RADCOM Recommendations
Grid Datasets

Grid Dataset Overview

Grid data is highly important for optimization purposes. The most accurate way to provide this data is via geo-location data (RAN trace/crowd source), but these data sources are not always available (RAN trace) or at the correct level of aggregation (crowd source). The goal is to provide a standardized grid data set for optimization unbounded by the available data sources. The only variable factor should be an accuracy metric (described later) based on data source availability.

- Data sources
  - Cell GIS data **Required**
  - CM data (neighbor relation data) **Enhancement**
  - PM data (timing advance) **Enhancement, used if no geolocation data available**
  - PM data (neighbor relation counters) **Enhancement**
  - Impact counters **Enhancement, can be used in conjunction with neighbor relation PM**
  - Geo-location data (RAN trace, crowd source) **Enhancement**
- Data source creation
  - Created data will be harmonized irrespective of the input data to ensure that the same feature methodology can be used independent of data source availability. This requires additional feature engineering where geolocation data is not available
- Output data sources
  - Cell-Bin metrics – Intermediate data source used to create “Per Cell metrics” and “Merged Cell-Bin metrics”
    - Site classification (urban, suburban, rural)
    - Mean/median RSRP/RSPQ
    - Cell traffic parentage, etc.
  - Per Cell metrics
    - Site classification (urban, suburban, rural)
    - Weighted mean/median neighbor distance
    - Total bin area, dominant bins, interference bins
  - Merged Cell-Bin metrics
    - Cell ratios, interference index, coverage index, vulnerability index, etc.
  - Per Bin metrics
    - Cell count, dominant cells, interference cells

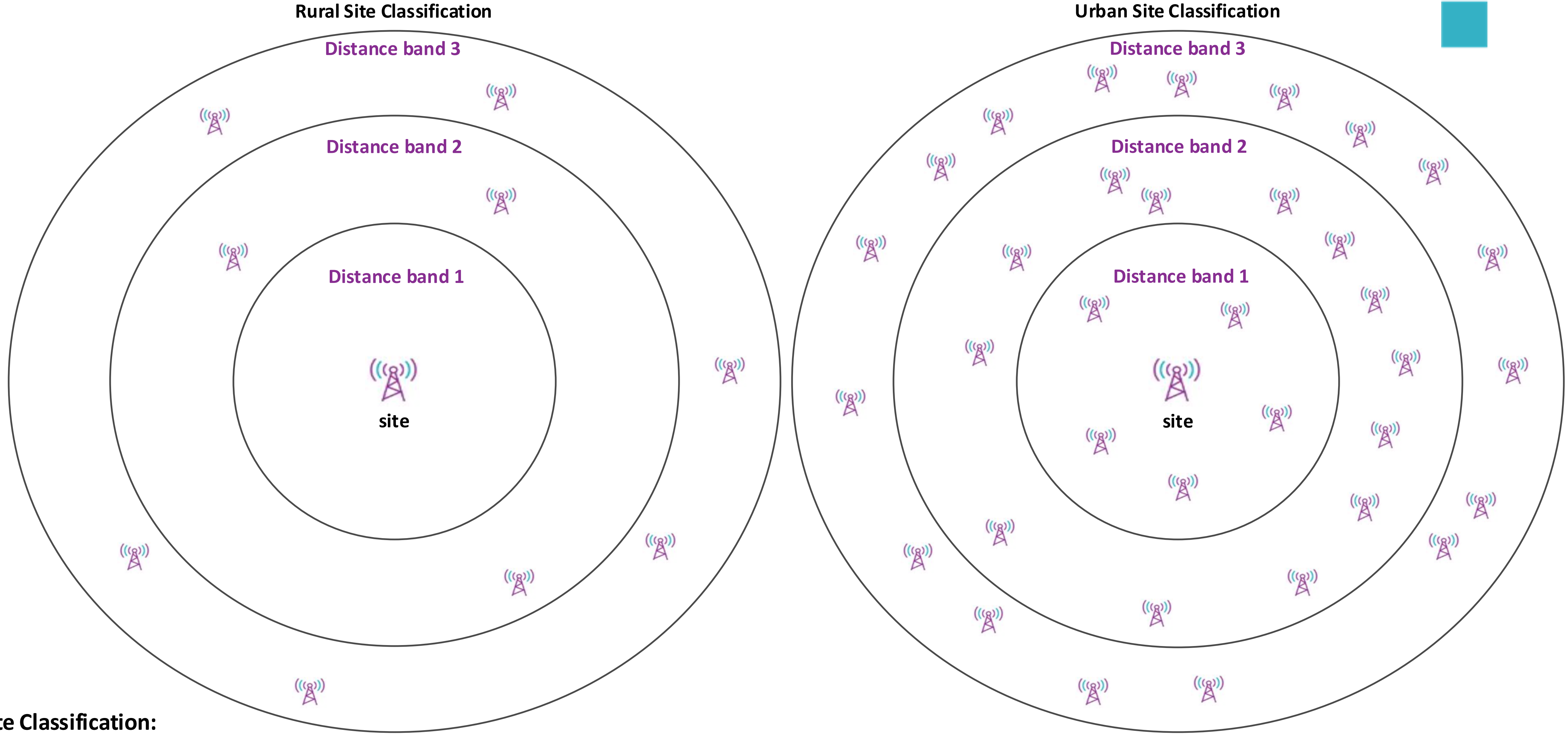
Data Sources

There are 4 relevant input data sources to consider; Cell GIS, Configuration Management (CM), Performance Management (PM), and Geo-location data.

- Cell GIS data
  - This is the most basic required data source. The information required here is;
    - Cell location (LAT/LON)
    - Antenna Azimuth
    - Antenna horizontal/vertical beamwidth
    - Antenna height
    - Antenna tilt
- CM data
  - CM data is not a requirement but provides valuable neighbor relation information
    - Neighbor relation data: This data is used in conjunction with PM/impacts to classify cells based on neighbor proximity/density
- PM data
  - PM data is not a requirement but provides an alternative to geo-spatial data (Timing advance) and enhancements to output data creation (neighbor relation information)
    - Timing advance: Used as an alternative grid building block when geo-spatial data is not available. It allows the modeling of antenna coverage which can be rationalized to bin aggregations
    - Neighbor relation counters: Used in conjunction with impact counters to assign neighbor weights
- Geo-location data (RAN trace, crowd source)
  - Geo-location data is not a requirement but provides the most accurate data source to build grid insights with
    - RAN trace: Provides the most granular data in terms of aggregation. Location accuracy +/- 75m
    - Crowd source: Provides the most accurate location (GPS). Data is useful once it has not been aggregated past the cell level

