Indoor Location Accuracy for 9-1-1

11/04/2014

APCO International
Emerging Technology Forum

TCS TeleCommunication Systems
Enabling Convergent Technologies®

Topics

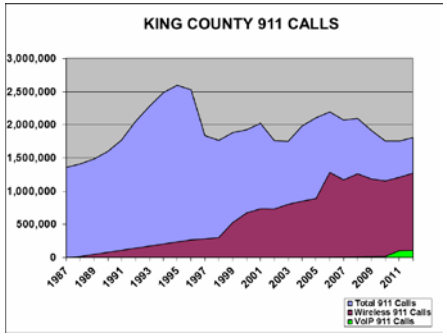
- Is there a concern?
- The Challenge
- The Options
  - Improving Existing Technologies
  - Focusing on Wi-Fi Initiatives
- A New Testing Paradigm
- The Power of Analytics
- Questions

THE CONCERN

More calls coming from indoors

» 40% of US population has “cut the cord”
- 2013 CDC study (37% of adults; 45% of children)
- http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201306.pdf

» 70% of 9-1-1 calls come from wireless
- 2012 King County, WA statistic



» Increase in “bad” 9-1-1 calls
- Tarrant County, TX: 2007=3.3%; 2013=7.5%

THE CHALLENGE

Wireless E9-1-1 Call/Data Flow: A Baseline

1: Person dials 9-1-1

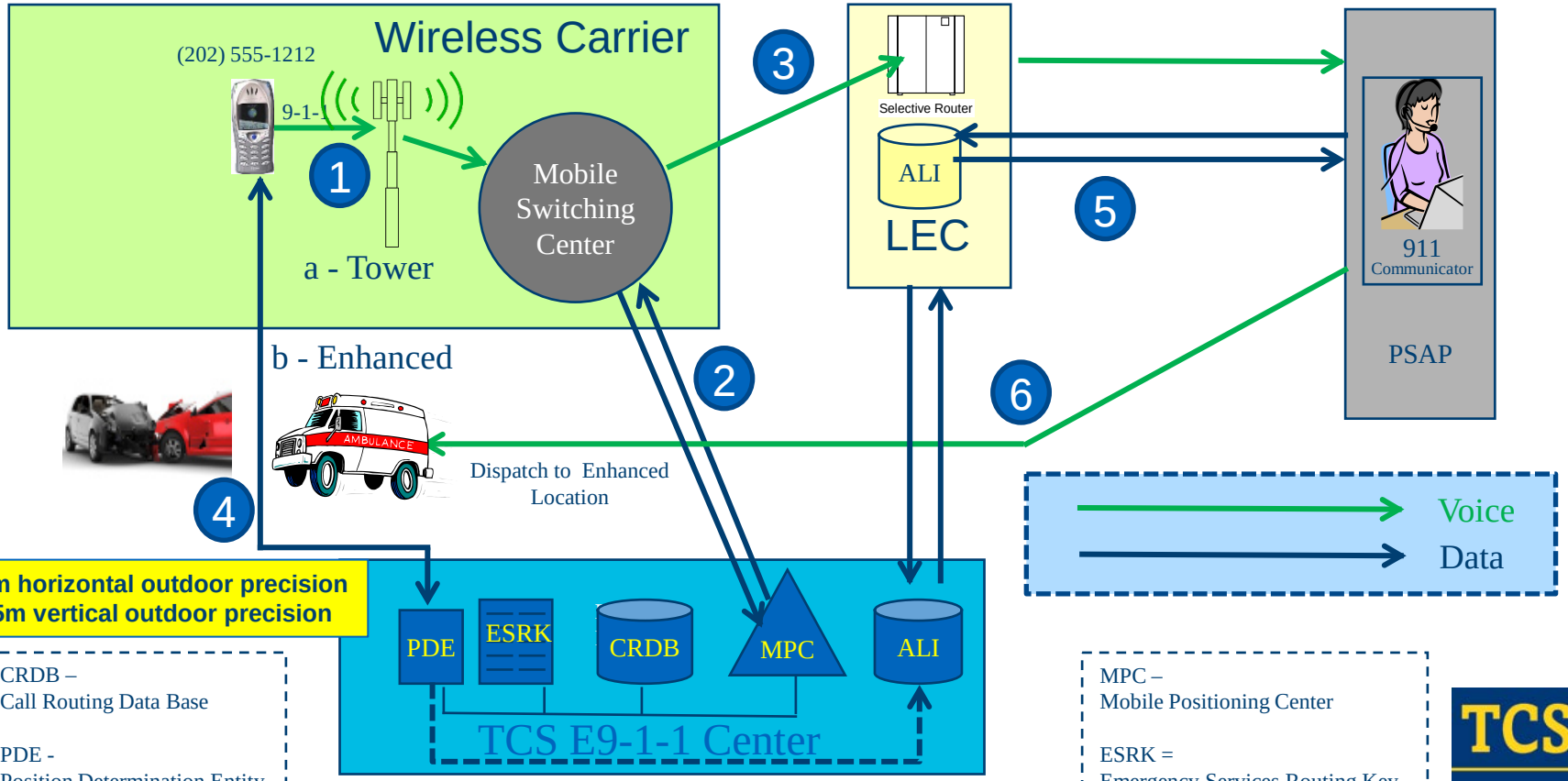
2: MSC requests routing instructions

3: MSC routes call to nearest PSAP

4: E9-1-1 Center gets enhanced location

5: PSAP queries for enhanced location

6: PSAP dispatches assistance



Wireless E9-1-1: Voice/Data Race Condition

1: Person dials 9-1-1

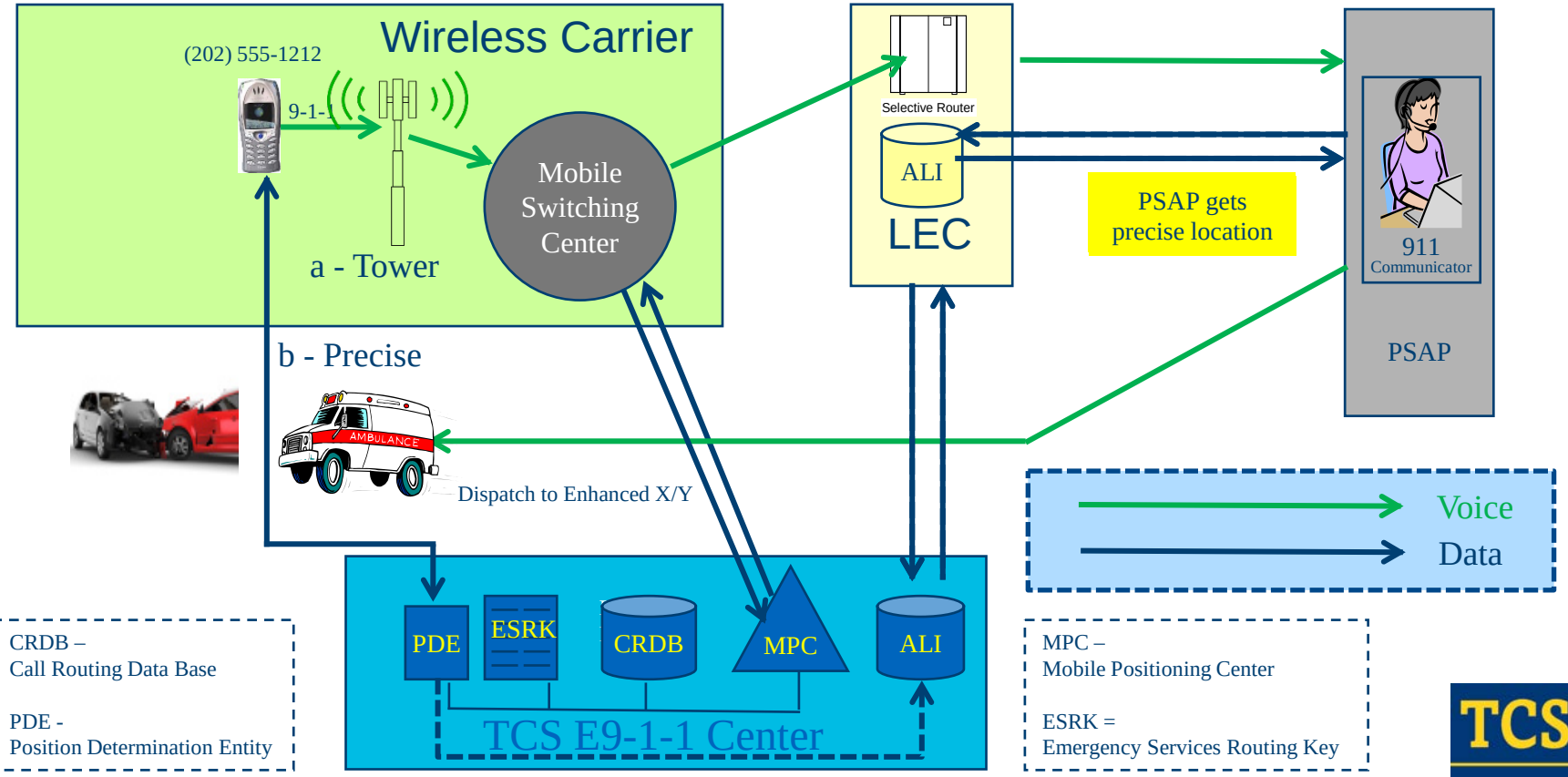
2: MSC requests routing instructions

