



StadiumCell Trial
at
Louis Brown Rutgers Athletic Center
LTE RF design



Lavinia Arpinte
Advanced RF design team

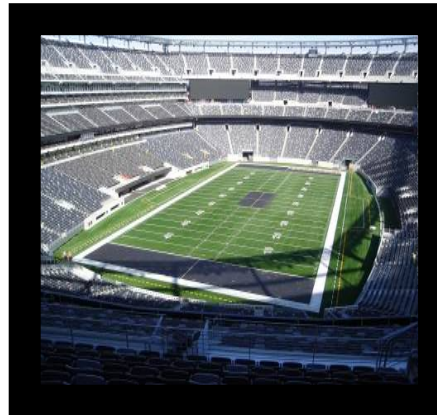
May 9, 2012

Agenda

1. Inputs and assumptions
2. RAC modeling
3. RF design
 - a. Scenario A - 3 MROs
 - b. Scenario B - 4 MROs
 - c. Coverage from outdoor macro
4. Conclusions

Trial Objectives

- Increase Confidence in Product and overall Solution
- Identify “real world” deployment preferences & issues
- Enable Better/Earlier Commercial deployments via early learnings



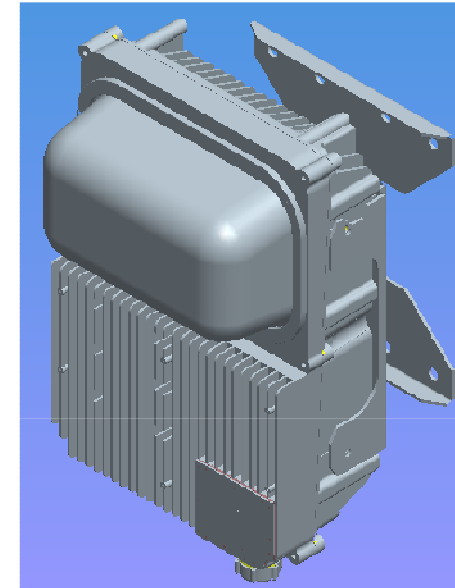
Inputs and assumptions

Scope: Provide LTE coverage on RAC using ALU metro cell solution

Frequency band: AWS band (band 4)

Carrier bandwidth: 10 MHz

Solution: Metro cell



Characteristics:

- Directive antenna with 7.3dBi gain
- Carrier bandwidth: 10 MHz
- Maximum transmission power: AWS is 1 W conducted output power (5 W EIRP) at each antenna (to be tested with much less power ~10-100mW)

Area to be covered: home team tribune of RAC

RF design tool: IBwave design (ALU in building design solution)

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Rutgers Athletic Center (RAC)

The Louis Brown Rutgers Athletic Center (RAC) is an ideal venue for testing and developing the stadiumcell product family, its cavernous 8000 person gymnasium resonates not just with cheering fans but with multi-path propagation of radio waves.



Modeling of the RAC in IBwave design

Process (1)

Required inputs:

- 3D plans (autocad) of the inside of RAC for RF planning purposes.

And/or

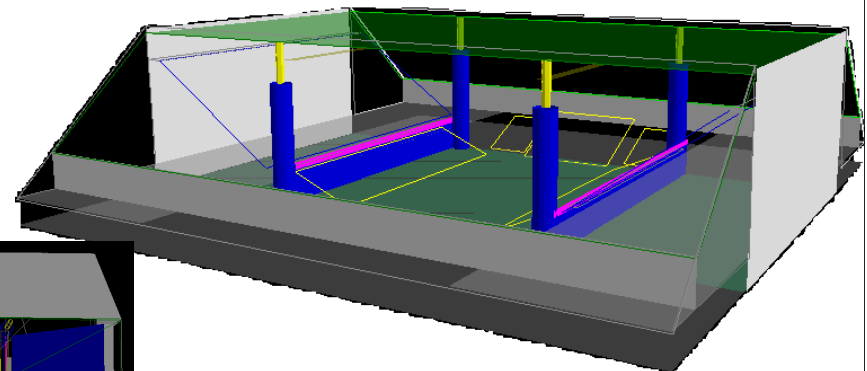
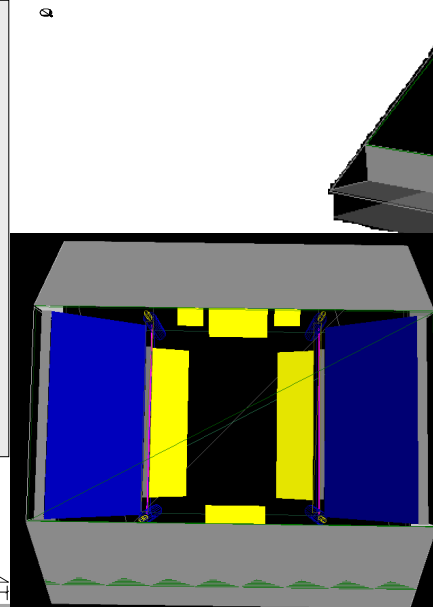
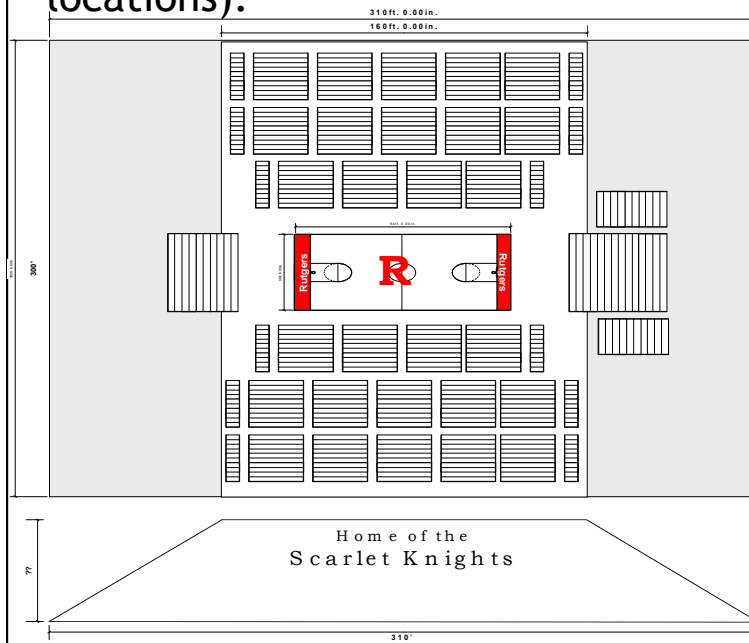
- Survey results (height of the bleachers, catwalks heights and locations).