RADCOM Recommendations
Create Cell-Bin Metrics

Create Site Classification – Requires Cell GIS

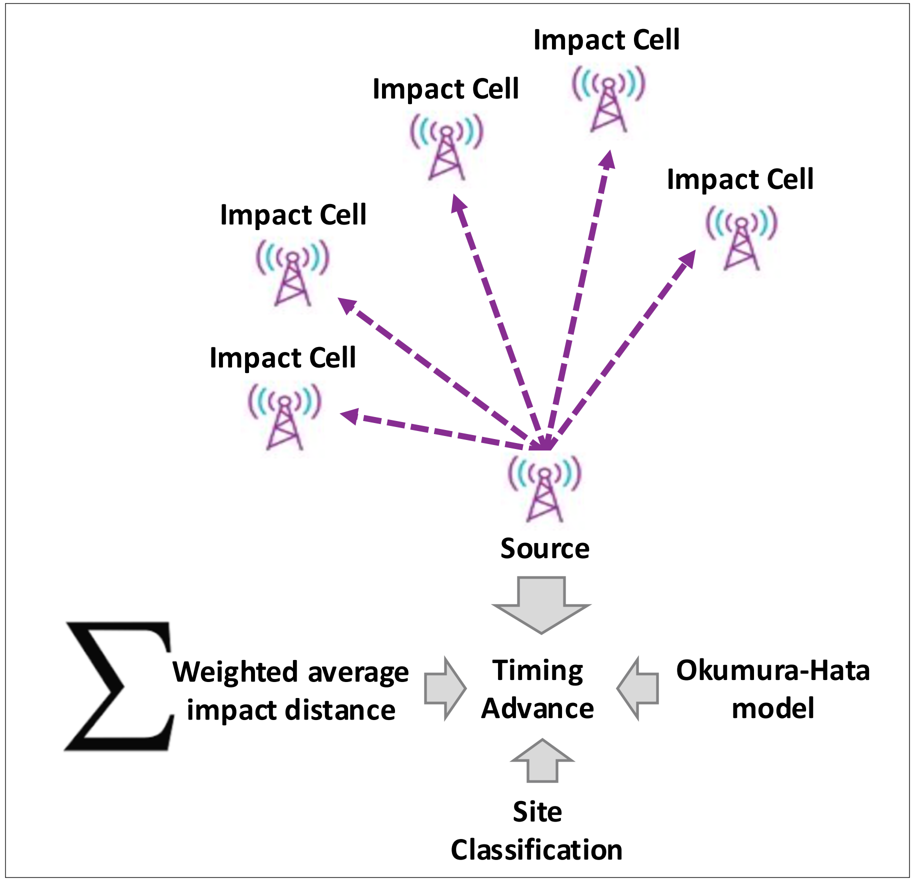


Site Classification:

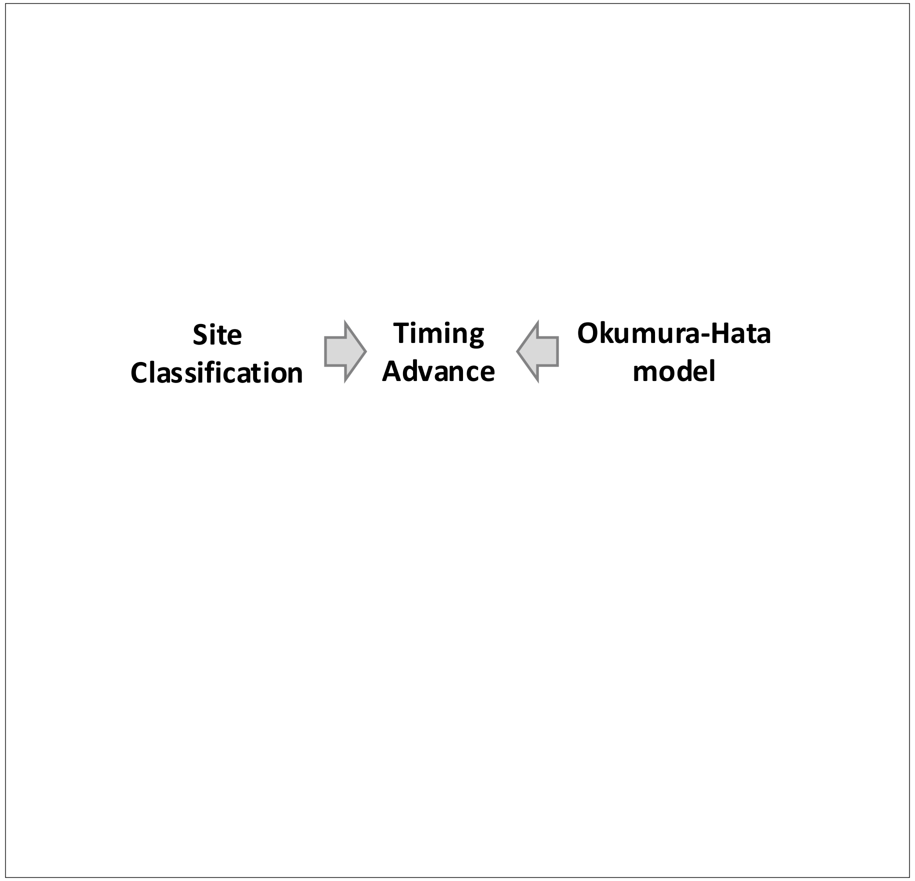
- Site classification is used as an input feature to downstream processes
- Calculation is completed using a site density per distance band ratio
- Sites are classified into the following 3 categories; "Urban", "Suburban", "Rural"