3: MSC routes call to PSAP

4: PSAP too soon for enhanced location

5: E9-1-1 Center gets enhanced location

6: PSAP must re-bid for enhanced location



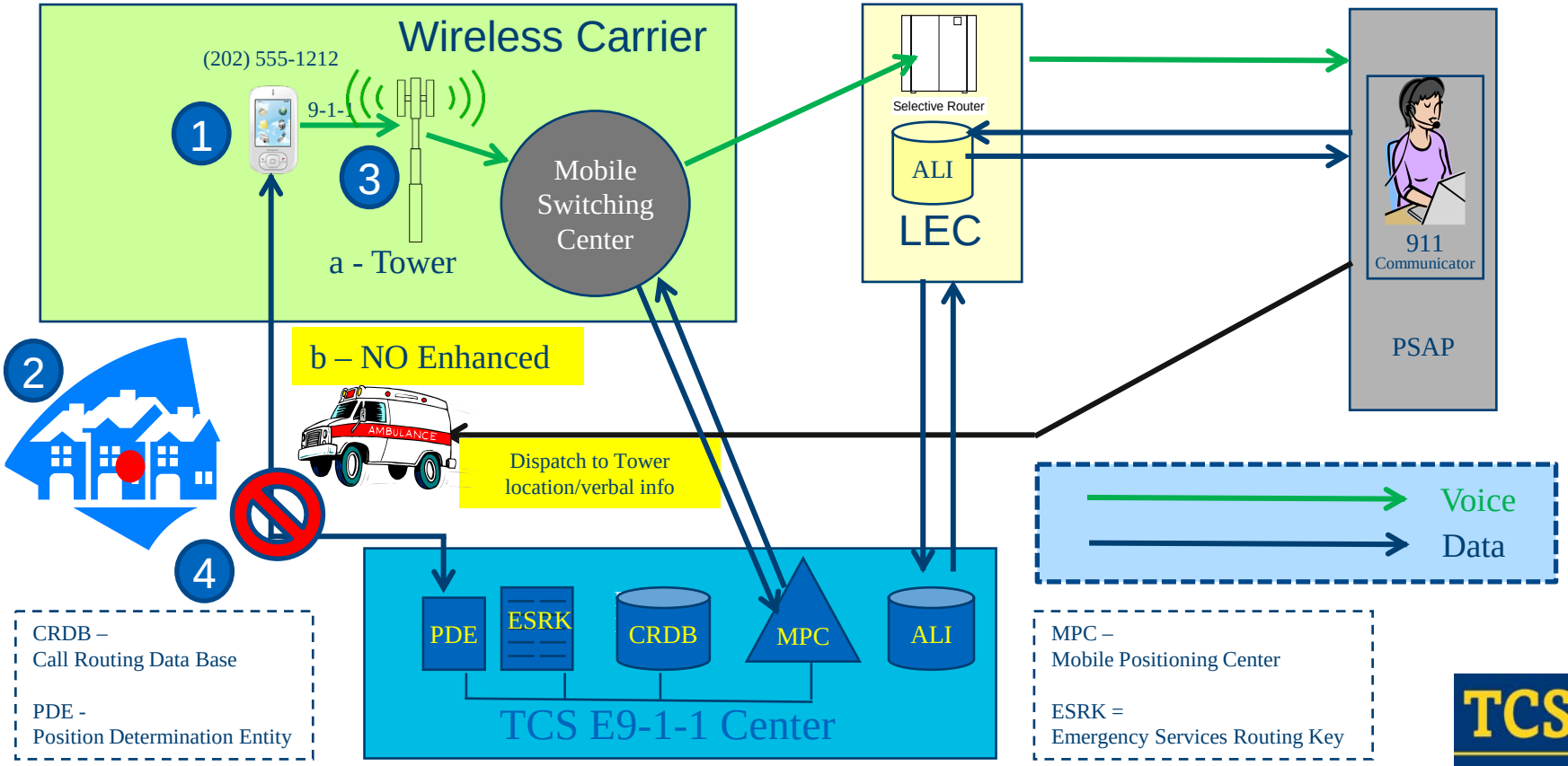
Wireless E9-1-1: Indoor Problems

1: Smartphones with GPS

2: Homes “cutting the cord”

3: 9-1-1 Calls from Indoor Locations

4: Failing to get an enhanced location!



THE OPTIONS

"Outdoor" technologies

- GNSS
- Metropolitan Beacons
- OTDOA

"Indoor" technologies

- Small Cells
- Femtocells
- Wi-Fi

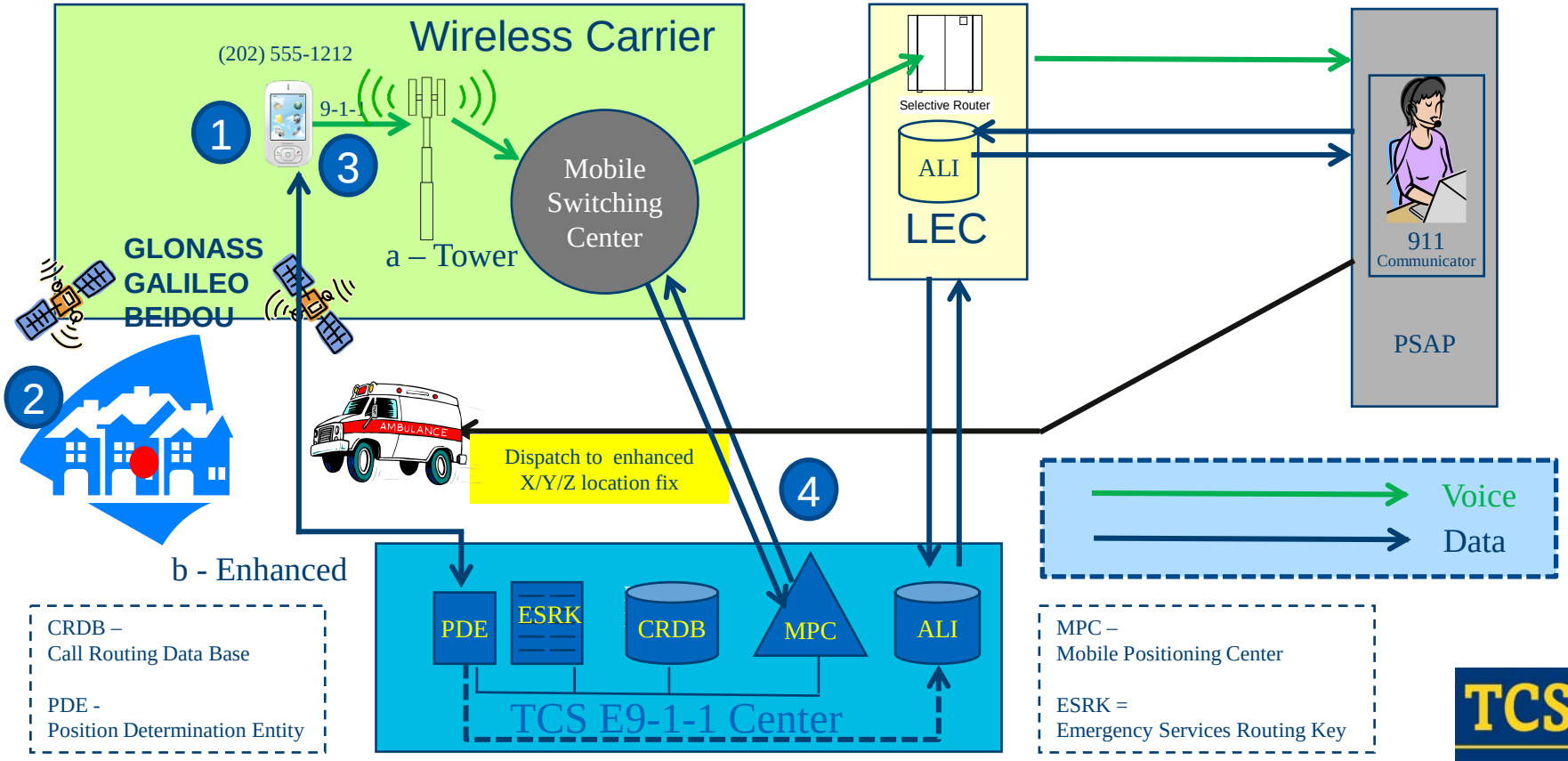
Wireless E9-1-1: Enhancing GPS

1: Smartphones with GPS

2: New Satellite constellations

3: 9-1-1 Calls from Indoor Locations

4: Multiple GPS satellites X/Y/Z fix



Expanding the GPS satellite ecosystem

- GLONASS - Deployed now
  - Russian ownership
  - Full global coverage
  - 21+3 satellites
  - 4-7m horizontal; 10-15m vertical precision
- Galileo – Deploying
  - European Union ownership
  - Full global coverage
  - 4 satellites now; 27+3 by 2019
  - 4m horizontal; 8m vertical precision (paid)
- Beidou – Deploying (COMPASS)
  - Chinese ownership
  - Regional, expanding to global coverage
  - 30+5 satellites
  - 25m horizontal; 30m vertical precision