IBwave Design

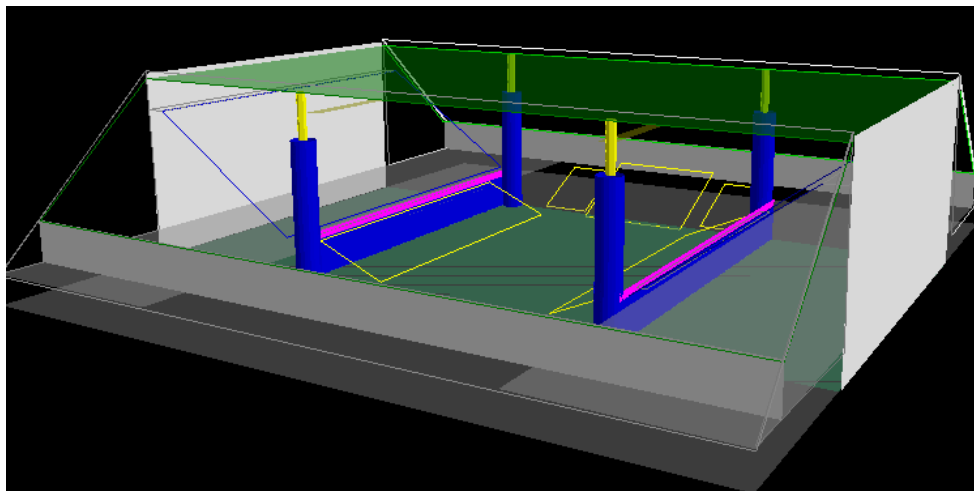
Outputs:

- 3D model of the RAC, considering building structures and material characteristics
- RF system modeling (MROs)
- Simulates network coverage using a 3D propagation model

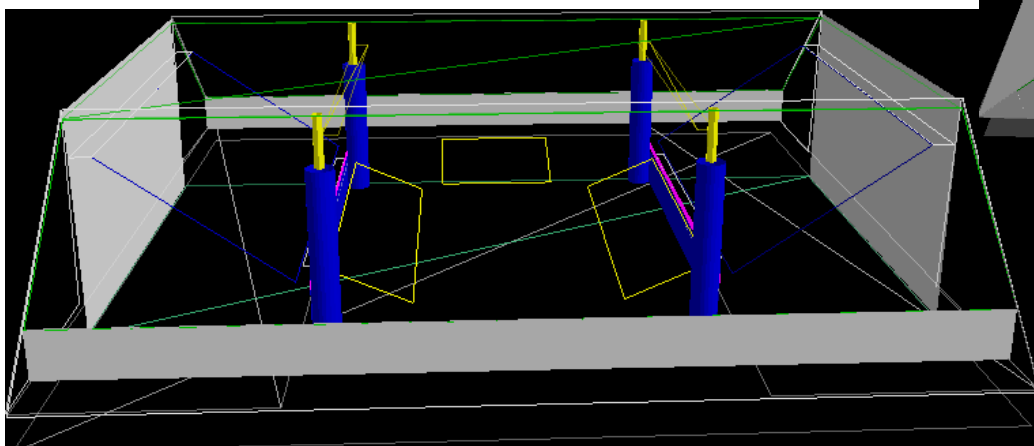
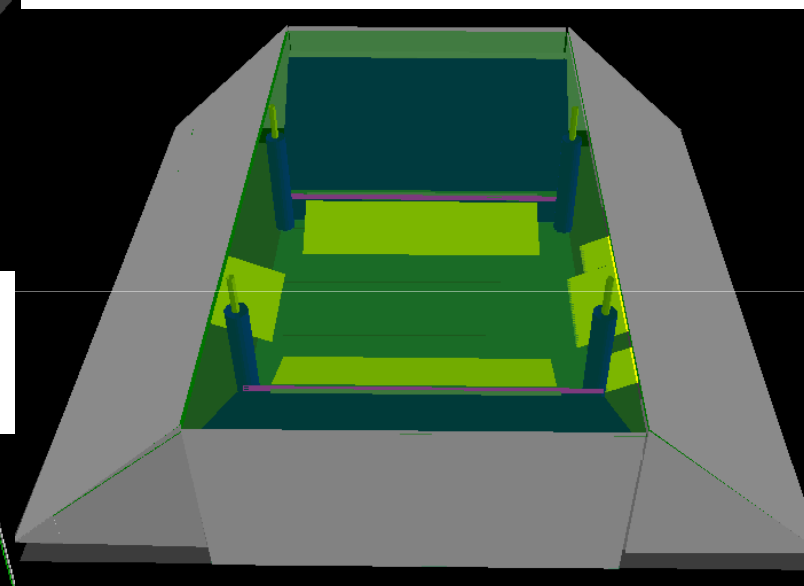


Modeling of the RAC in IBwave design

Process (2)



IBwave Design



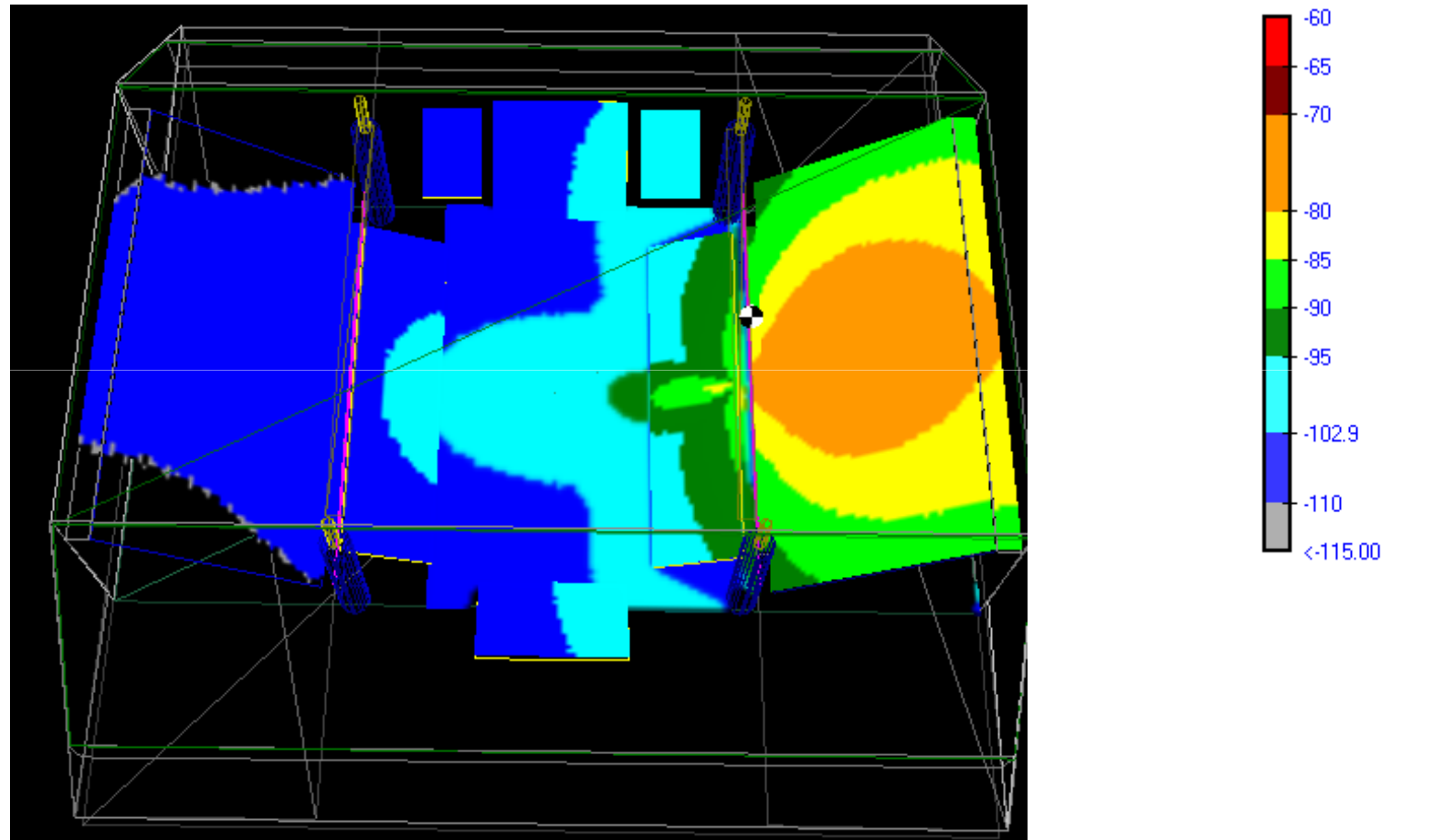
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RF design