Timing Advance Modeling – Without Geo-Spatial or PM Data

Impacts available + cell GIS available



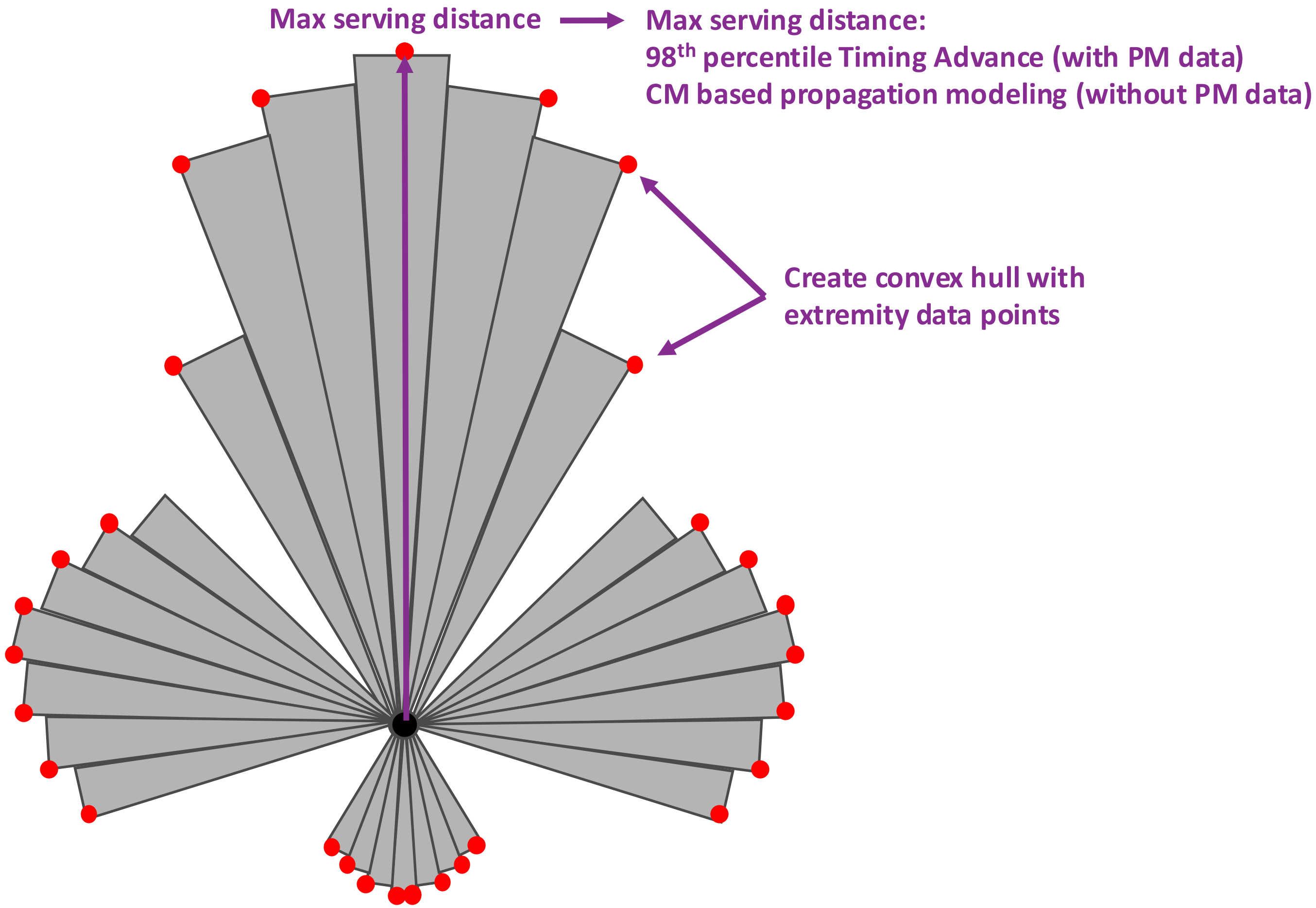
Cell GIS available



Timing Advance Modeling:

- Timing advance modeling is a simplistic process when geo-spatial or timing advance PM data is available
- When this is not available timing advance is modeled in 2 different ways depending on available data
    - Impacts + cell GIS
        - Model propagation using; weighted average impact distance, site classification, Okumura-Hata model
    - Cell GIS only
        - Model propagation using; site classification, Okumura-Hata model

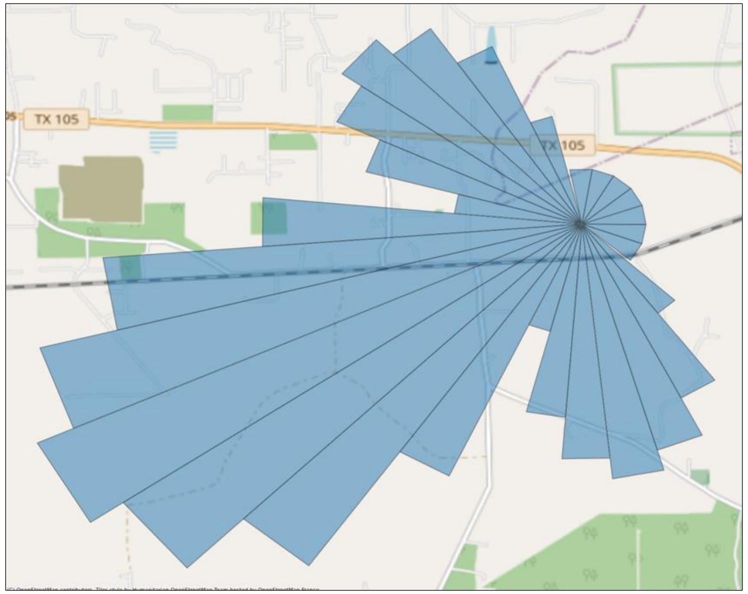
Create Coverage Model – Without Geo-Spatial data



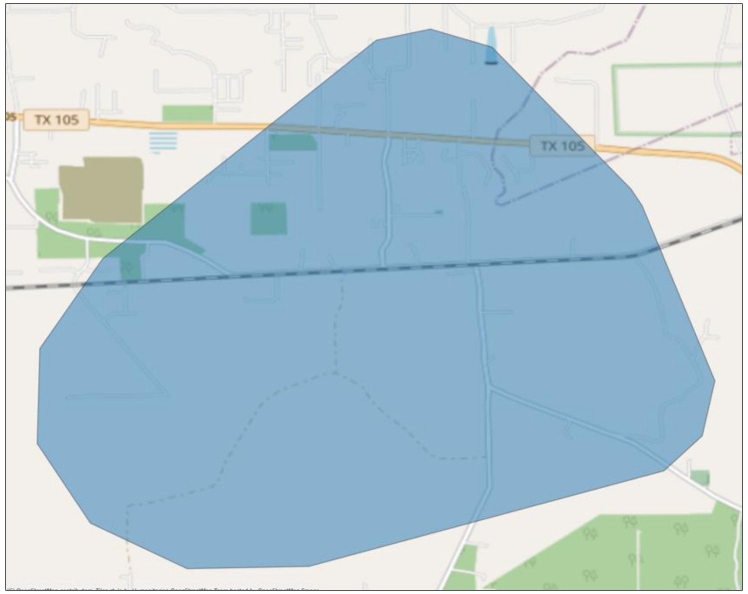
Coverage model without geo-spatial data:
Without geo-spatial data 2 coverage models are available
- Predicted coverage using PM (Timing Advance) + Cell Geo
- Predicted coverage using CM (neighbor relations) + Cell Geo

PM provides the most accurate of these methods. CM predicted coverage has inherent issues but can be used as a last resort.