Combining satellite systems is expected to double precision

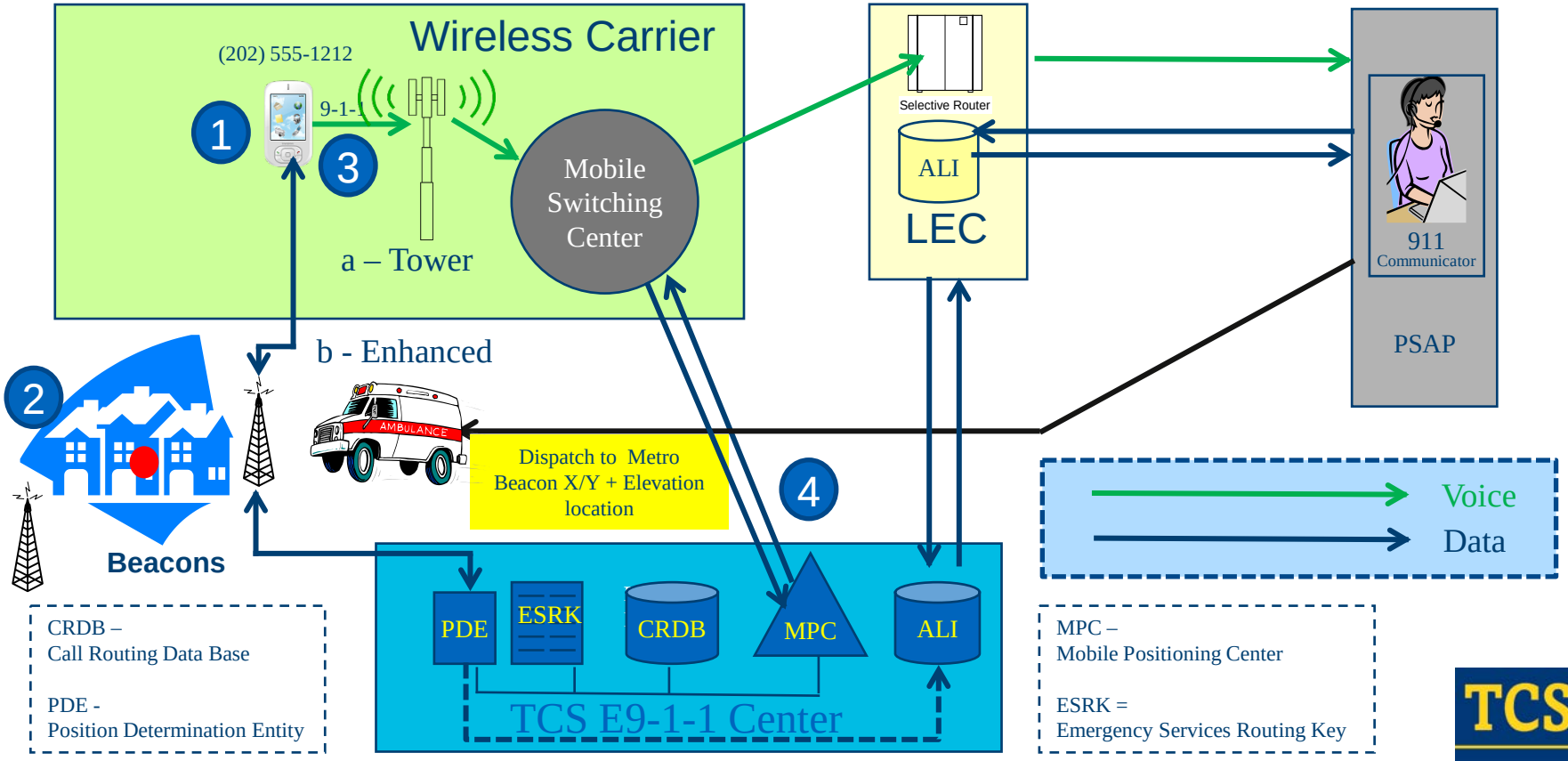
Wireless E9-1-1: Metropolitan Beacons

1: Smartphones with MBS

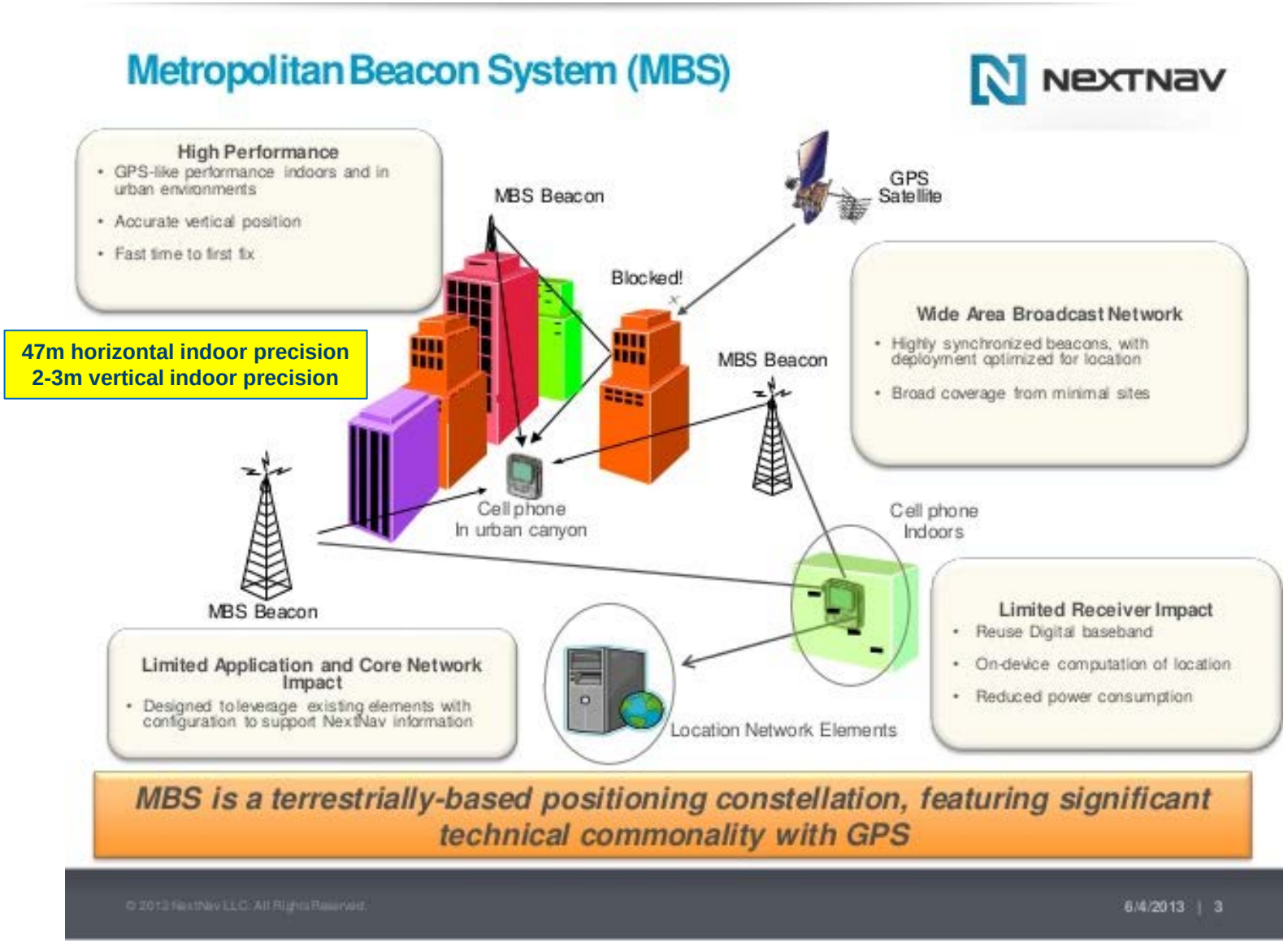
2: Metropolitan Beacons deployed

3: 9-1-1 Calls from Indoor Locations

4: X/Y + Elevation from Metro Beacons



Overview of MBS from NextNav



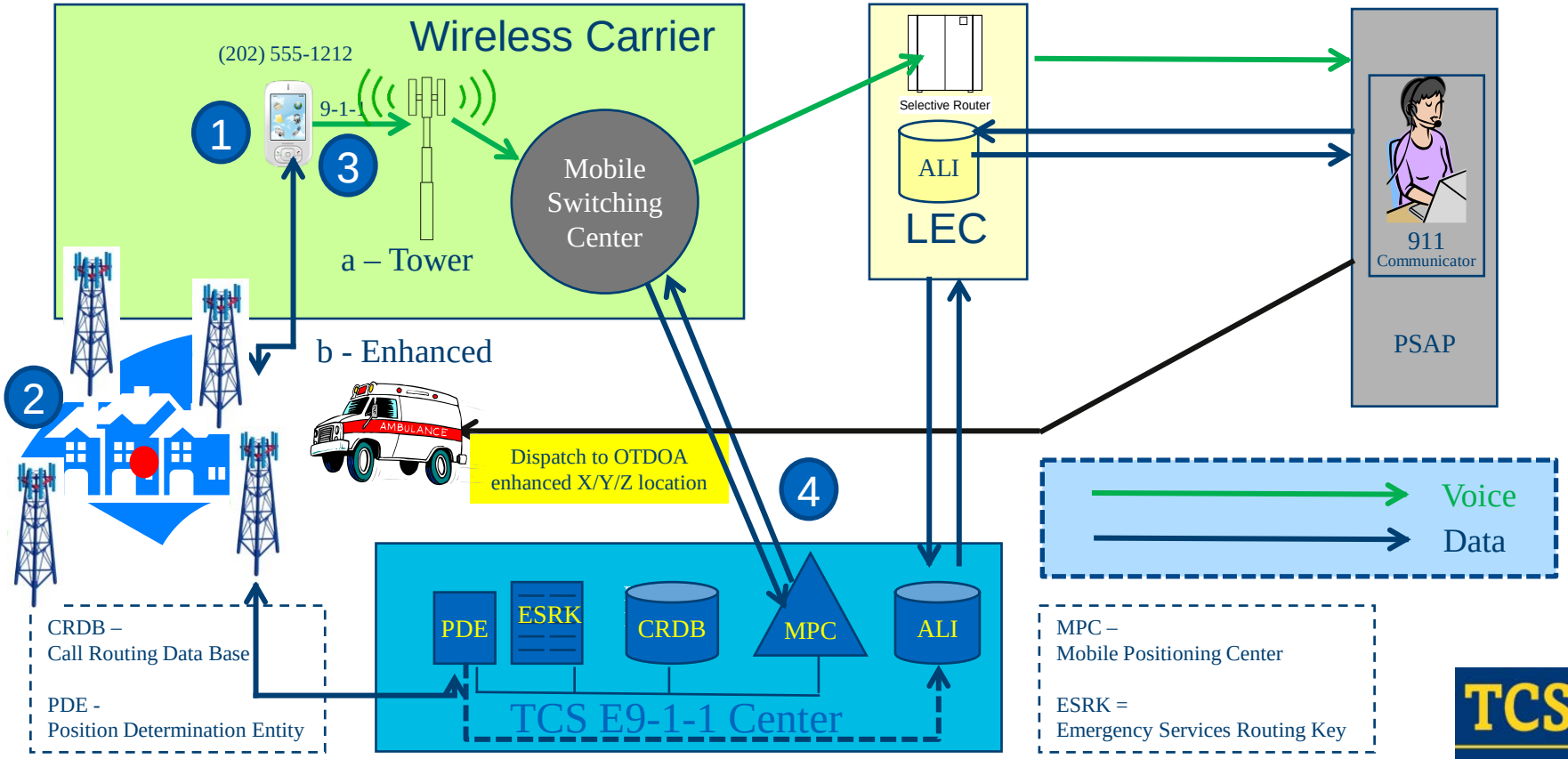
Wireless E9-1-1: OTDOA

1: Smartphones with LTE

2: Dense LTE network deployed

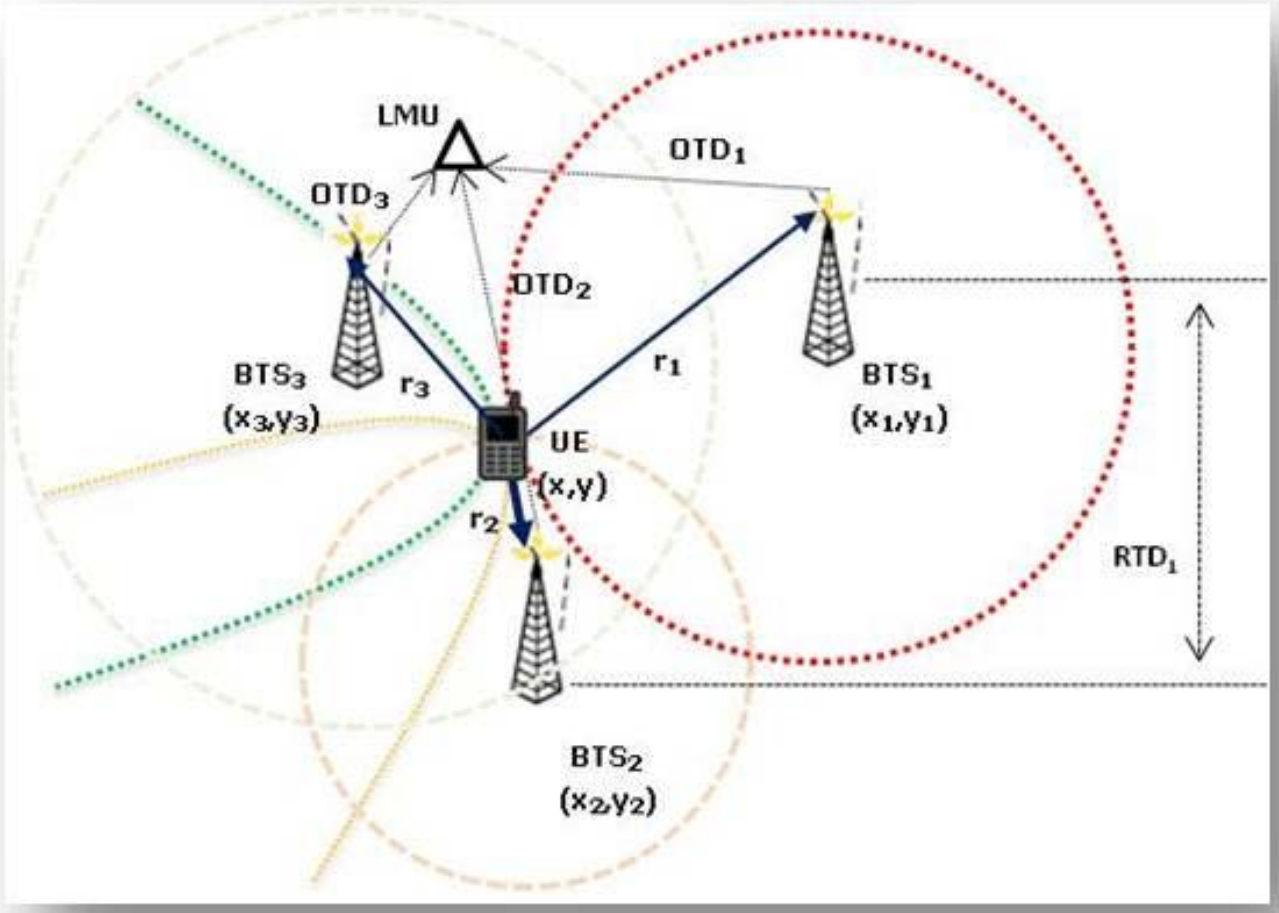