Single MROs - RSRP coverage area

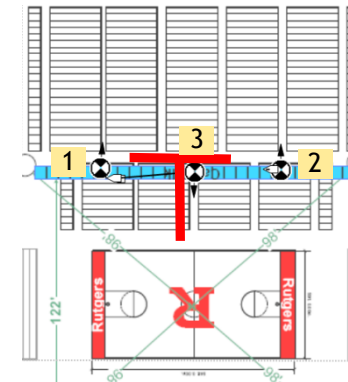
Tx power per MRO: 10mW; RS EPRE: -18dBm, tilt: 30 deg



Optimal scenario analysis

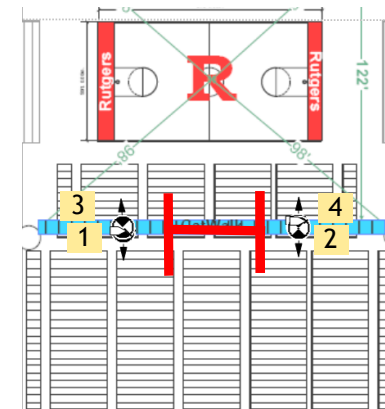
For the trial 3 MROs are assigned, with possibility to increase it to 5.

The design is a small scale design, reusable for large stadiums with several tribunes side by side.



Thus 2 scenarios were analyzed:

- 3 cells scenario with the MROs mounted on the side of the catwalk on top of the home team tribune in a T configuration (2 facing upward with parallel azimuths and one facing downward to the retractable bleaches).
- 4 cells scenario with the MROs mounted on the side of the catwalk on top of the home team tribune in a H configuration (2 x 2 MROs back to back).

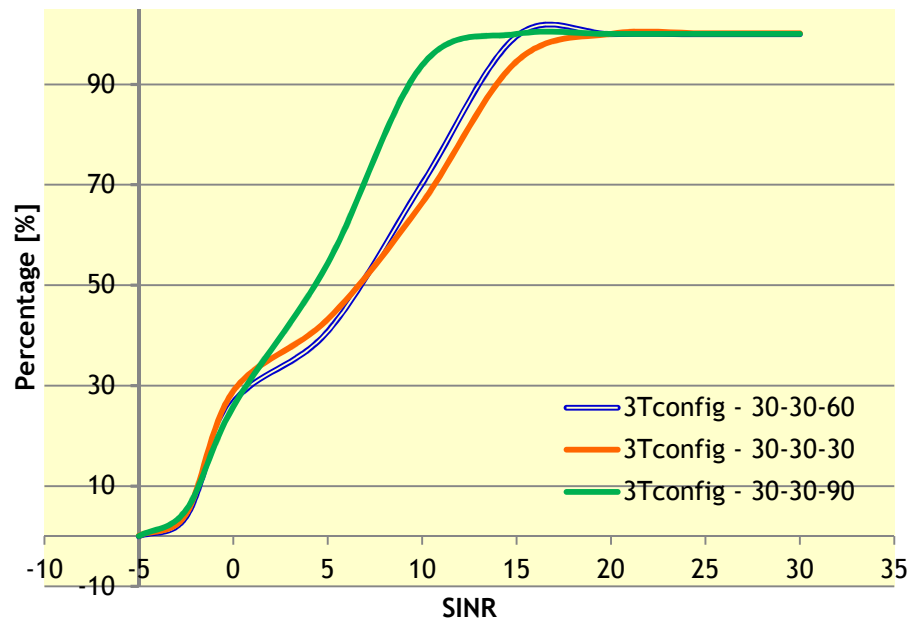


Optimal scenario analysis

SINR CDF comparison

A SINR comparison was done for the 3 MROs scenario and 4MROs scenario considering different tilt values for the antenna, in order to identify the best scenario

SINR CDF for different configurations with 3 cells



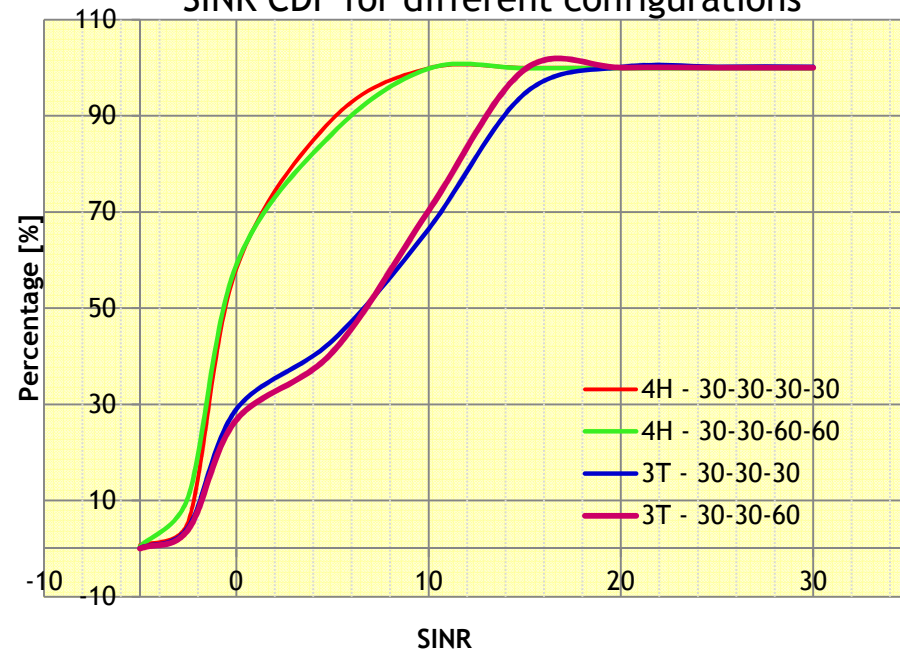
Legend: x - a-b-c-d

X - configuration (3 or 4MROs)

A - tilt of cell 1; B - tilt of cell 2

C - tilt of cell 3; D - tilt of cell 4

SINR CDF for different configurations



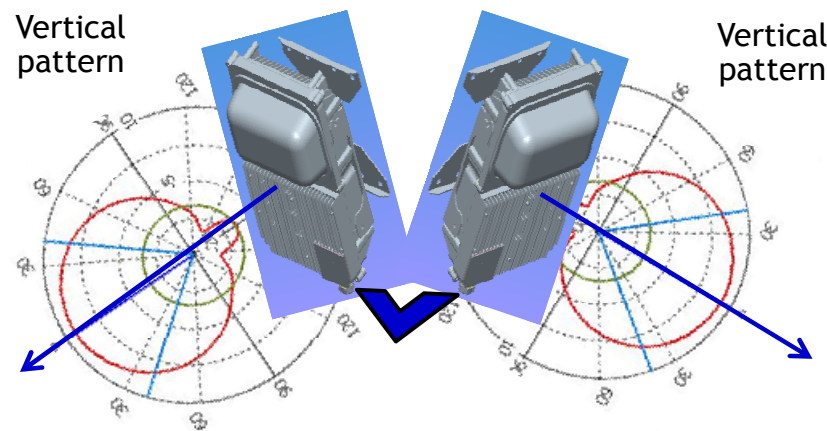
Optimal scenario analysis

SINR CDF comparison

A SINR comparison was done for the 3 MROs scenarios and 4MROs scenario considering different tilt values for the antenna, in order to identify the best scenario

Conclusions:

- Best results are obtained with smaller tilt values (30, 60 degrees)
- Worst results are obtained when using 90 deg tilt, as the cell with 90 deg tilt will generate high interference on the adjacent cell
- As antennas are back to back and considering that the HPBW of the antenna is ~ 80 deg it is recommendable to keep at least 90 degrees between the main radiation direction of the 2 antennas.