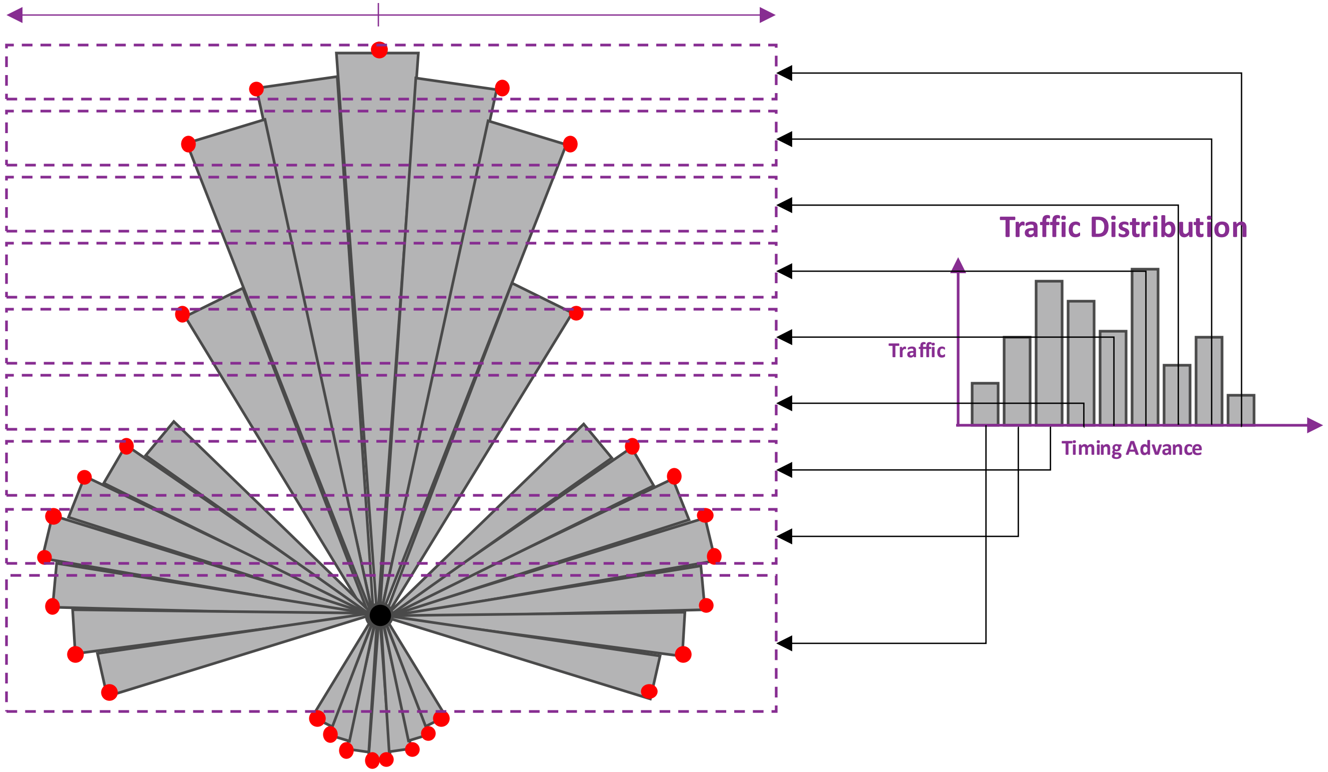
Cell example – coverage model construction



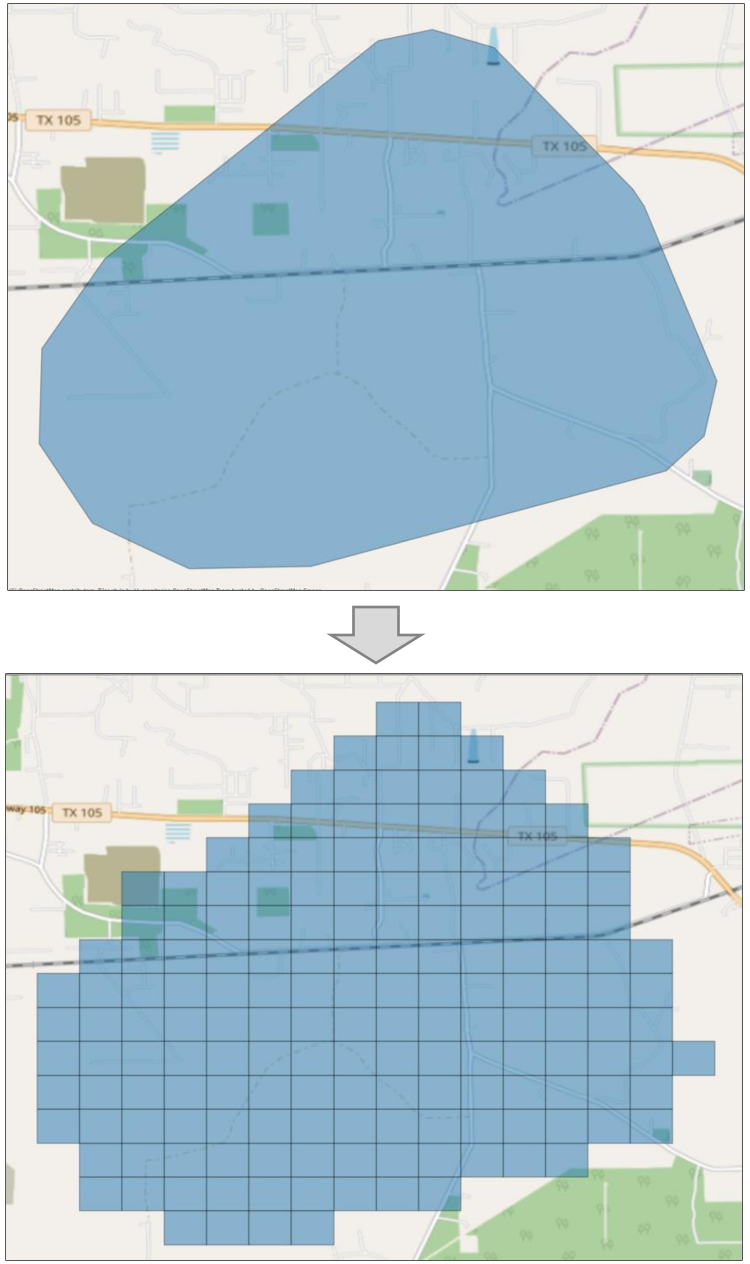
Cell example – coverage mode, applied convex hull



Traffic Distribution – Without Geo-Spatial data (With PM)