3: 9-1-1 Calls from Indoor Locations

4: X/Y/Z from dense OTDOA



OTDOA – Math, Physics & Geometry

Observed Time Difference of Arrival



http://technowizz.tumblr.com/

Part of LTE standard

3GPP Release 9+

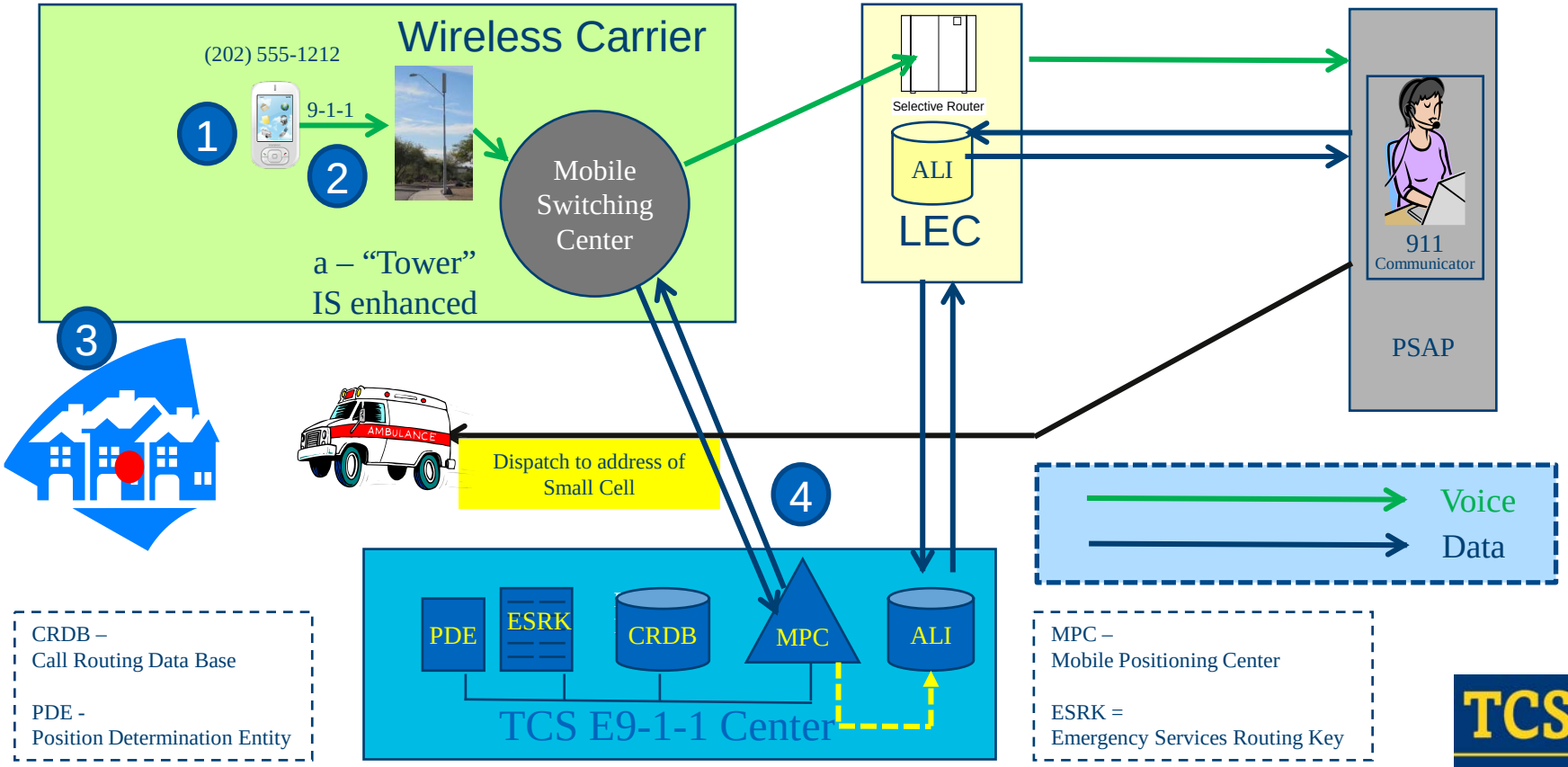
Wireless E9-1-1: Small Cells

1: Any wireless phone (usually LTE)

2: Small Cells deployed

3: 9-1-1 Calls from Indoor Locations

4: Dispatchable Address of Small Cell



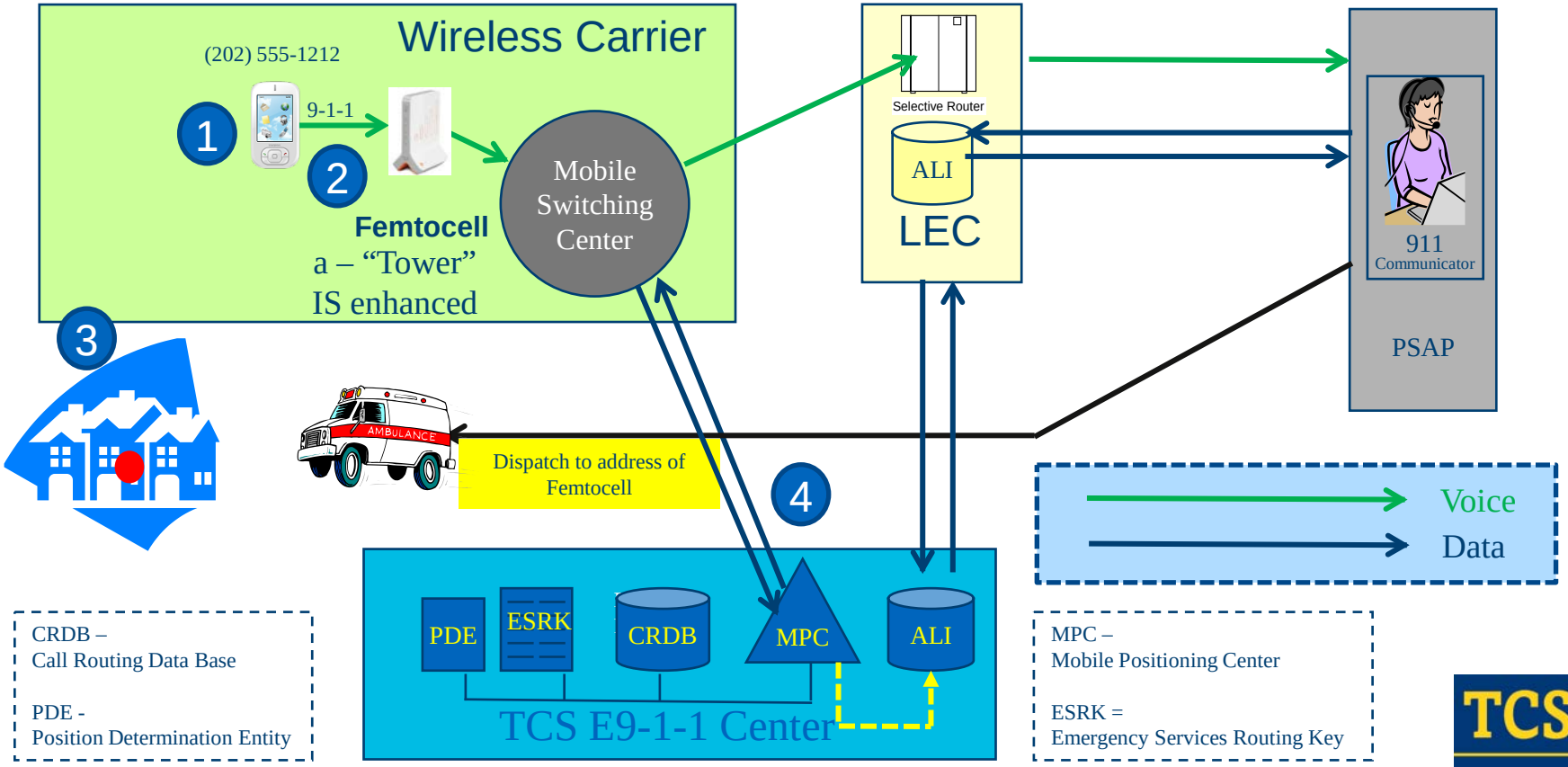
Wireless E9-1-1: Femtocells

1: Any wireless phone (usually LTE)