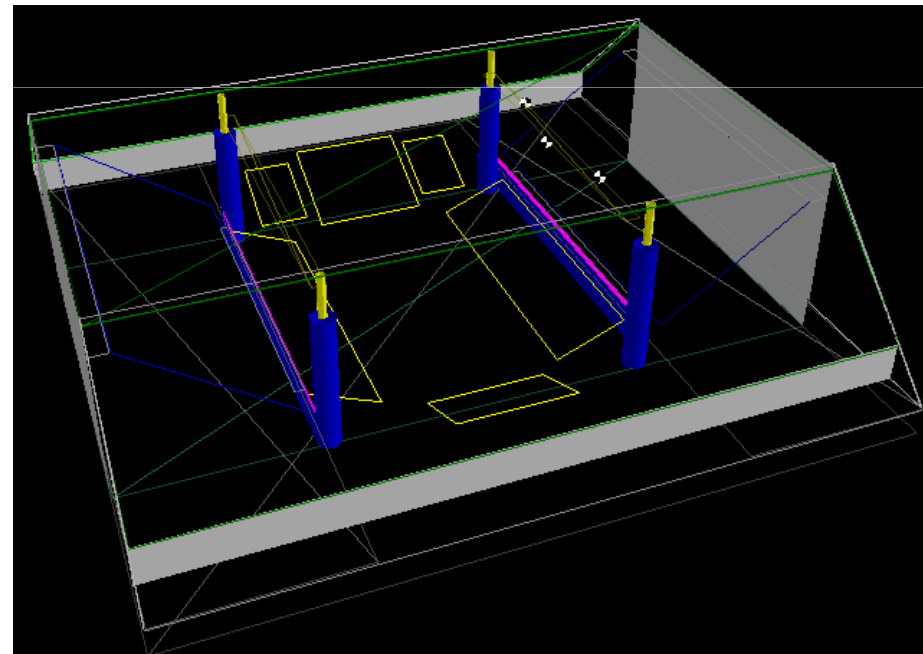
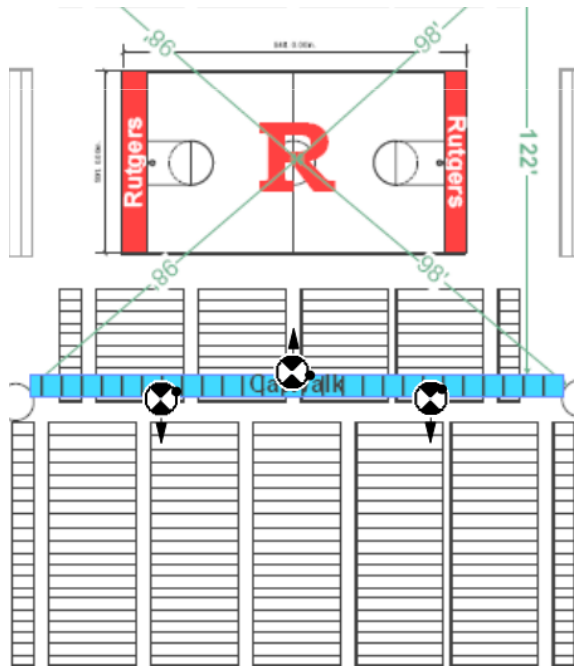


Design proposal

Scenario A - 3MROs - Configuration

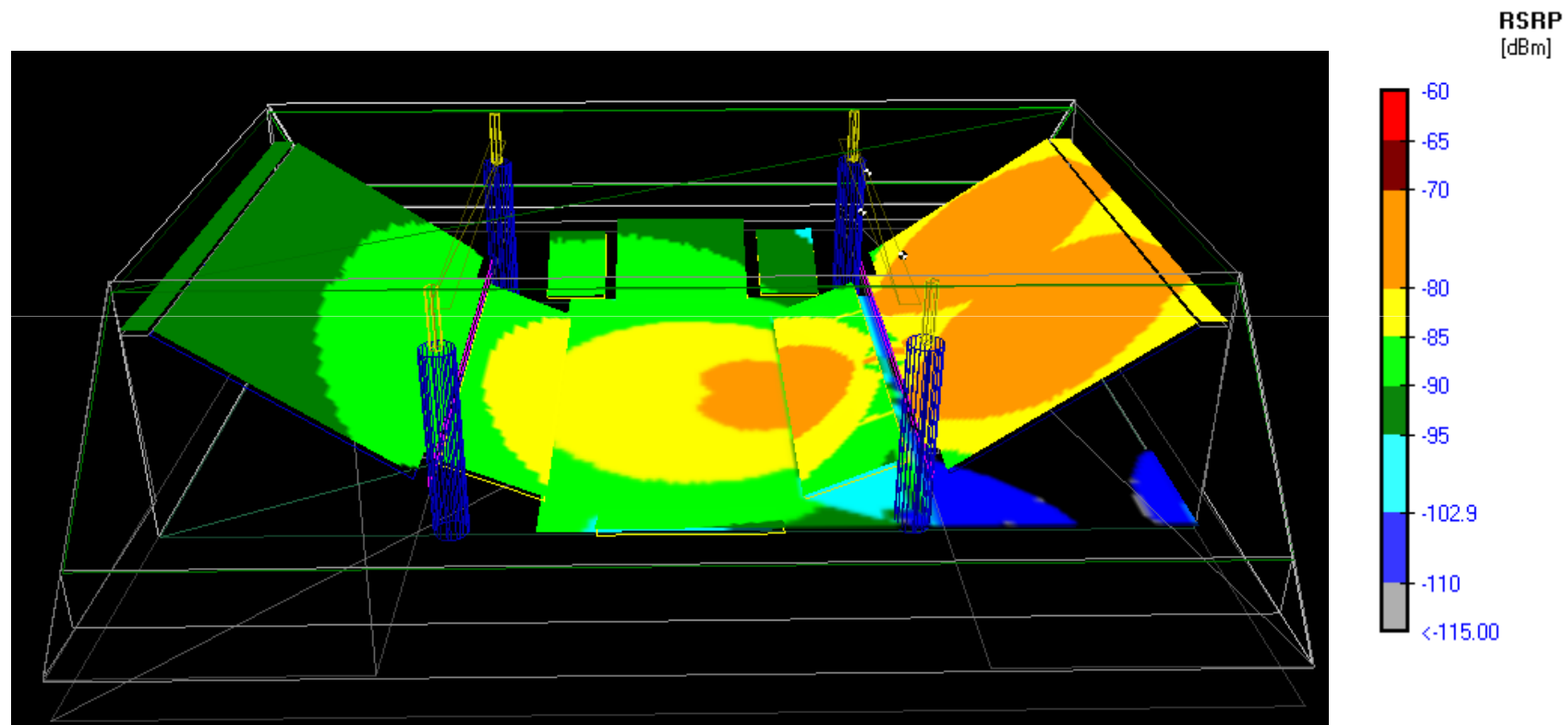
Configuration:

- 3 MROs installed on the sides of the catwalk
- 2 MROs for upper seats with 30deg tilt/ 1 MROs for the retractable seats with 60deg tilt
- Tx power per MRO: 10mW; RS EPRE: -18dBm



