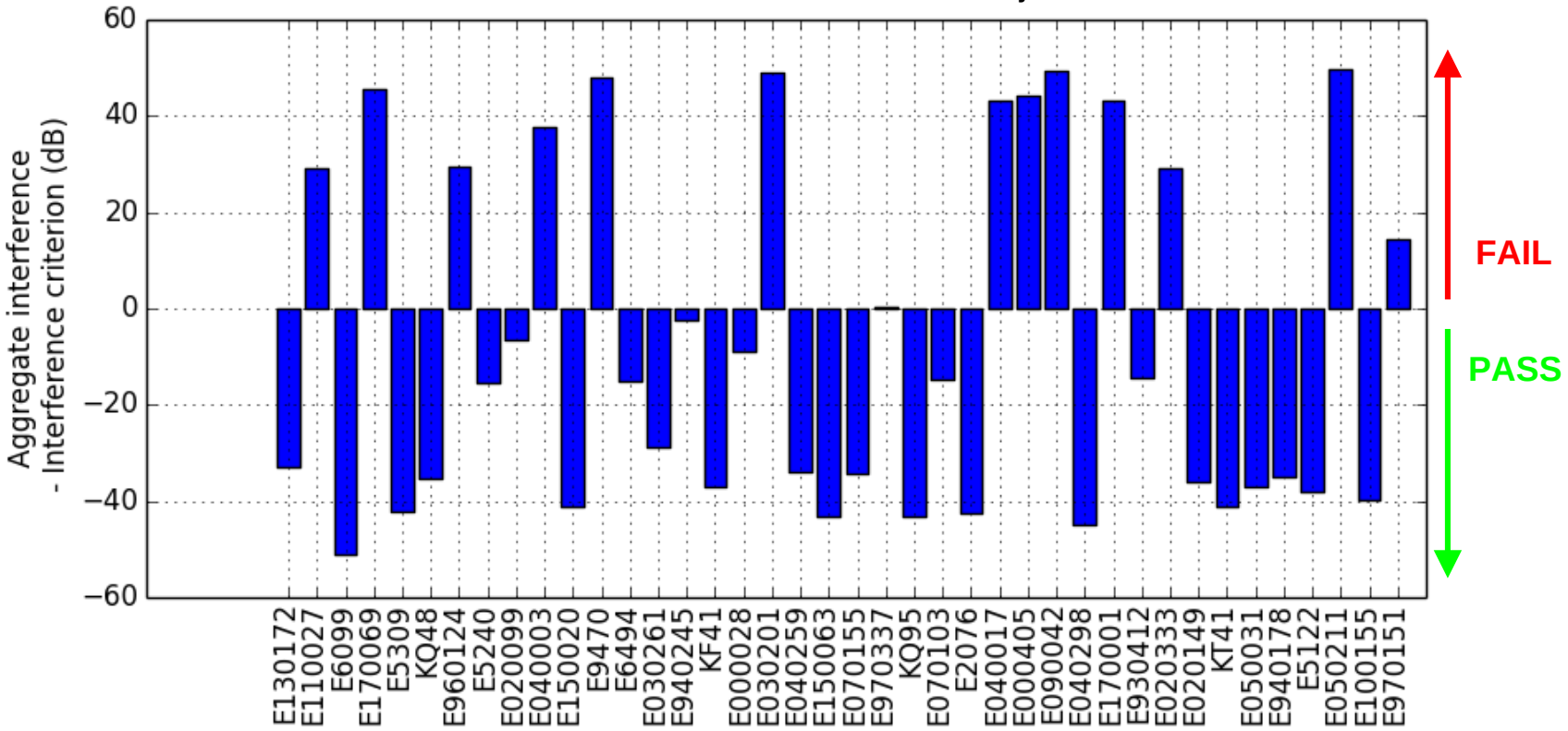
Propagation loss to FSS site E000405, located within the boundary of the analysis area (circle). Transmitter height is 30 m and the reliability factor is 10%. (Note different scale).