2: Consumer purchases Femtocell

3: 9-1-1 Calls from Indoor Locations

4: Dispatchable Address of Femtocell



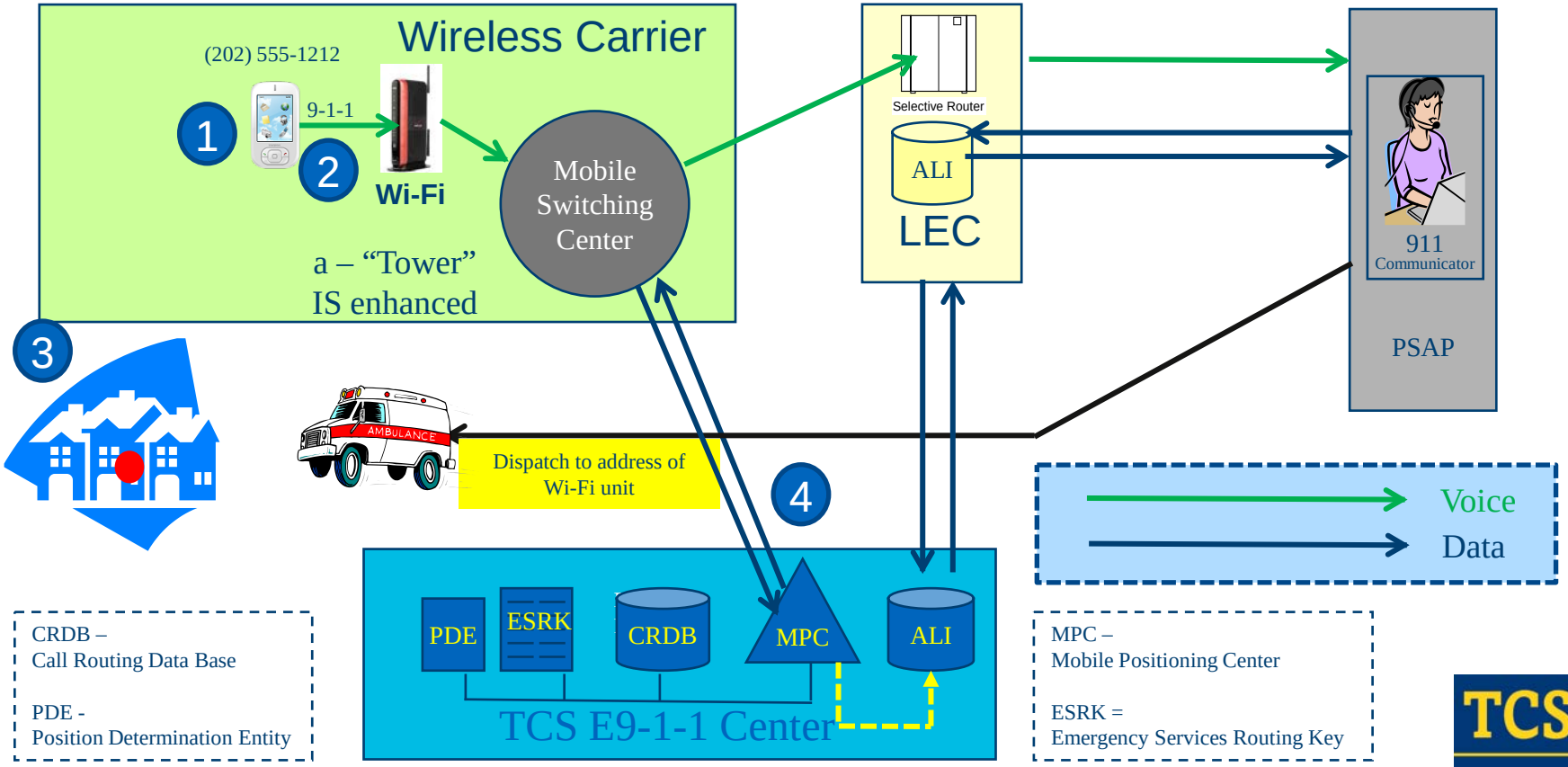
Wireless E9-1-1: Consumer Voice-over-WiFi

1: Smartphones with Wi-Fi

2: Consumer purchases/installs Wi-Fi

3: 9-1-1 Calls from Indoor Locations

4: Dispatchable address of Wi-Fi unit



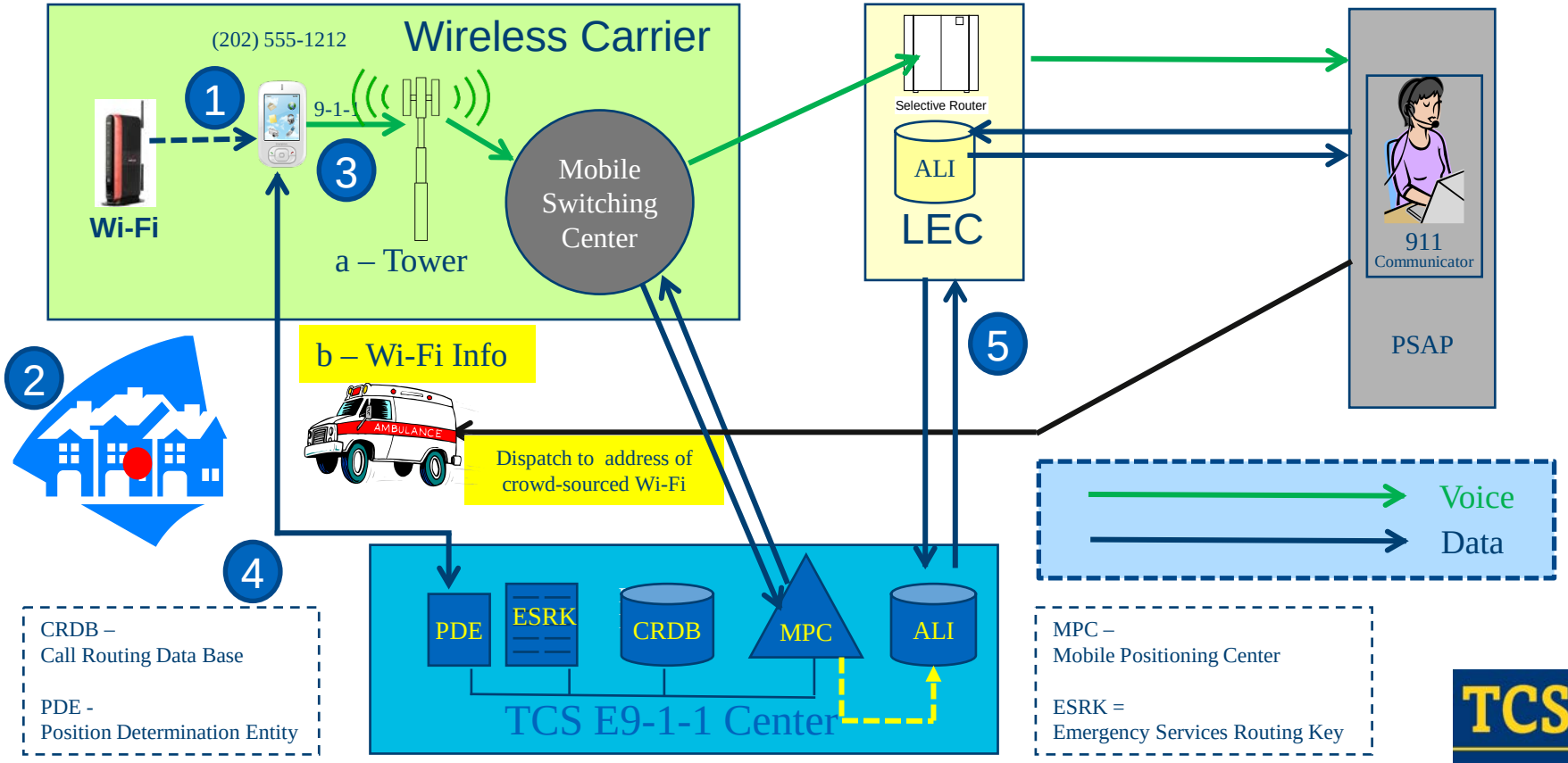
Wireless E9-1-1: Query Crowd-Sourced Wi-Fi

1: Smartphones with Wi-Fi

2: Homes “cutting the cord”