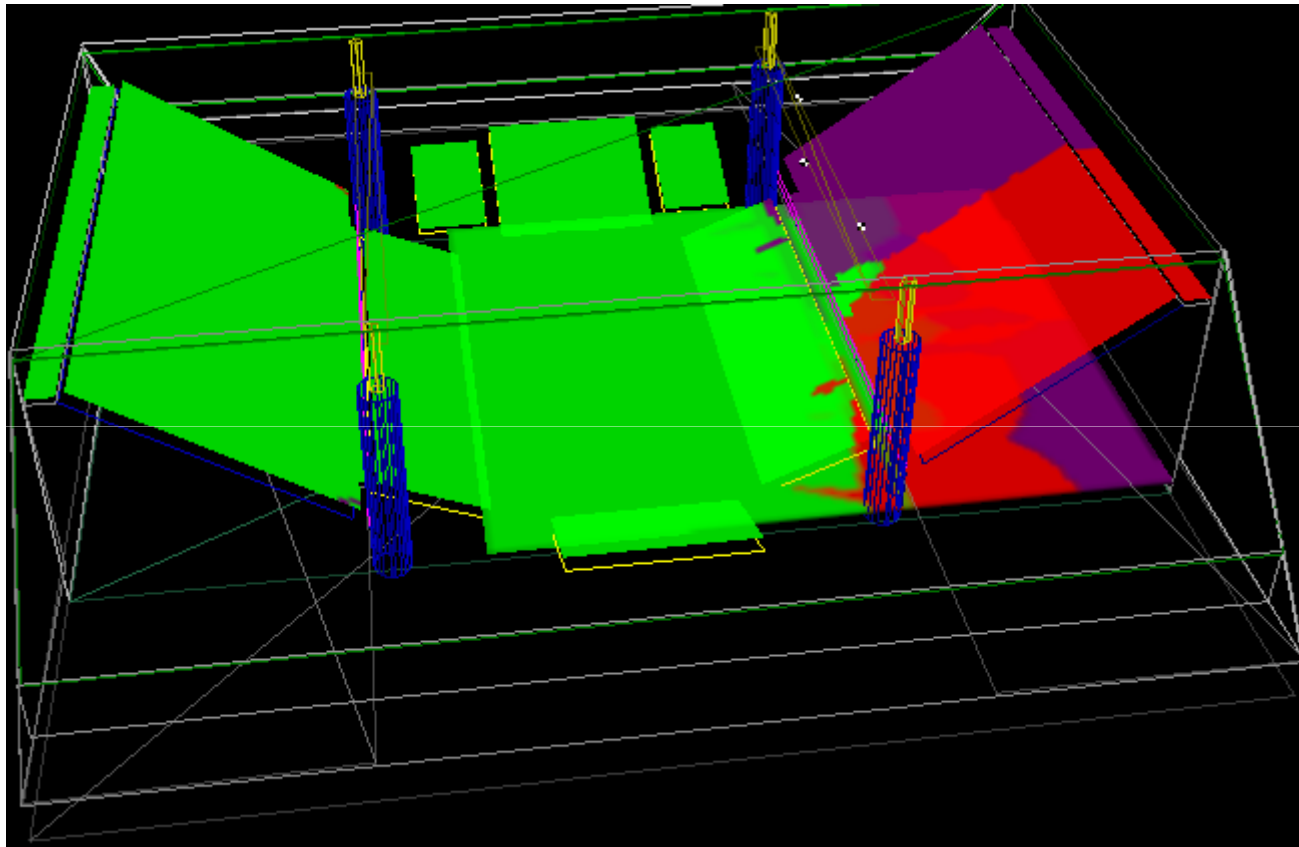
Design proposal

Scenario A - 3 MROs - RSRP coverage



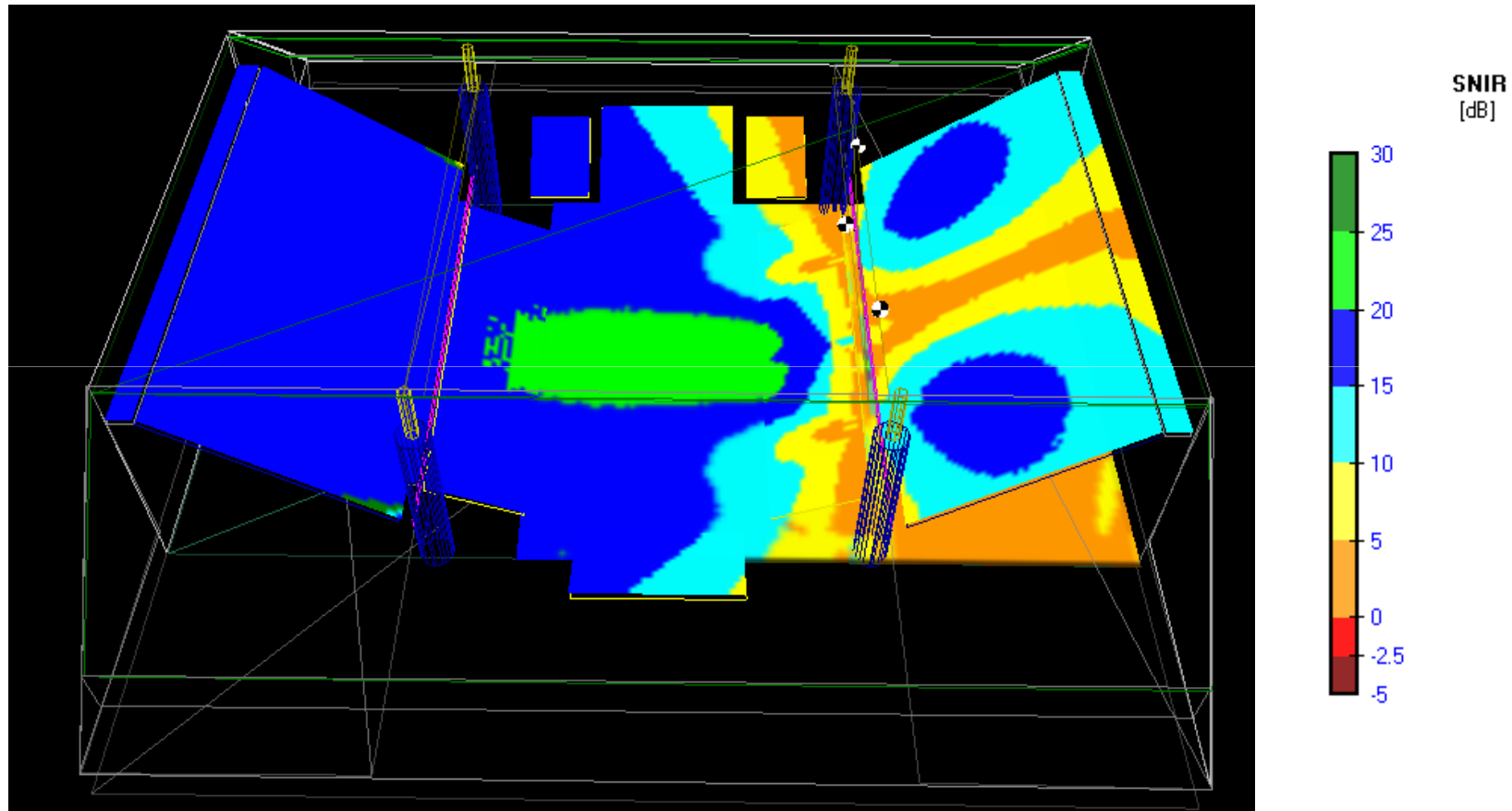
Design proposal

Scenario A - 3 MROs - Best server plot



Design proposal

Scenario A - 3 MROs - PDSCH SINR plot for 50% cell load

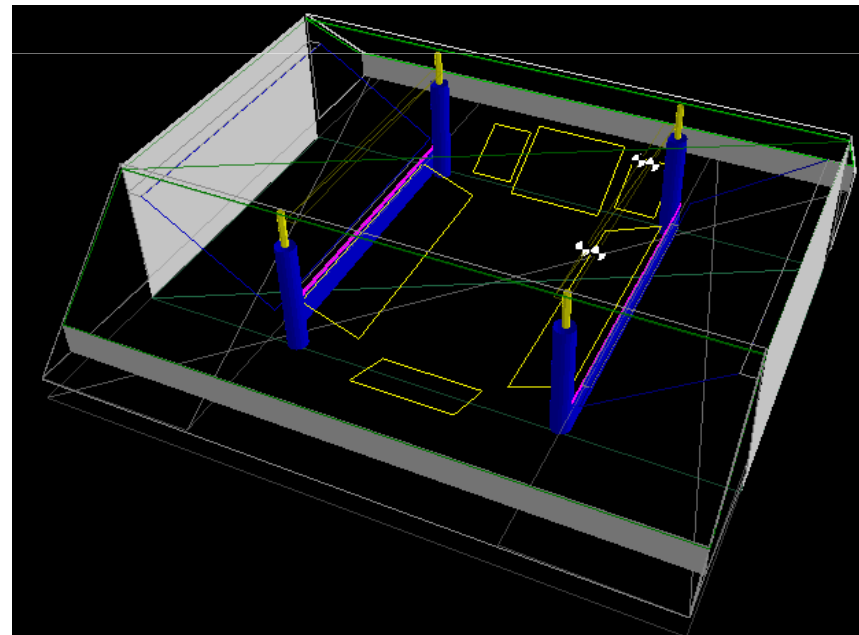
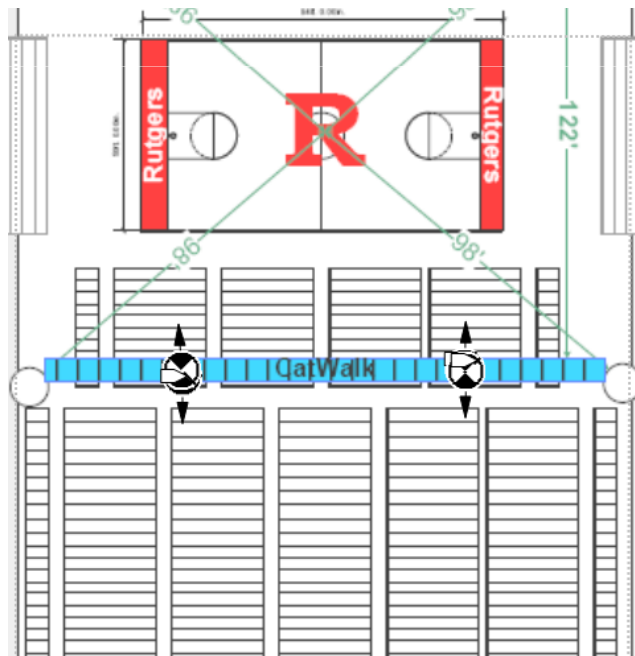