From convex hull to spatial grid



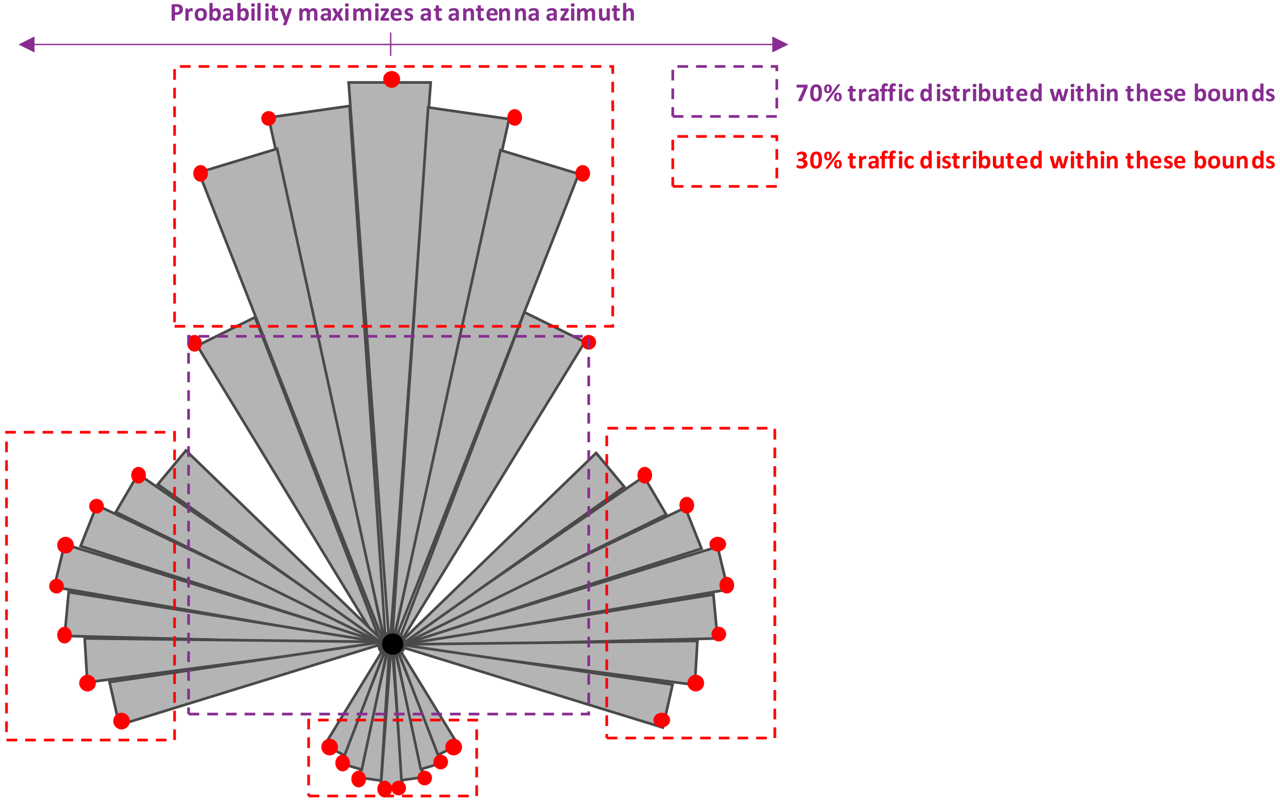
Traffic distribution without geo-spatial data – with PM data:

Traffic is distributed across the cell based on

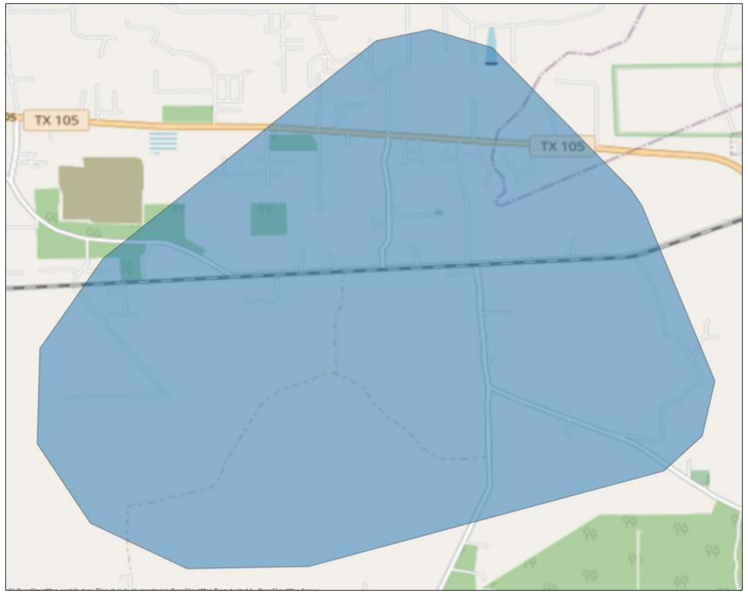
- PM Timing Advance traffic distribution
- Distance from antenna azimuth
- Front/side lobe

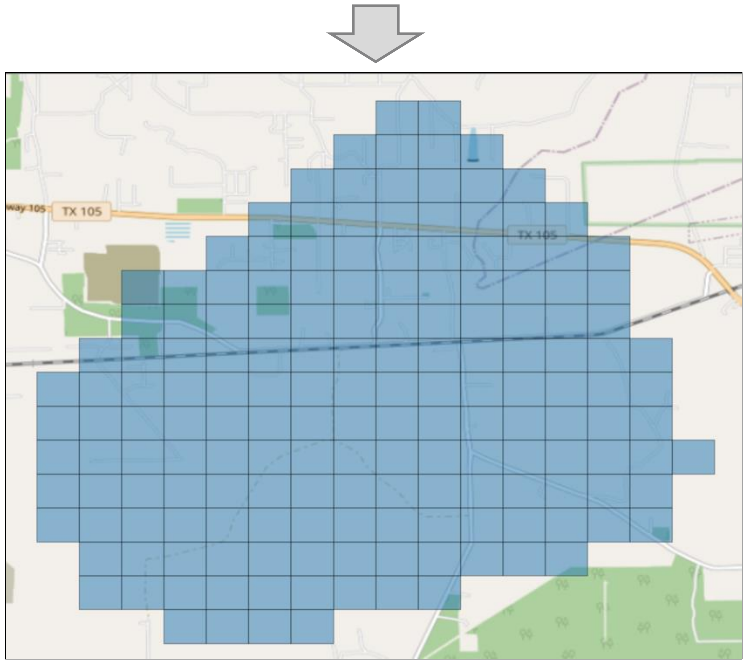
Traffic distribution is shown above pre-spatial bin creation for explanation purposes, traffic distribution phase is actually completed post-spatial bin creation. Traffic distribution can be improved using population density geo-spatial layer (not discussed in this document)

Traffic Distribution – Without Geo-Spatial data (Without PM)



From convex hull to spatial grid





Traffic distribution without geo-spatial data – without PM data:

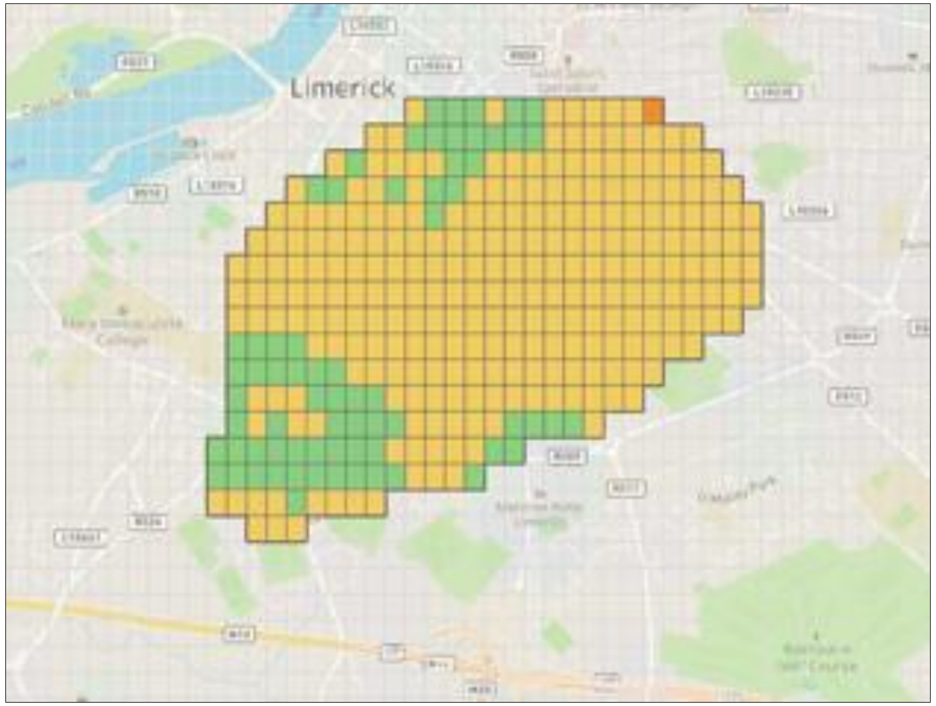
Traffic is distributed across the cell based on

- Cell distance bands
- Distance from antenna azimuth
- Front/side lobe

Traffic distribution is shown above pre-spatial bin creation for explanation purposes, traffic distribution phase is actually completed post-spatial bin creation. Traffic distribution can be improved using population density geo-spatial layer (not discussed in this document)

Traffic Distribution – With Geo-Spatial data

Traffic density map based on cell trace data



Traffic distribution with geo-spatial data:

When geo-spatial data is available traffic distribution is an inherent part of the dataset. No probabilistic measurements required. It is only required to receive the binned data with the aggregation of the cell and cell session count included.

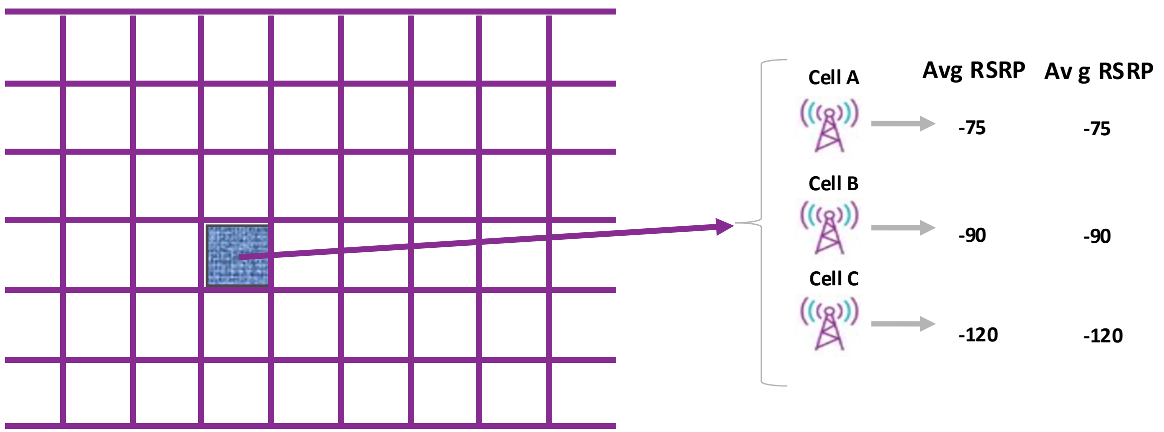
Cell-Bin data set should include

- All bins which the cell interacted with
- A way to calculate the bin contribution to the cell in percentage terms, e.g. session count

Coverage Distribution – With and Without Geo-Spatial data

With Trace/Crowd based geo-spatial data

Trace/Crowd based geo-spatial data



Without Trace/Crowd based geo-spatial data

$$L = 69.55+26.16\log(f)-13.82\log(H_b)-a(H_m)+(44.9-6.55\log(H_b))\log(d)$$

Where;

L = path loss (dB)

f = frequency (MHz)

H_b = transmitter antenna height above ground (m)

H_m = receiver antenna height above ground (m)

d = distance between transmitter and receiver (km)

$a(H_m)$ = antenna height correction factor

Basic model shown above, additional offsets apply for specific environments urban/suburban/rural (shown in appendix)

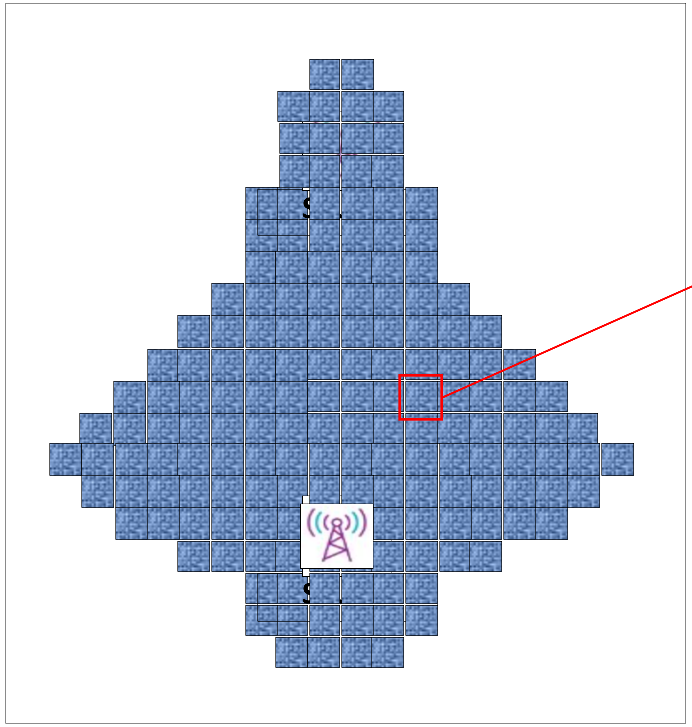
Coverage distribution:

There are 2 distinct cases here

- With geo-spatial data
  - With geo-spatial data the RSRP/RSRQ distribution is an inherent part of the dataset
- Without geo-spatial data
  - Without geo-spatial data the RSRP/RSRQ distribution must be predicted using standard models (e.g. Okumura-Hata)