3: 9-1-1 Calls from Indoor Locations

4: Dispatchable address of nearby Wi-Fi



Wireless E9-1-1: Query Enterprise Wi-Fi

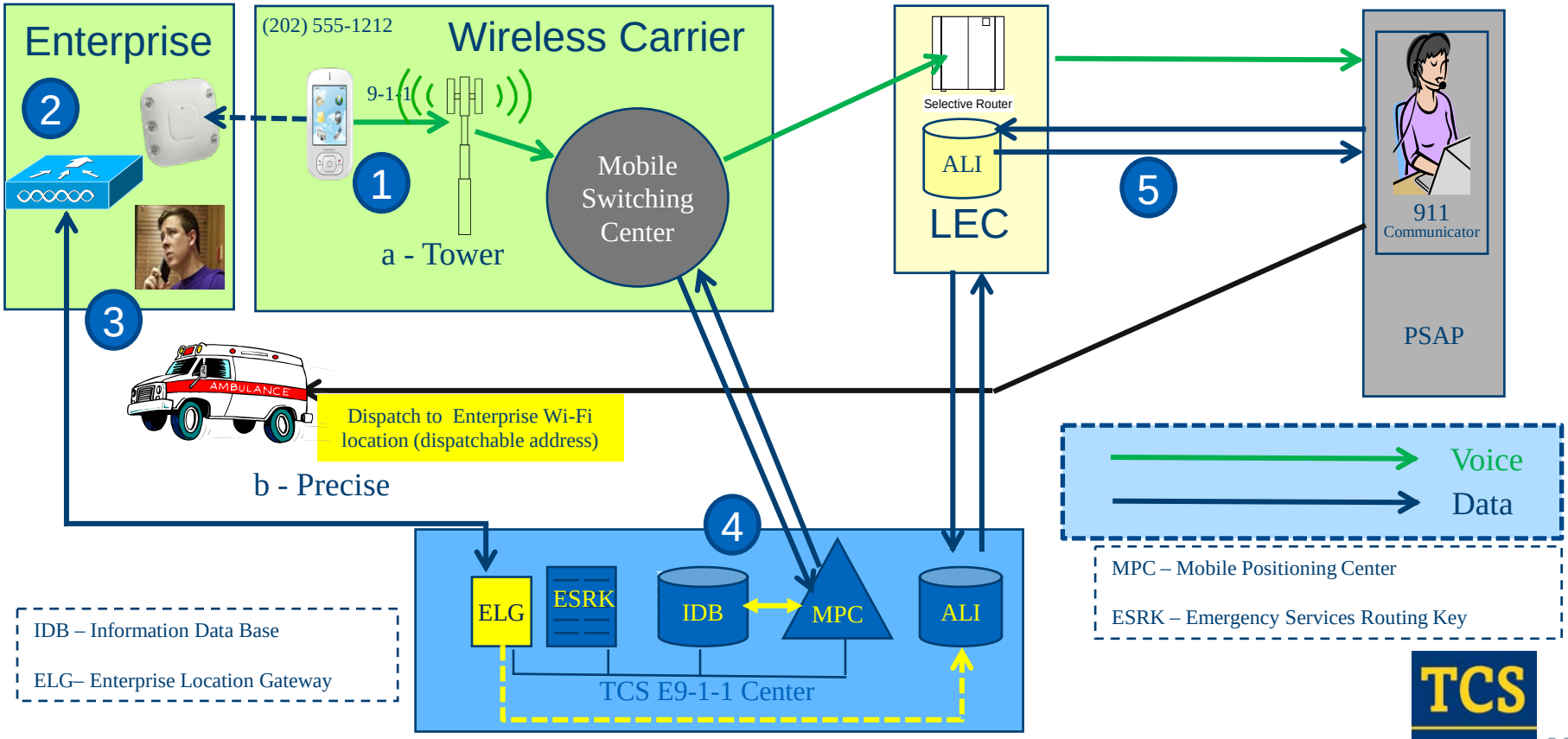
1: Smarphone with Wi-Fi

2: Enterprise installs Wi-Fi access

3: Person in Enterprise calls 9-1-1

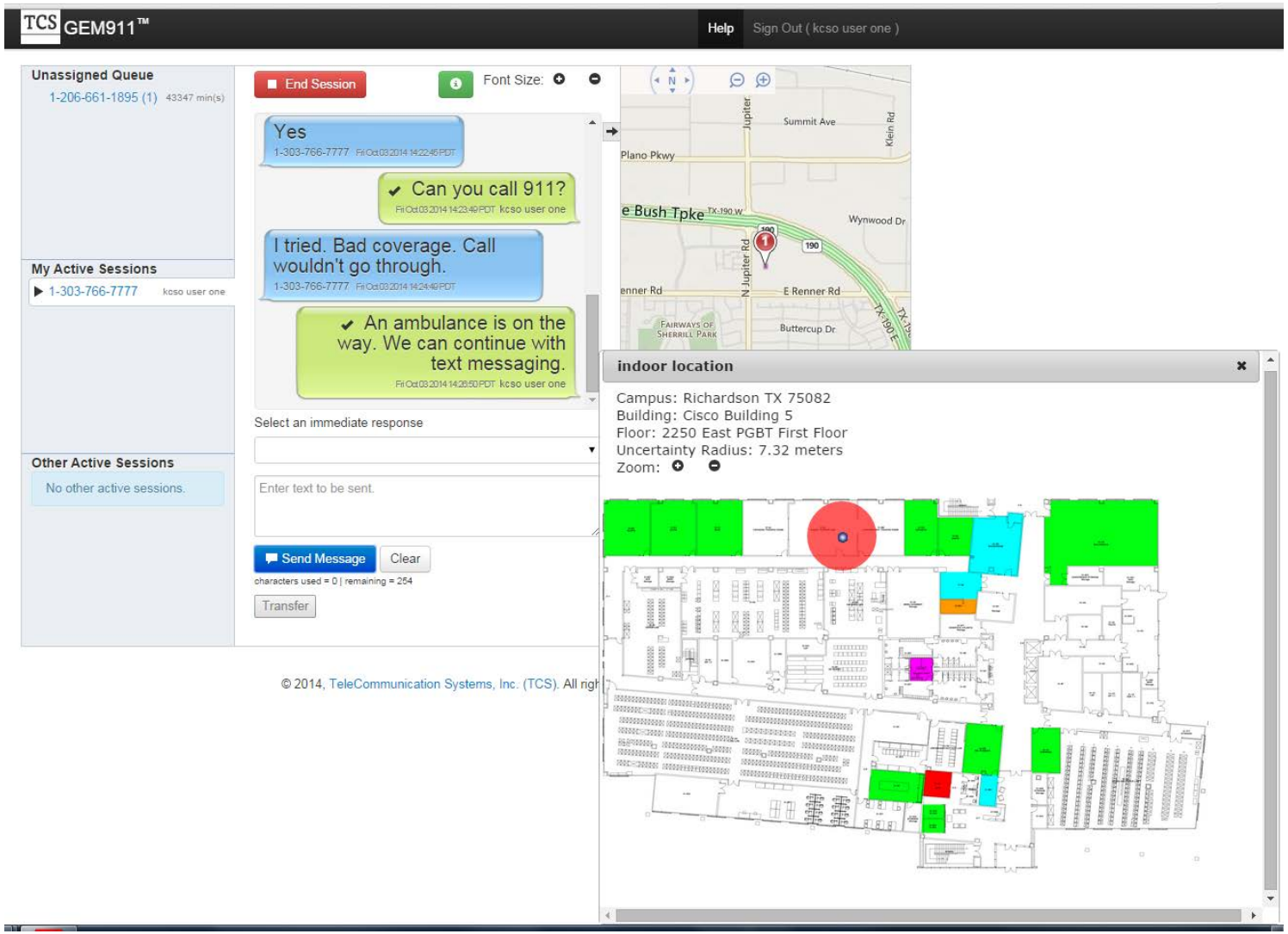
4: E9-1-1 Center prepares query

5: E9-1-1 Center queries Enterprise Wi-Fi



TCS GEM9-1-1 Client – Indoor Location

Using Text Messaging Interface with Indoor Location



A NEW TESTING PARADIGM

Indoor: Challenges Location Testing Paradigm

» Only outdoor location has requirements today

Outdoor location requirements today

- Outdoor requirements = outdoor testing
  - Outdoor location accuracy testing done by carriers
  - Now must be done county-by-county
  - Typically performed by drive testing
  - No requirement on where to conduct drive testing
- Outdoor requirements by technology
  - 50m/150m accuracy; 67%/(80/90%); Handset (AGPS)
  - 100m/300m accuracy; 67%/(80/90%); Network
  - All major wireless carriers have moved to AGPS

Indoor: Challenges Location Testing Paradigm

- Only outdoor location requirements today
- OET-71 applies to outdoor testing only

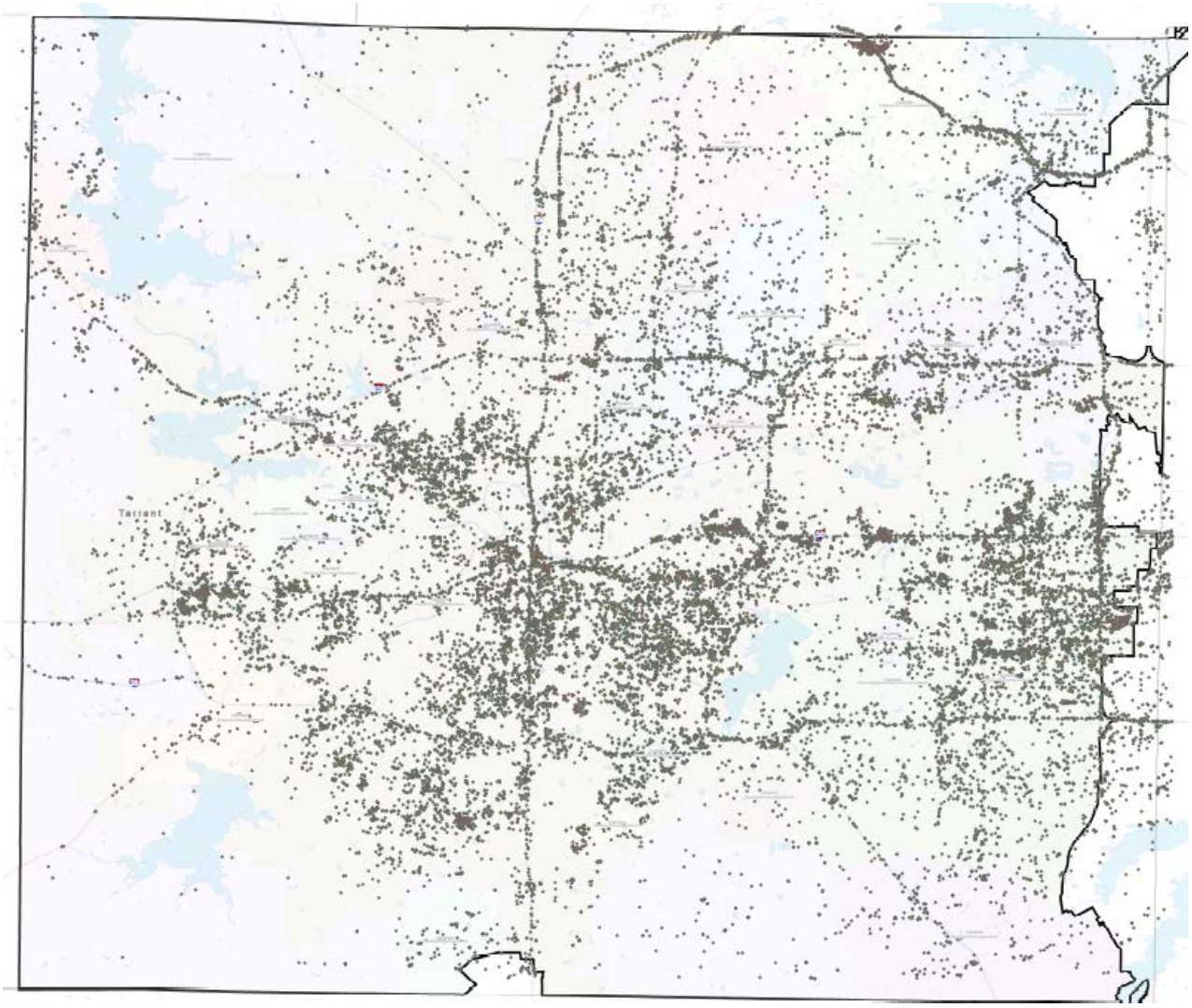
Outdoor location testing guidelines

» OET 71 provides outdoor testing guidelines

- Likely better information will be developed regarding locations from which wireless 911 calls are made but does not establish where testing should be done[1]
- Discusses weighting on likelihood of a 9-1-1 call[3]
- Reporting a vertical dimension is not required[4]
- Predictive models based on different types of environments where technology performance varies[5]
- Suggests randomly selecting and uniformly distributing test locations[2]

[1]OET Bulletin 71 (April 12th, 2000); p.2 [2]Ibid. p.6 [3]Ibid. p.6 [4]Ibid. p.7 [5]Ibid. p.8

Real-World Data Can Guide Our Testing



- Actual 911 calls
- Tarrant County
- All carriers
- August, 2013

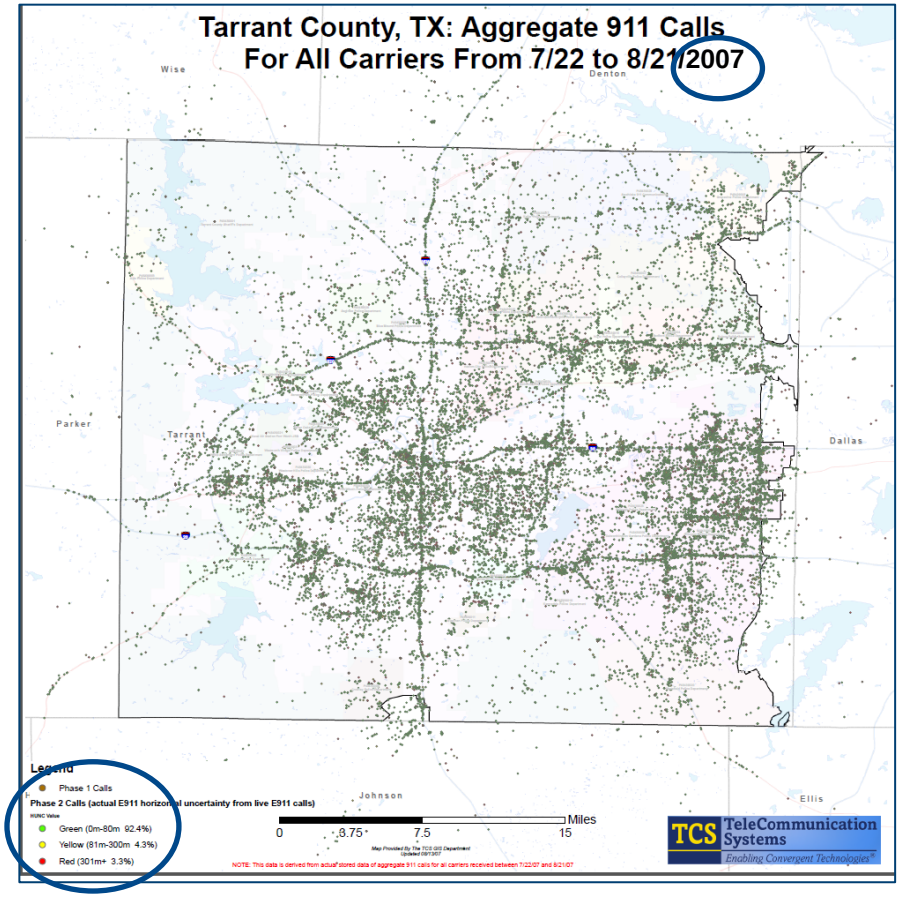
Random?
Uniformly distributed?