Preliminary Analysis

Method (Mobile)

- Assume mobile penetration as proportion of population
- At each grid point, place a number of mobiles equal to the penetration rate times the population times a uniform random number in the range (0,1).
- Assume mobile power of 23 dBm omnidirectional, 10 MHz bandwidth, 3 m height
- Assume FSS off-axis response of -10 dBi
- Calculate aggregate interference at each FSS site from all mobiles at all grid points
- Compare aggregate interference to -129 dBm/MHz interference criterion

23 dBm per tx, penetration rate = 1%, 3 m mobile height
26 of 40 FSS sites meet interference objective



Method (Fixed)

- Height 10 m
- EIRP of 50 dBm
- FSS discrimination of 10 dB
- Antenna gain 14 dBi
- Antenna beamwidth 45 deg
- Beam pattern envelope corresponding to WinnForum CBRS Requirement R2-SGN-20 (-20 dBr floor)
- Pointing angles of [0, 45, 90, …, 315] deg
- At each grid point, can the specified antenna pointing in the specified direction operate without exceeding the interference criterion of any FSS earth station?

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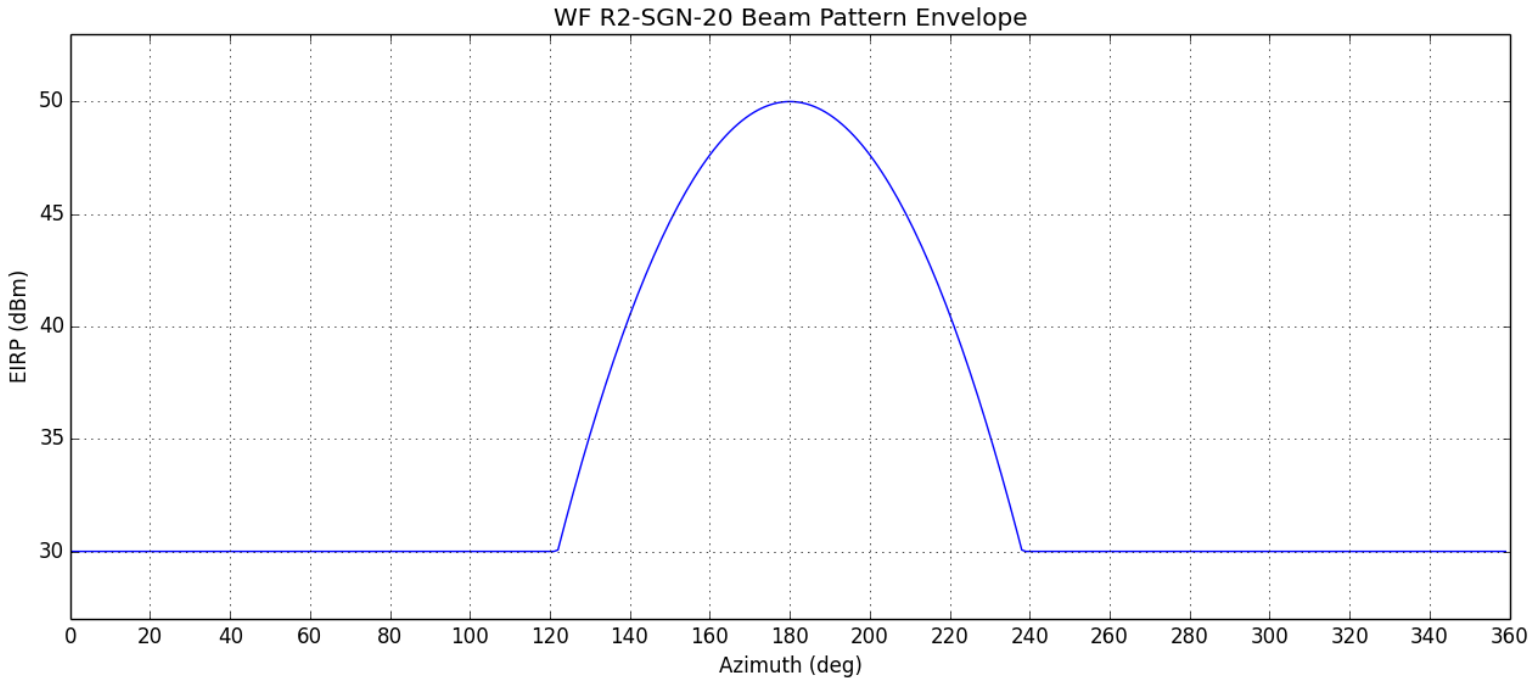
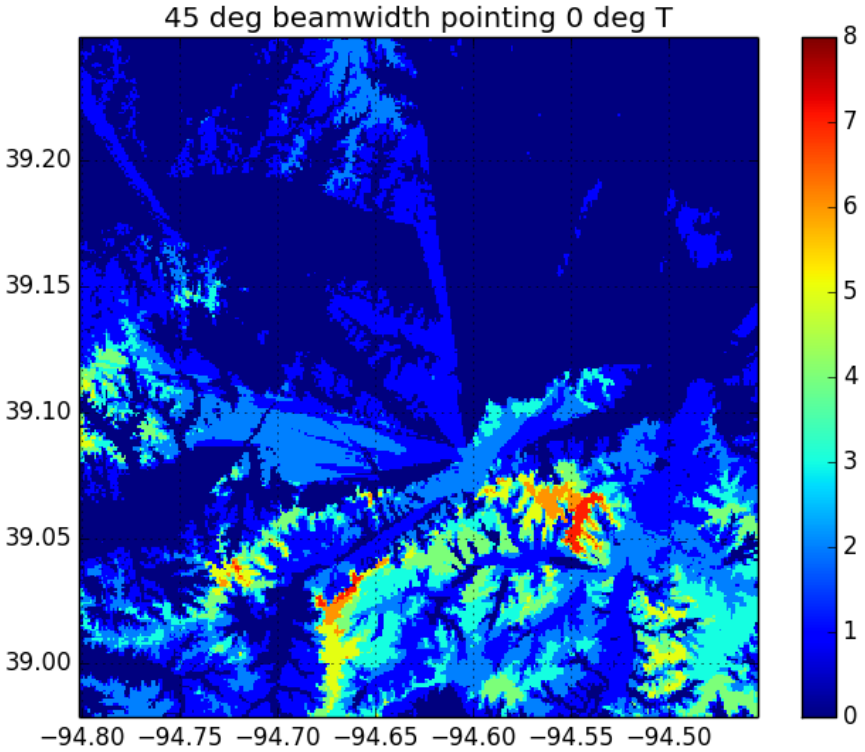
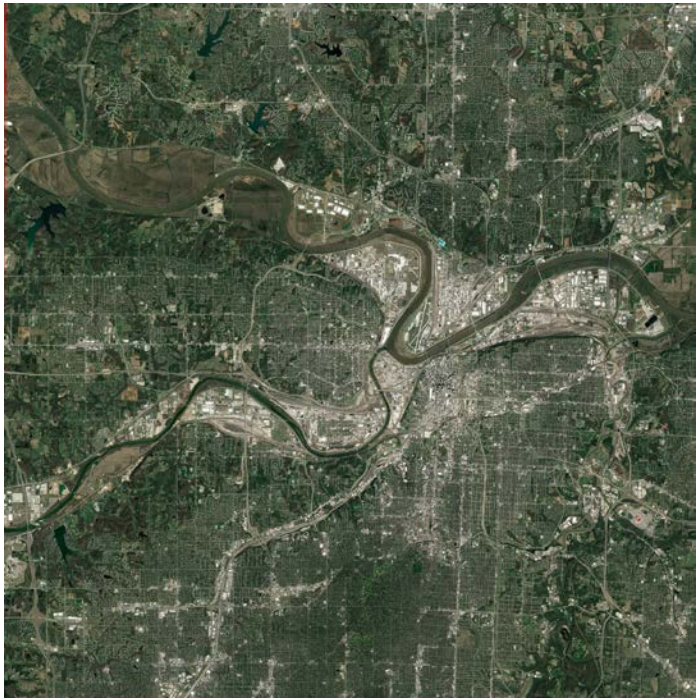
Fixed Beam Pattern Example