Cell-Bin Geo-Spatial Metrics

Unified per-cell geo-spatial metrics irrespective of input data sources



Fields per Cell-Bin aggregation

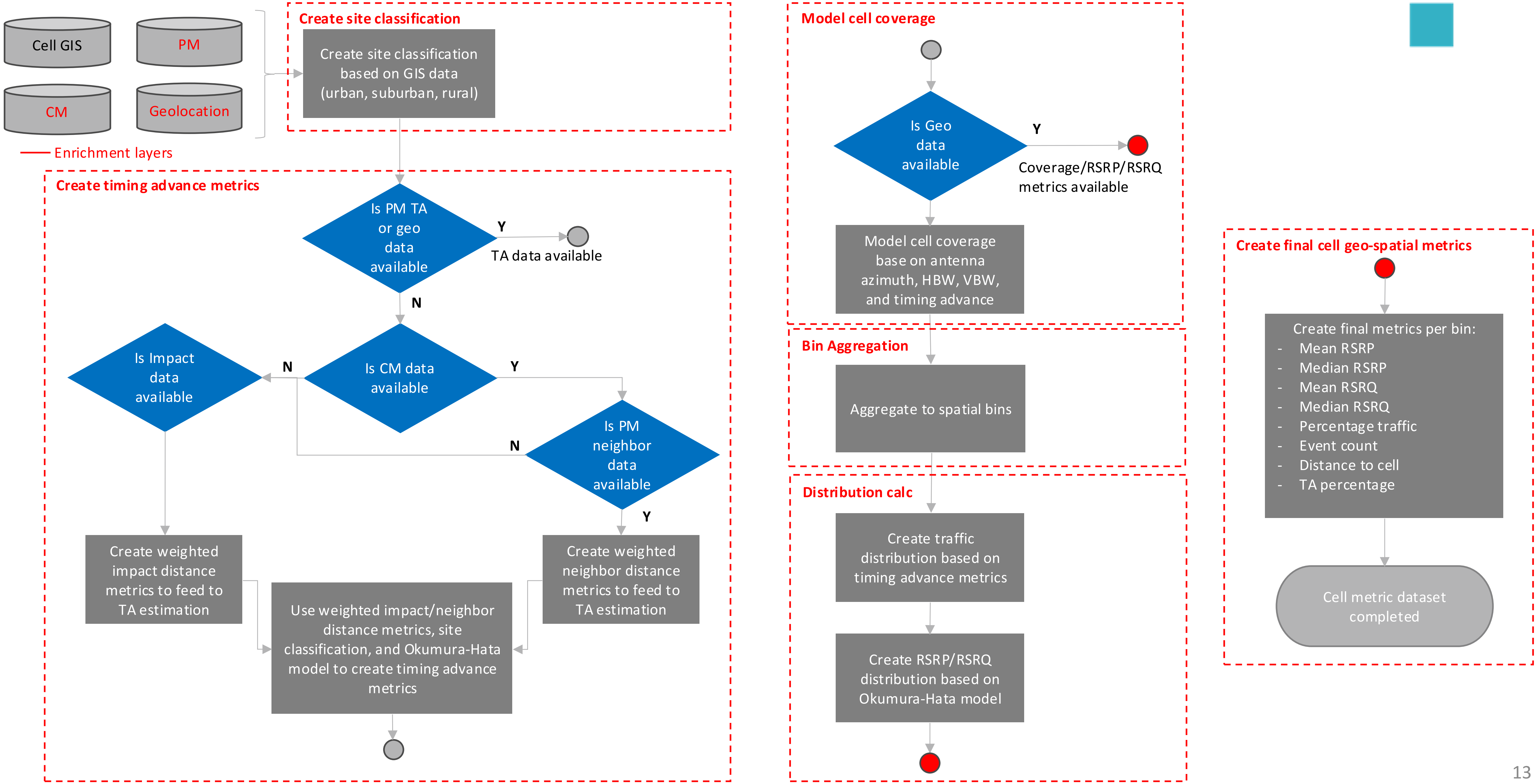
- Mean RSRP
- Median RSRP
- Mean RSRQ
- Median RSRQ
- Percentage traffic
- Event count
- Distance to cell
- TA percentage

Cell-Bin geo-spatial metrics creation:

All building blocks for the geo-spatial metrics dataset have now been completed, final dataset can now be created.

- Building blocks
  - Site classification
  - Timing advance modeling
  - Traffic distribution to spatial bins
  - Coverage distribution to spatial bins
- Final dataset
  - Coverage/quality metrics
  - Traffic distribution modeling
  - Distance to source cell / percentage of max timing advance

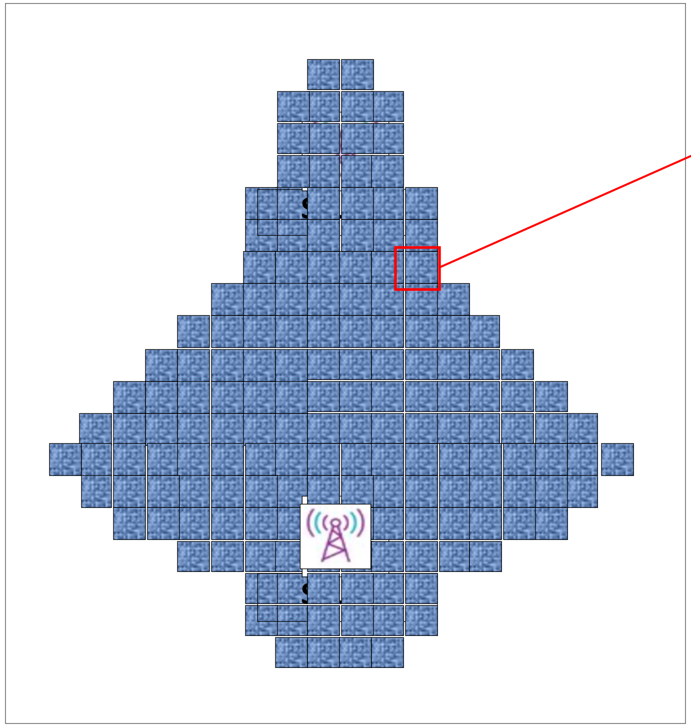
Create Cell-Bin Geo-Spatial Metrics - Flowcharts



RADCOM Recommendations
Create Per Cell Metrics

Per Cell Metrics

Cell-Bin Metrics



Fields per Cell-Bin aggregation

- Mean RSRP
- Median RSRP
- Mean RSRQ
- Median RSRQ
- Percentage cell traffic
- Event count
- Distance to cell
- TA percentage

Fields per cell aggregation

- 98th percentile timing advance
- Count of cell coverage bin
- Excellent RSRP bins
- Good RSRP bins
- Average RSRP bins
- Poor RSRP bins
- Bad RSRP bins
- Excellent RSRQ bins
- Good RSRQ bins
- Average RSRQ bins
- Poor RSRQ bins
- Bad RSRQ bins
- Average distance - excellent RSRP bins
- Average distance - good RSRP bins
- Average distance - average RSRP bins
- Average distance - poor RSRP bins
- Average distance - bad RSRP bins
- Average distance - excellent RSRQ bins
- Average distance - good RSRQ bins
- Average distance - average RSRQ bins
- Average distance - poor RSRQ bins
- Average distance - bad RSRQ bins