Which are Indoors?
Which are Outdoors?

Indoor: Challenges Location Testing Paradigm

- Only outdoor location requirements today
- OET-71 only provides outdoor testing guide
- Cannot distinguish outdoor from indoor

Are more calls from indoors?

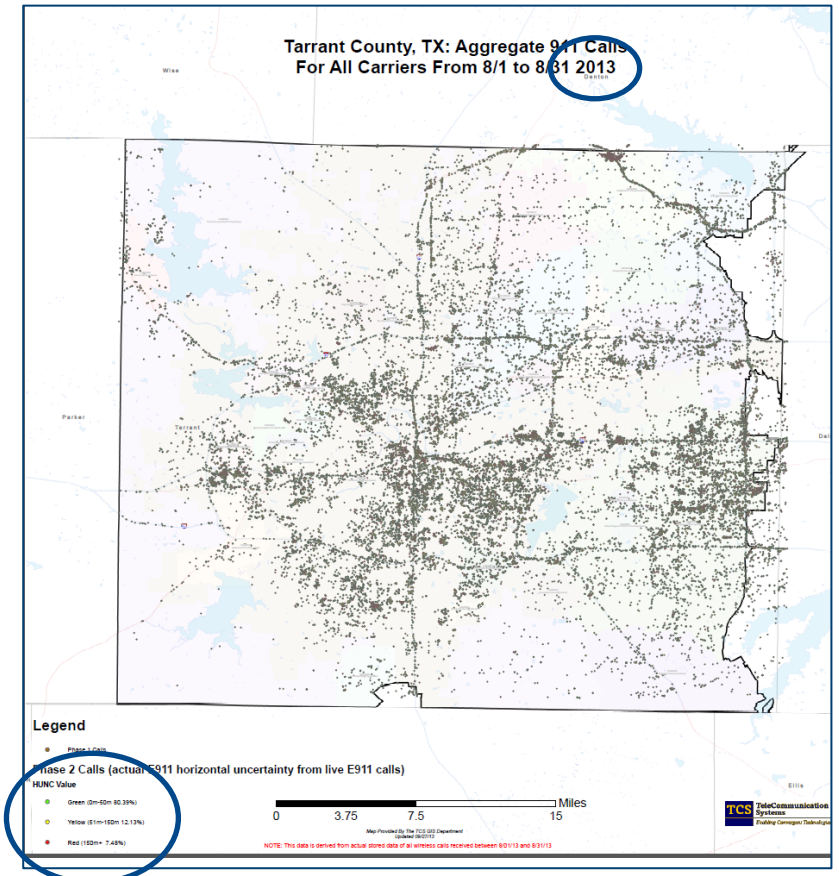


2007

3.3% exceeded Phase II upper bound (red)

2013

7.5% exceeded Phase II upper bound (red)



3.3% → 7.5% (more calls from indoor locations?)

Indoor: Challenges Location Testing Paradigm

- Only outdoor location requirements today
- OET-71 only provides outdoor testing guide
- Cannot distinguish outdoor from indoor
- Suggested: Indoor location in a test bed

Suggested: Indoor Location in a Test Bed

- OET-71 refers to a "independent test area"[1]
  - Must be validated based upon experience
  - Does not result in a certification
- 3rd FNPRM suggested use test beds
  - Demonstrate compliance through participation in an independently administered test bed program[2]
- Outdoor testing foundation for Indoor Test Bed[3]
- Spec for Indoor Location Accuracy Test Bed[4]

[1]OET-71 p.2 [2]3rd FNPRM, 07-114, (Feb. 21st, 2014); p.3
[3]CSRIC III, WG3 Report (March 14th, 2012) [4]CSRIC IV, WG1 Report (June, 2014)

Indoor Location Test Bed – For Compliance?

- FNPRM highlights Public Safety concerns
  - IACP suggested a testing regime that requires periodic indoor testing to verify compliance[1]
  - APCO asked for indoor testing, repeated within a reasonable time frame[2]
- Public Safety comments expect testing
  - NASNA expects some form of “real-world” testing[3]
- Public Safety comments give no Safe Harbor
  - BRETSA strongly rejects Safe Harbor via test bed[4]

[1]3rd FNPRM, 07-114, (Feb. 21st, 2014); p.32 [2]Ibid. p.33

[3]NASNA 3rd FNPRM Comments; pp.8-9 [4]BRETSA 3rd FNPRM Comments; p.19

Indoor: Challenges Location Testing Paradigm

- Only outdoor location requirements today
- OET-71 only provides outdoor testing guide
- Cannot distinguish outdoor from indoor
- Suggested: Indoor location in a test bed
- Headed: Indoor and Outdoor accuracy testing

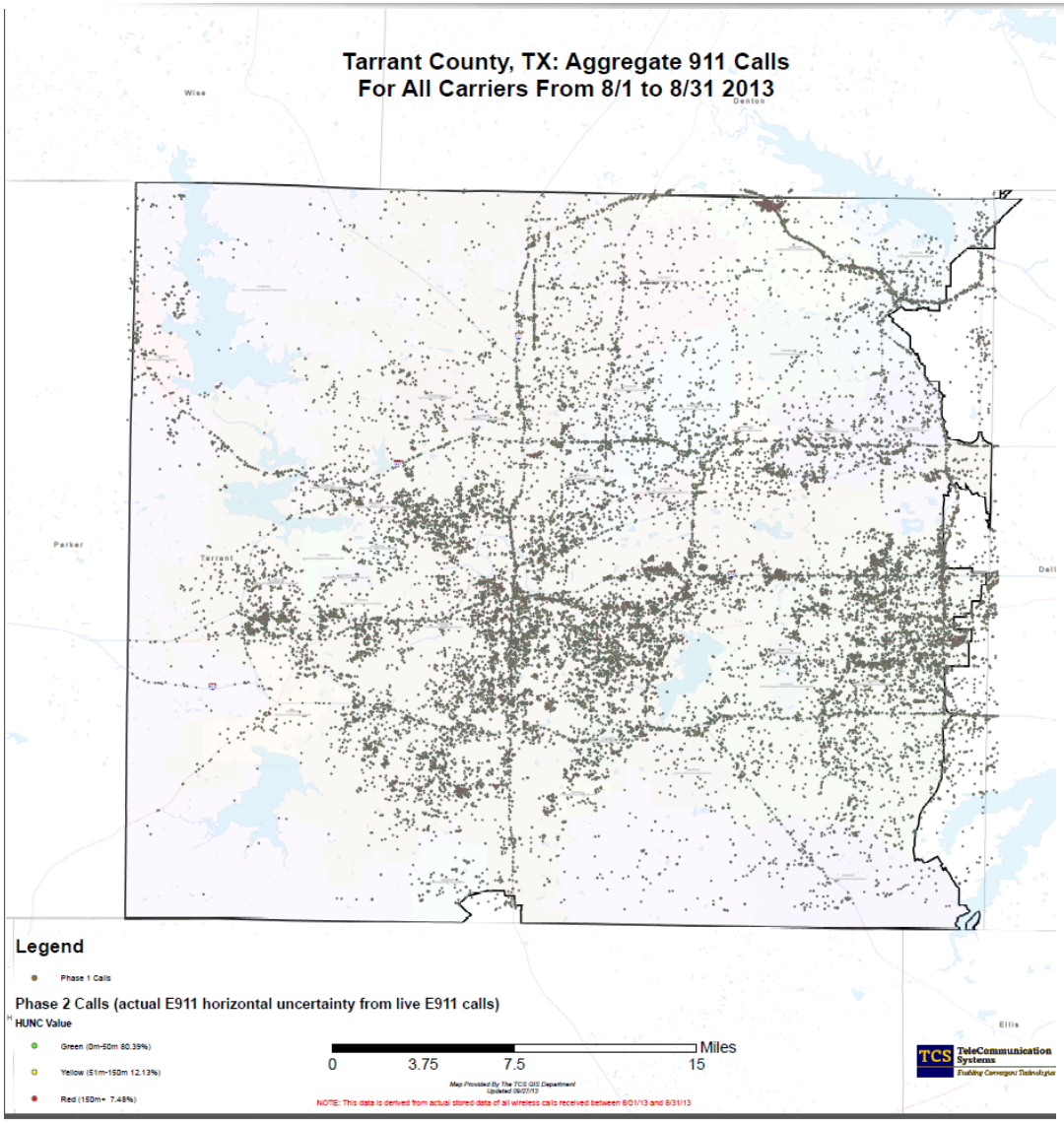
Indoor: Challenges Location Testing Paradigm

- Only outdoor location requirements today
- OET-71 only provides outdoor testing guide
- Cannot distinguish outdoor from indoor
- Suggested: Indoor location in a test bed
- Headed: Indoor & Outdoor accuracy testing

- Recommend: Use Analytics – 3-step process
  - Testing accuracy/correlating uncertainty in a test bed
  - Using Analytics to generate compliance metrics
  - Require in-county testing where metrics show issues