Design proposal

Scenario B - 4 MROs - Configuration

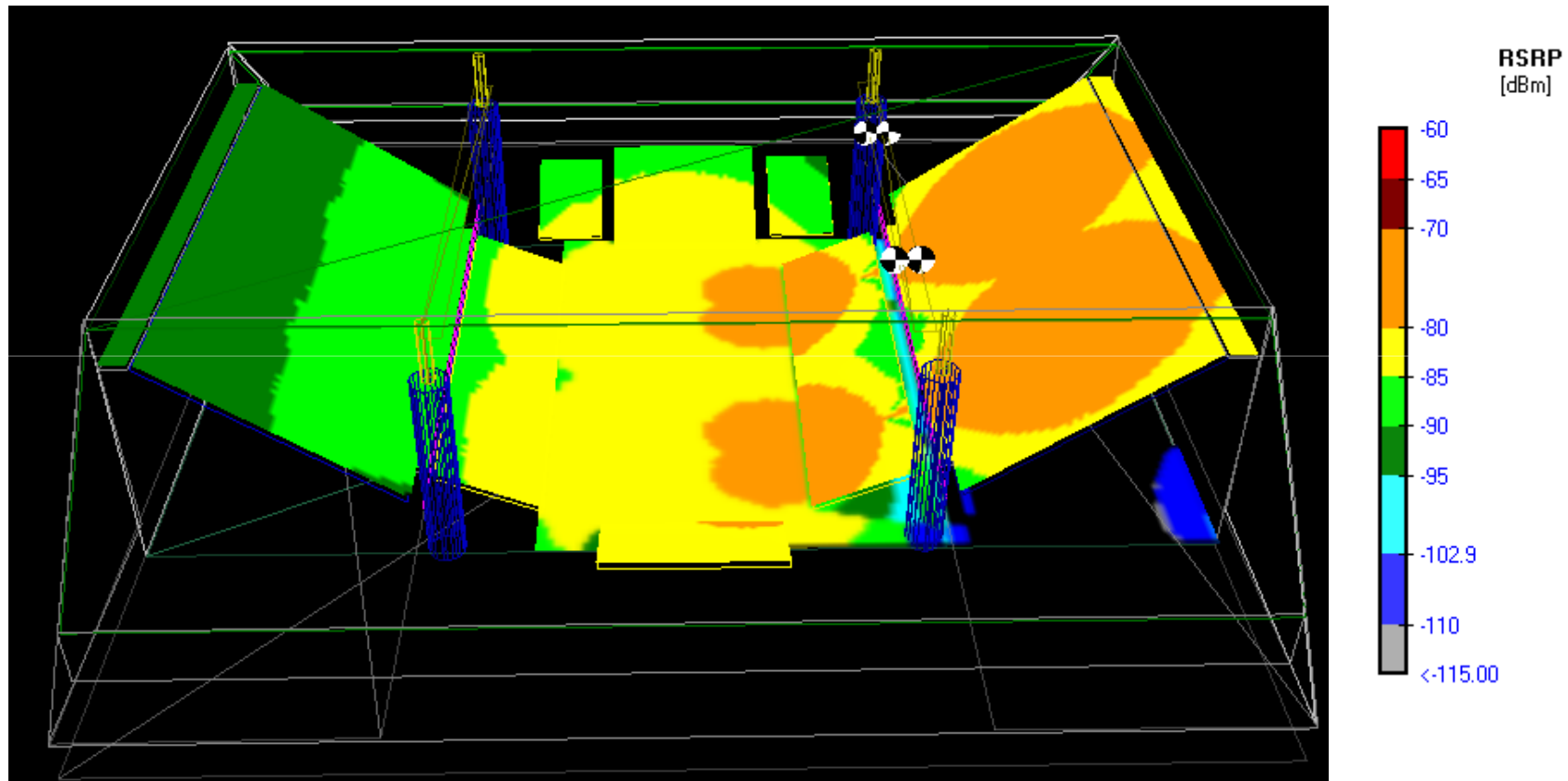
Configuration:

- 4 MROs installed on each side of the catwalk, 2 x 2 back to back
- 2 MROs for upper seats with 30deg tilt/ 2 MROs for the retractable seats with 60deg tilt
- Tx power per MRO: 10mW; RS EPRE: -18dBm