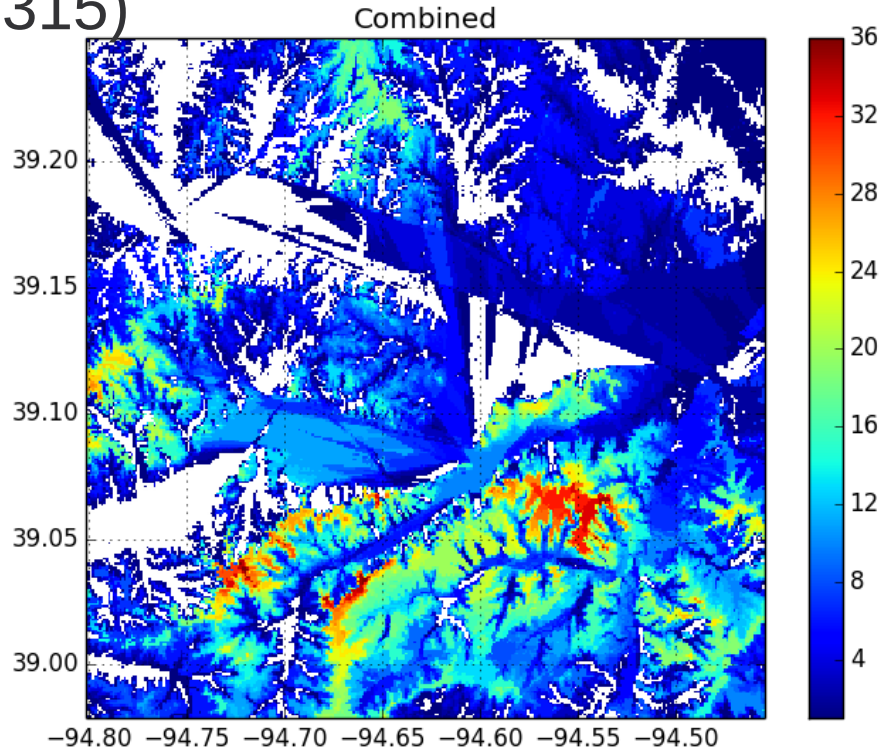


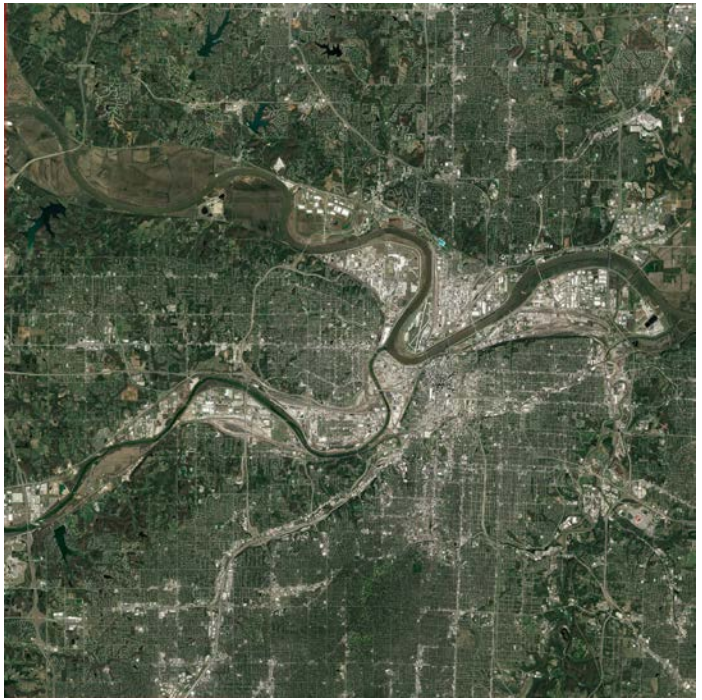
Example Result -- Single Pointing (45 deg beam, 0 deg T)





Example Result -- All Pointings (45 deg beam, 0, 45, …, 315)





Very Preliminary Results

- A framework for analyzing co-existence between mobile/fixed broadband use and fixed-satellite service systems is being developed
- The analysis depends on improvements in FSS database accuracy
- Mobile use of 3.7-4.2 GHz band cannot meet FSS interference objectives in Kansas City under the assumed operating parameters
- Fixed use of the band is possible in 17% of the land area under the corresponding assumptions, not considering aggregation
- Future work will incorporate aggregation for fixed deployments, based upon RF plans reflective of population density, and should also evolve beyond ITM to include the impacts of clutter.