THE POWER OF ANALYTICS

Real-World Data Can Guide Our Testing



» Geospatially review data

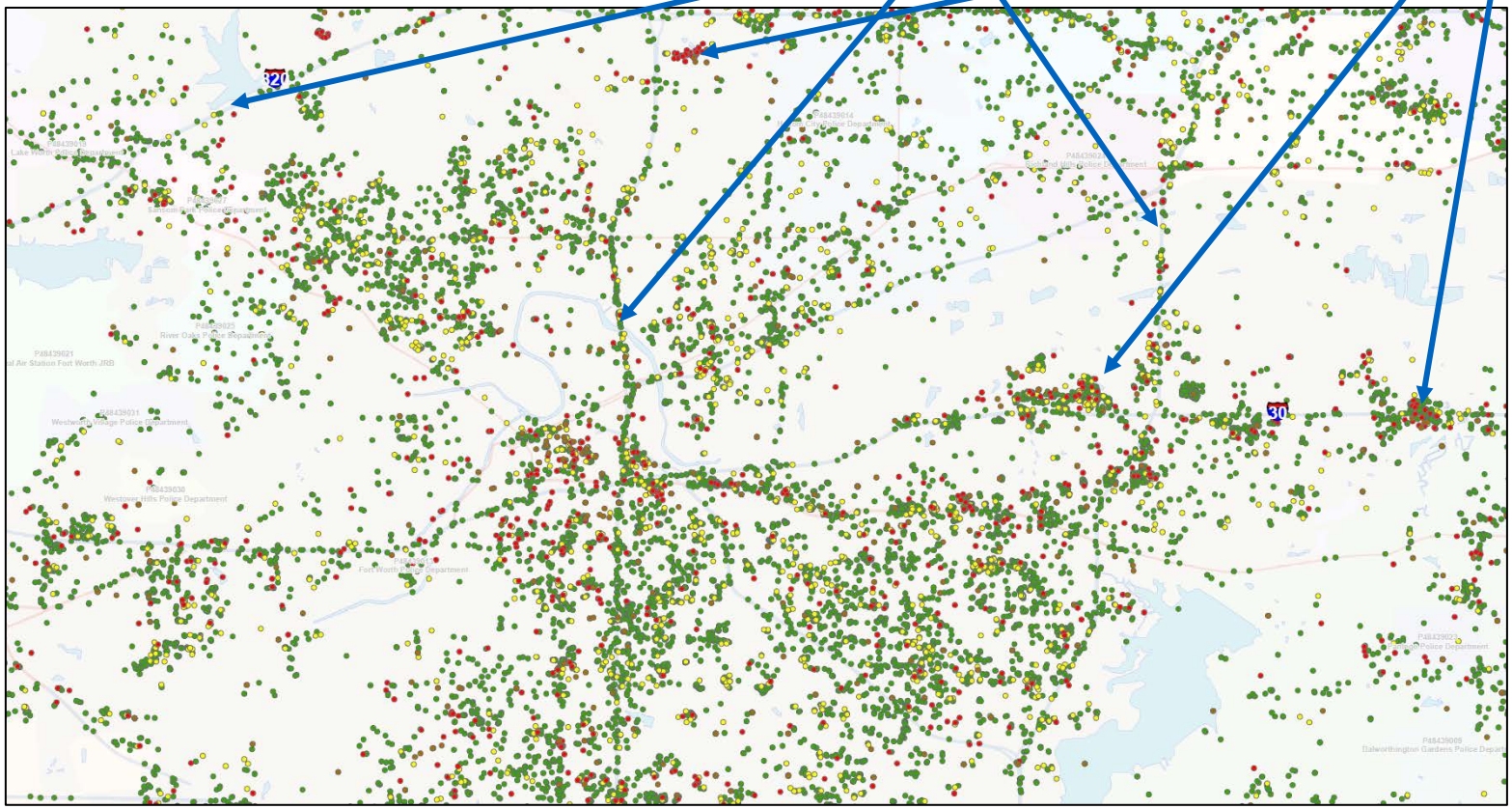
- Color-code X/Y locations based upon uncertainty:
  - Brown = Phase I only
  - Green = meets stricter reqmt.
  - Red = misses looser reqmt.
  - Yellow = between strict/loose
- Review data over extended time periods
- Identifies areas of location accuracy problems

Testing Accuracy/Correlating Uncertainty

- Procedures for accuracy testing already exist
  - Verify location technology meets required accuracy levels
  - Test location technology in various morphologies
  - “Morph the morphology” to test technology adaptation
- Develop correlation: uncertainty -> accuracy
  - Uncertainty = accuracy errors based on physics
    - Lower gain
    - Fewer satellites seen
    - Known uncertainty of satellite positions
    - Signal multipath
- Use uncertainty as a proxy for accuracy

Uncertainty Is a Good Proxy for Accuracy

- Uncertainty/Accuracy correlates
  - Can draw roadways
- Uncertainty error clusters



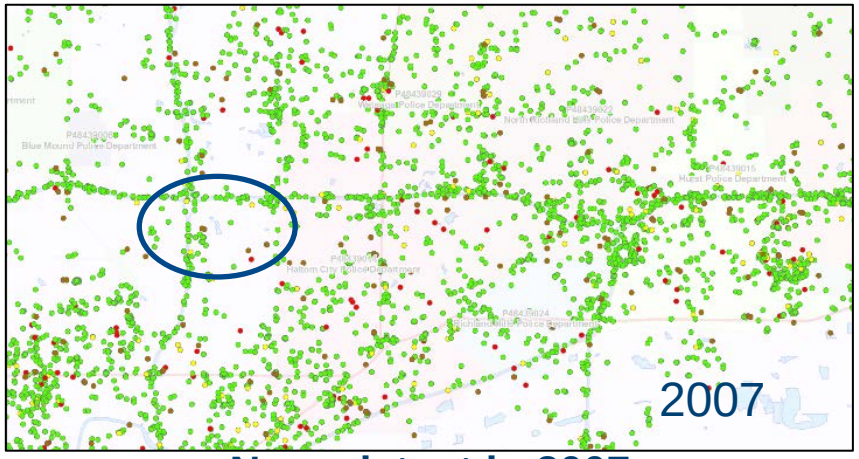
Tarrant County, TX – Multiple wireless carriers – August, 2013 data

Analytics Can Generate Compliance Metrics

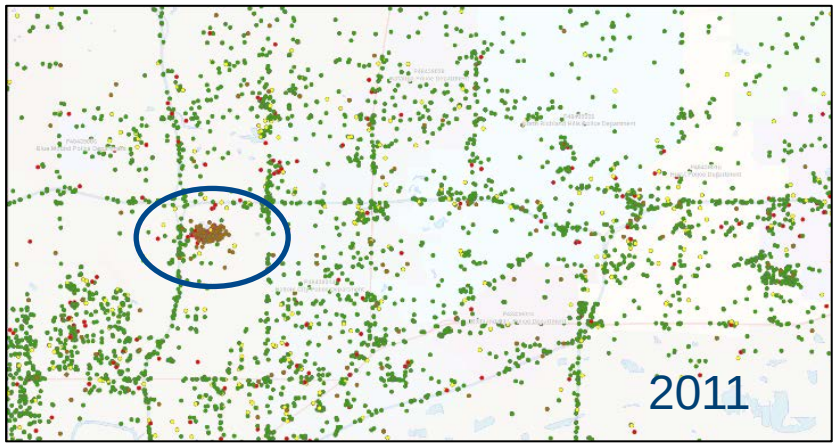
- Collect actual 9-1-1 call data
  - No need to establish “likelihood of a 9-1-1 call”
- Analytics has broader uses
  - Data can be corroborated
    - Data is sent to PSAPs for every 9-1-1 call
    - Intermediaries can analyze
  - Monthly reports can be generated
    - Trends can be seen over time
    - Seasonal variations would be accounted for
  - Analytics can provide feedback to Test Bed
    - Changes to morphology/environment can be suggested
    - Provide feedback on the impact of signal attenuation
- Problem areas can be identified
  - Uncertainty error clusters identify poor coverage

Trend/Analyze (and Correct) Error Clusters

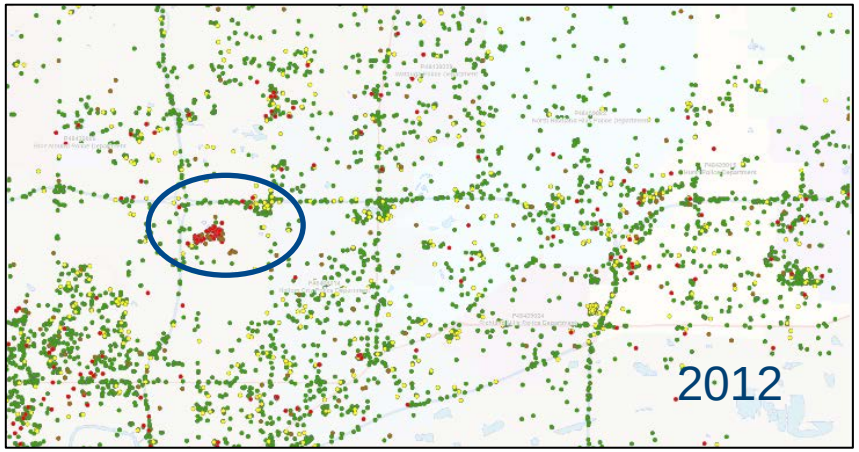
Problem area seen in 2011



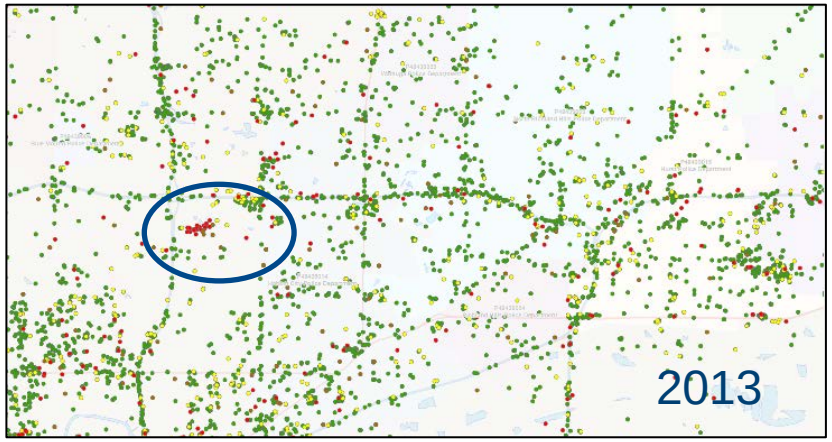
Nonexistent in 2007



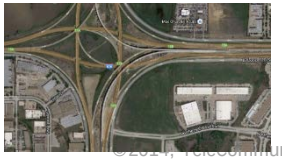
Major problem area in 2011



Improved in 2012



Greatly improved in 2013



Goodrich Warehouse Built in 2007

Analytics Can Identify Areas to Be Tested

- Uncertainty error clusters identify problems
- Carriers can deploy technologies to improve
  - Deploy small cells to generate better location fixes
  - Connect Enterprise Wi-Fi for commercial venues
  - Provide Residential Wi-Fi for apartment complexes
  - Crowd-source commercial Wi-Fi in problem areas
- Carriers can do in-county testing to verify
  - Final step to address difficult situations
  - Can document new problem areas for FCC study

Summary

- Reasonable concern: more indoor 9-1-1 calls
- Indoor 9-1-1 calls are challenges for current technology
- There are a number of good options
  - Outdoor techniques get broad improvement
  - Indoor techniques get to the final goal of dispatchable address
- But Indoor Location will break our testing paradigm
  - Cannot distinguish indoor from outdoor calls
  - Test Bed concepts may not be trusted county-by-county
  - Heading toward an indoor accuracy testing paradigm – EXPENSIVE!
- Use the power of location analytics
  - Test accuracy/correlate uncertainty in a test bed
  - Use Location Analytics to generate compliance metrics
  - Require in-county testing where metrics show issues
  - Collect real-world data to evaluate our progress!

Thank you!

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