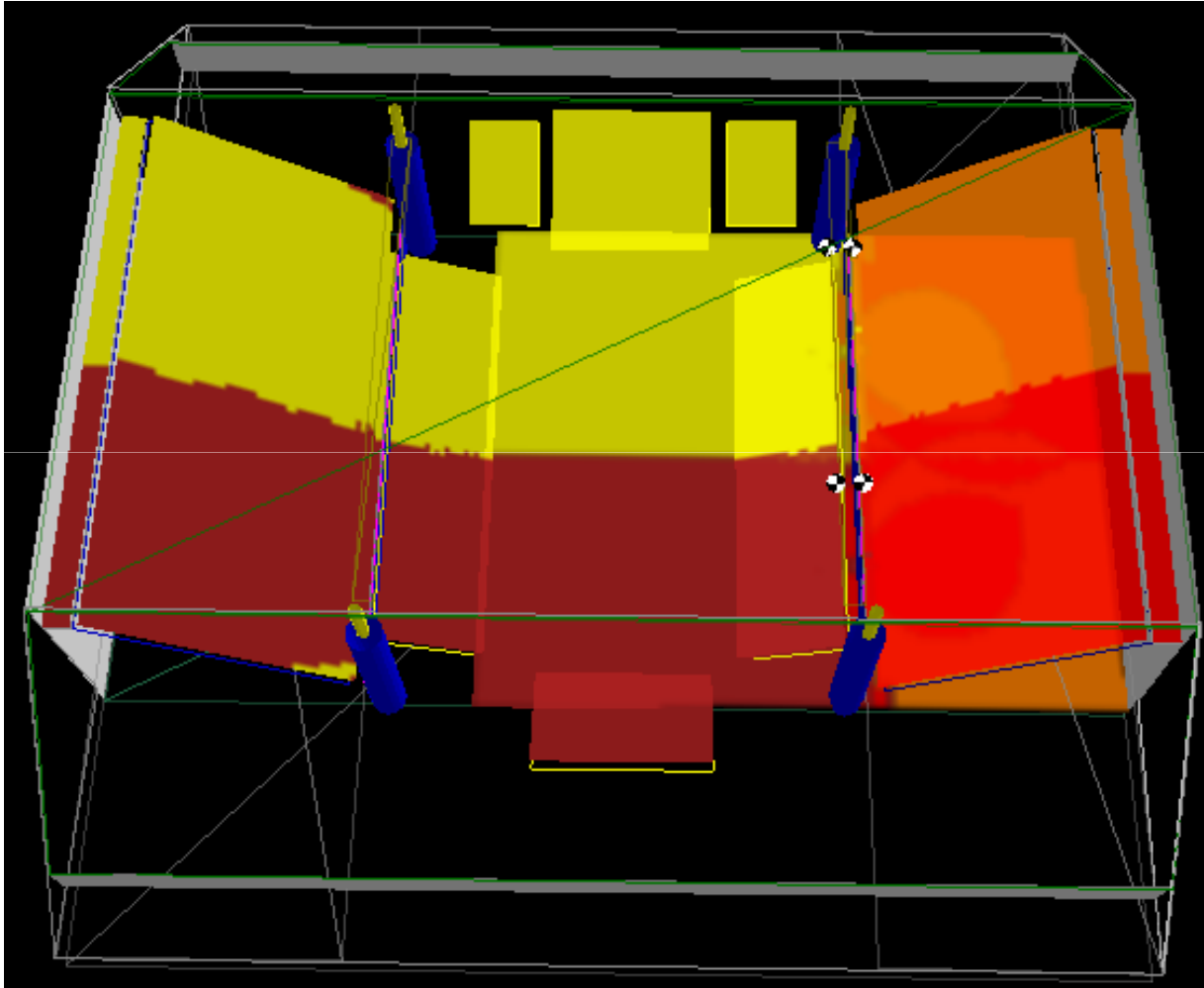
Design proposal

Scenario B - 4 MROs - RSRP coverage



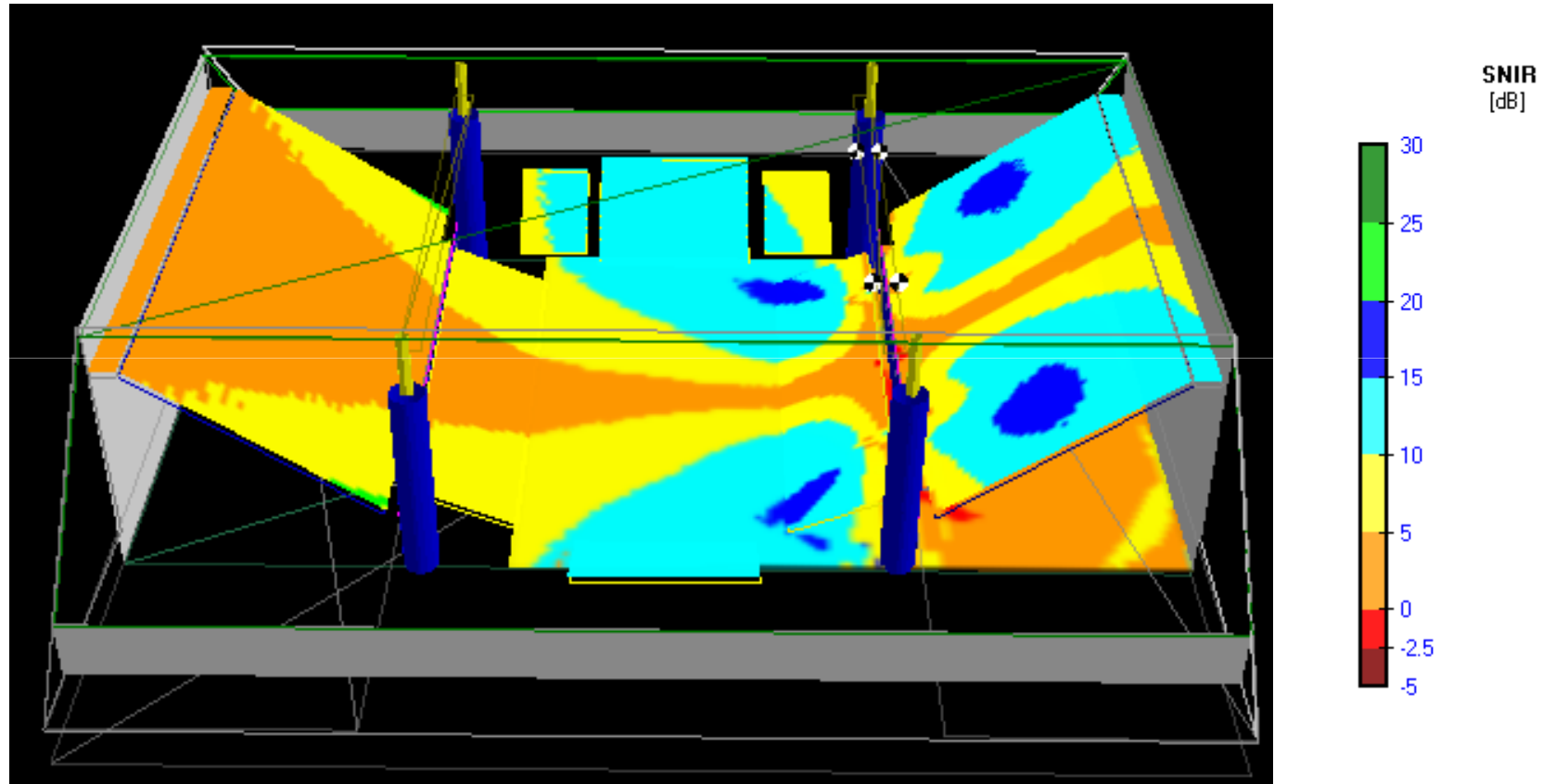
Design proposal

Scenario B - 4 MROs - Best server plot



Design proposal

Scenario B - 4 MROs - PDSCH SINR plot for 50% cell load

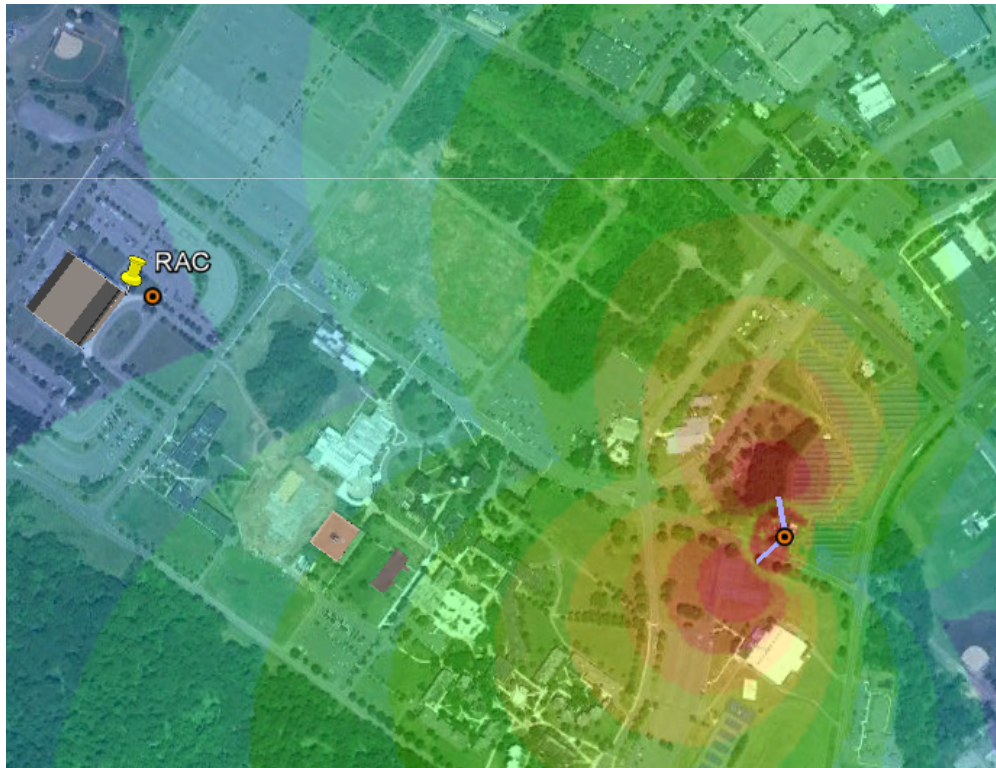


Design proposal

RSRP coverage from outdoor macro sites

Assumptions:

- ❑ 2 macro sectors installed on Joyce Kilmer Road site (azimuth 230° and 350°)
- ❑ TX power: 2 x 30W; Height: 24m
- ❑ Power Wave antenna with 17.7 dBi gain and 4 deg electrical tilt
- ❑ RSRP level around RAC > -105dBm



RSRP Coverage 0

Allow RSRP coverage calculation criterion as defined in 3GPP

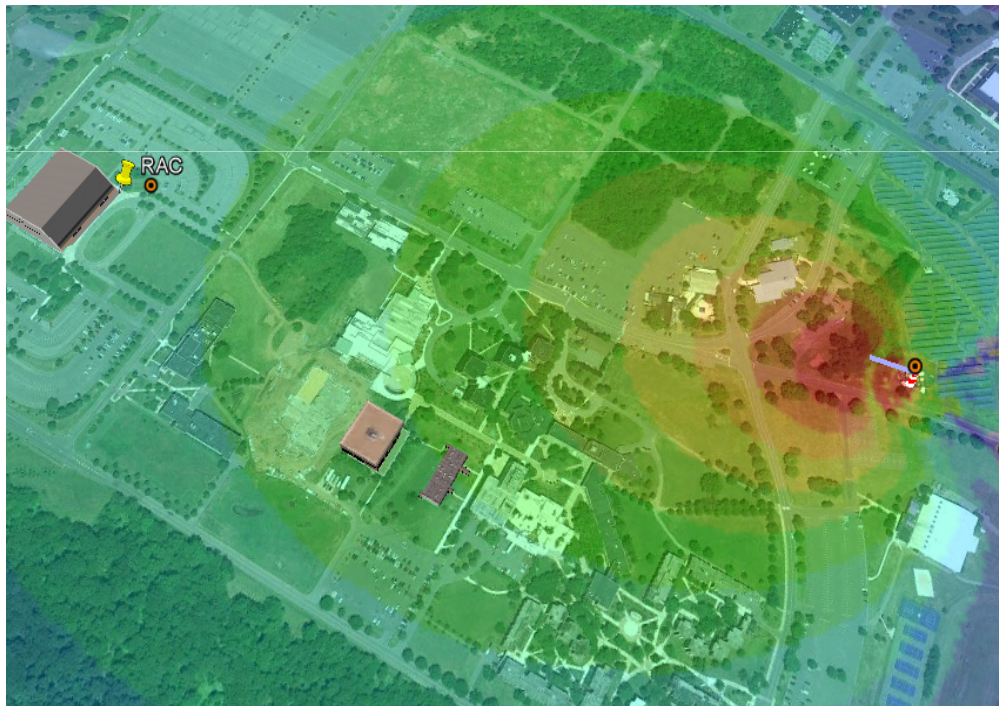
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -60
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -65
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -70
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -75
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -80
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -85
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -90
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -95
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -100
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -105
- Best RSRP (RS EPRE) Level (DL) (dBm) >= -110

Design proposal

RSRP coverage from outdoor macro sites

Assumptions:

- ❑ 1 macro sectors installed on Joyce Kilmer Road site (azimuth 295°)
- ❑ Tx power: 2 x 30W; Height: 24m
- ❑ Power Wave antenna with 17.7 dBi gain and 4 deg electrical tilt
- ❑ RSRP level around RAC > -95dBm