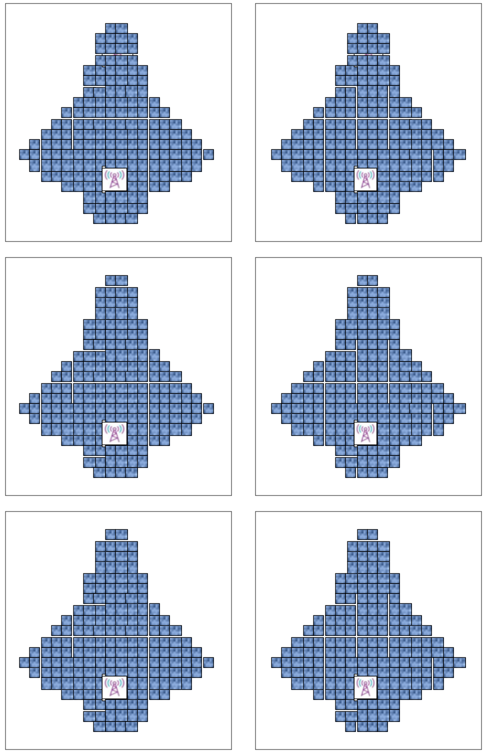
Per cell metrics:

- Cell-Bin metrics are generalized to cell aggregation
- These are used for identifying optimization opportunities
- This table will be further enriched with data from the per bin metrics table (discussed in following sections)

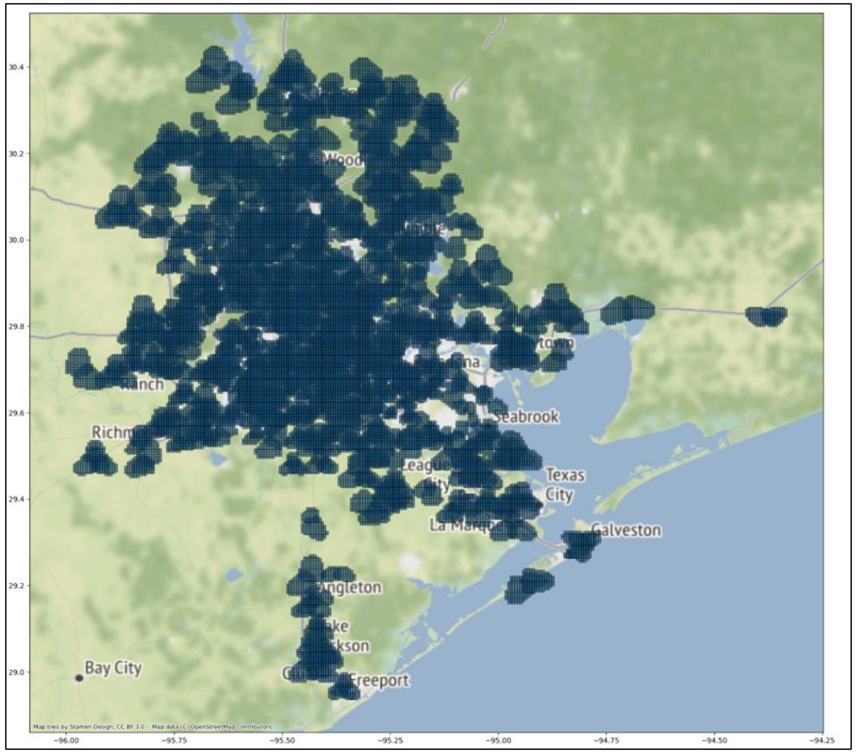
RADCOM Recommendations
Merged Cell-Bin Metrics

Merge Cell-Bin Dataset

Cell-Bin dataset



Merge to create Merged Cell-Bin Metrics dataset



Fields Merged Cell-Bin aggregation

- Mean RSRP
- Median RSRP
- Mean RSRQ
- Median RSRQ
- Percentage cell traffic
- Event count
- Distance to cell
- TA percentage
- Percentage bin traffic

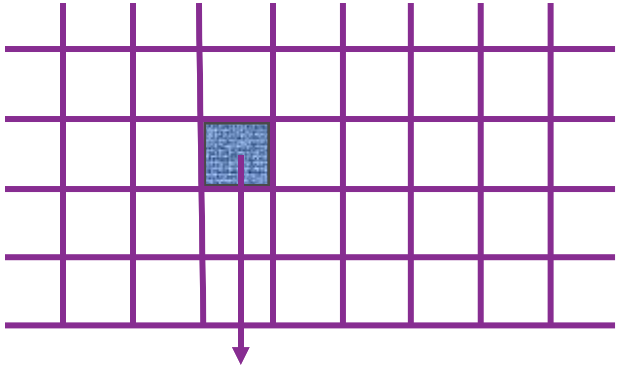
Per cell metrics:

- Cell-Bin metrics are generalized to cell aggregation
- These are used for identifying optimization opportunities
- This table will be further enriched with data from the overall bin metrics table (discussed in next section)

RADCOM Recommendations
Per Bin Metrics

Per Bin Metrics Dataset

Merged Cell-Bin metrics dataset



	Mean RSRP	Median RSRP	Mean RSRQ	…. Dominant cell	Interference cell
Cell A	-75	-71	-10	Y	N
Cell B	-90	-92	-14	N	N
Cell C	-120	-121	-20	N	Y

Fields Merged Cell-Bin aggregation

- Mean RSRP
- Median RSRP
- Mean RSRQ
- Median RSRQ
- Percentage cell traffic
- Event count
- Distance to cell
- TA percentage
- Percentage bin traffic
- Dominant cell
- Interference cell
- Coverage deviation from dominant cell

Fields Per Bin aggregation

- Mean RSRP
- Median RSRP
- Mean RSRQ
- Median RSRQ
- Event count
- Total cell list
- Dominant cell list
- Interference cell list
- Coverage deviation from dominant cell

Fields per cell aggregation

- 98th percentile timing advance
- Cell coverage bin
- Excellent RSRP bins
- Good RSRP bins
- Average RSRP bins
- Poor RSRP bins
- Bad RSRP bins
- Excellent RSRQ bins
- Good RSRQ bins
- Average RSRQ bins
- Poor RSRQ bins
- Bad RSRQ bins
- Average distance - excellent RSRP bins
- Average distance - good RSRP bins
- Average distance - average RSRP bins
- Average distance - poor RSRP bins
- Average distance - bad RSRP bins
- Average distance - excellent RSRQ bins
- Average distance - good RSRQ bins
- Average distance - average RSRQ bins
- Average distance - poor RSRQ bins
- Average distance - bad RSRQ bins

Merged Cell-Bin metrics:

- Spatial union of all Cell-Bin metrics data
- Contains all fields from Cell-Bin metrics data along with additional fields
    - Percentage bin traffic
    - Dominant cell
    - Interference cell
    - Coverage deviation from dominant cell