RSRP Coverage 0

Allow RSRP coverage calculation criterion as defined in 3GPP

- Best RSRP (RS EPRE) Level (DL) (dBm) > = -60
- Best RSRP (RS EPRE) Level (DL) (dBm) > = -65
- Best RSRP (RS EPRE) Level (DL) (dBm) > = -70
- Best RSRP (RS EPRE) Level (DL) (dBm) > = -75
- Best RSRP (RS EPRE) Level (DL) (dBm) > = -80
- Best RSRP (RS EPRE) Level (DL) (dBm) > = -85
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- Best RSRP (RS EPRE) Level (DL) (dBm) > = -110

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Challenges for stadium RF designs

Specific challenges for stadiums/arenas:

- High density of users in a limited space and lack of mobility for the subscribers
- No means to provide isolation between neighboring sectors over one tier. The only mean is to isolate sectors over different seating tiers
- External network interference

Solutions:

- Create signal dominance over each cell
- Increase capacity by reducing the coverage footprint of each cell and fitting more cells in the same physical space.
- Cover the seating from above (roof/catwalk) to overcome limitations of rear installation (increased body loss) and front installation (obstructed view)
- Correlate the height of the MROs in order to illuminate the targeted area and limit the leakage between cells to an acceptable level
- Correlate the tilt of the MROs in order to provide dominance over each cell, but also to reduce the leakage in the adjacent cell due to HPBW of the antenna

Remarks:

- Smaller VBW antennas are recommended for a higher isolation between cells

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