Sprint E911 Performance and Design

August 20, 2008

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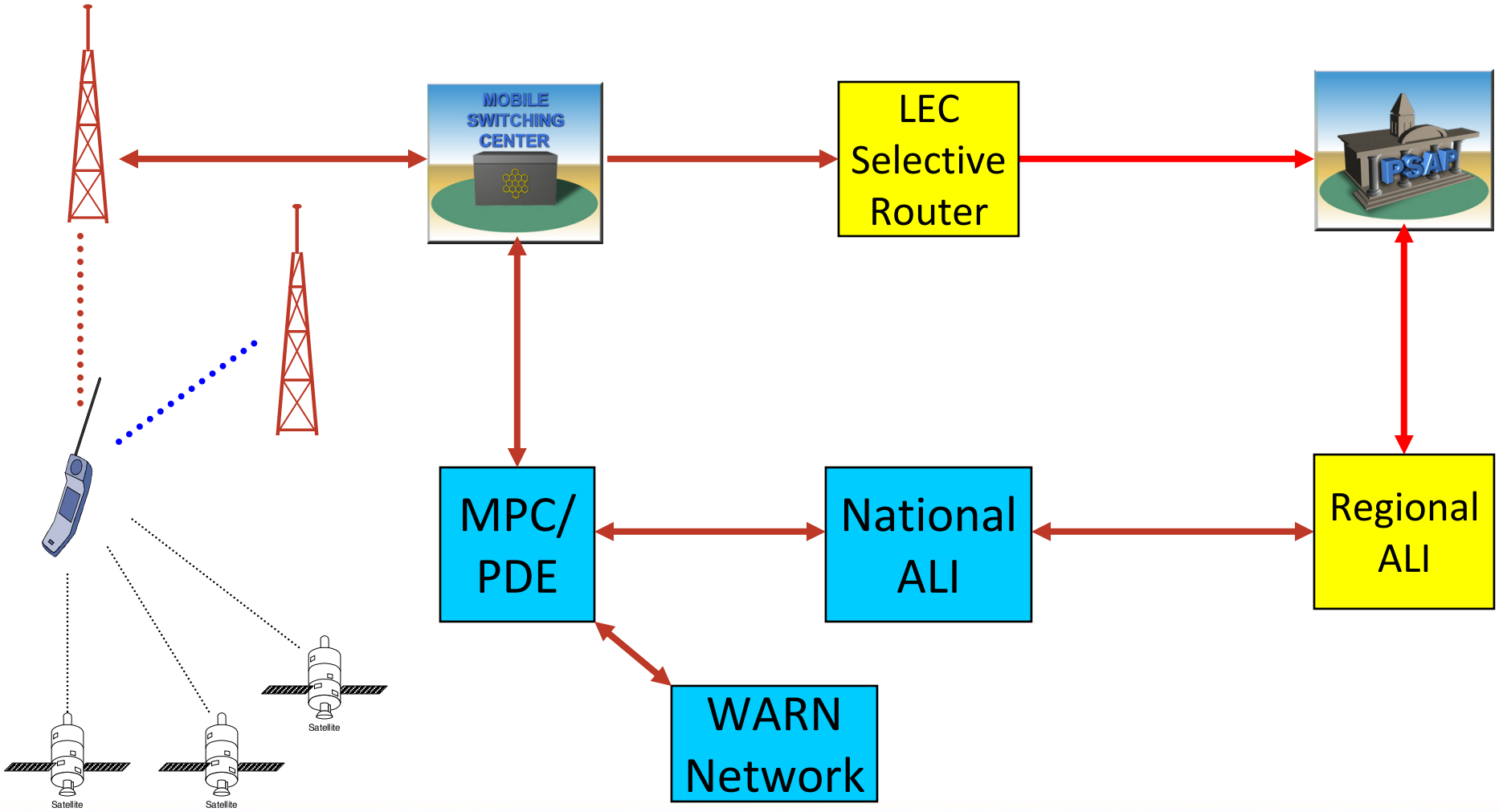
Sprint ahead

Simplified Phase II Architecture
Assisted GPS Handset System



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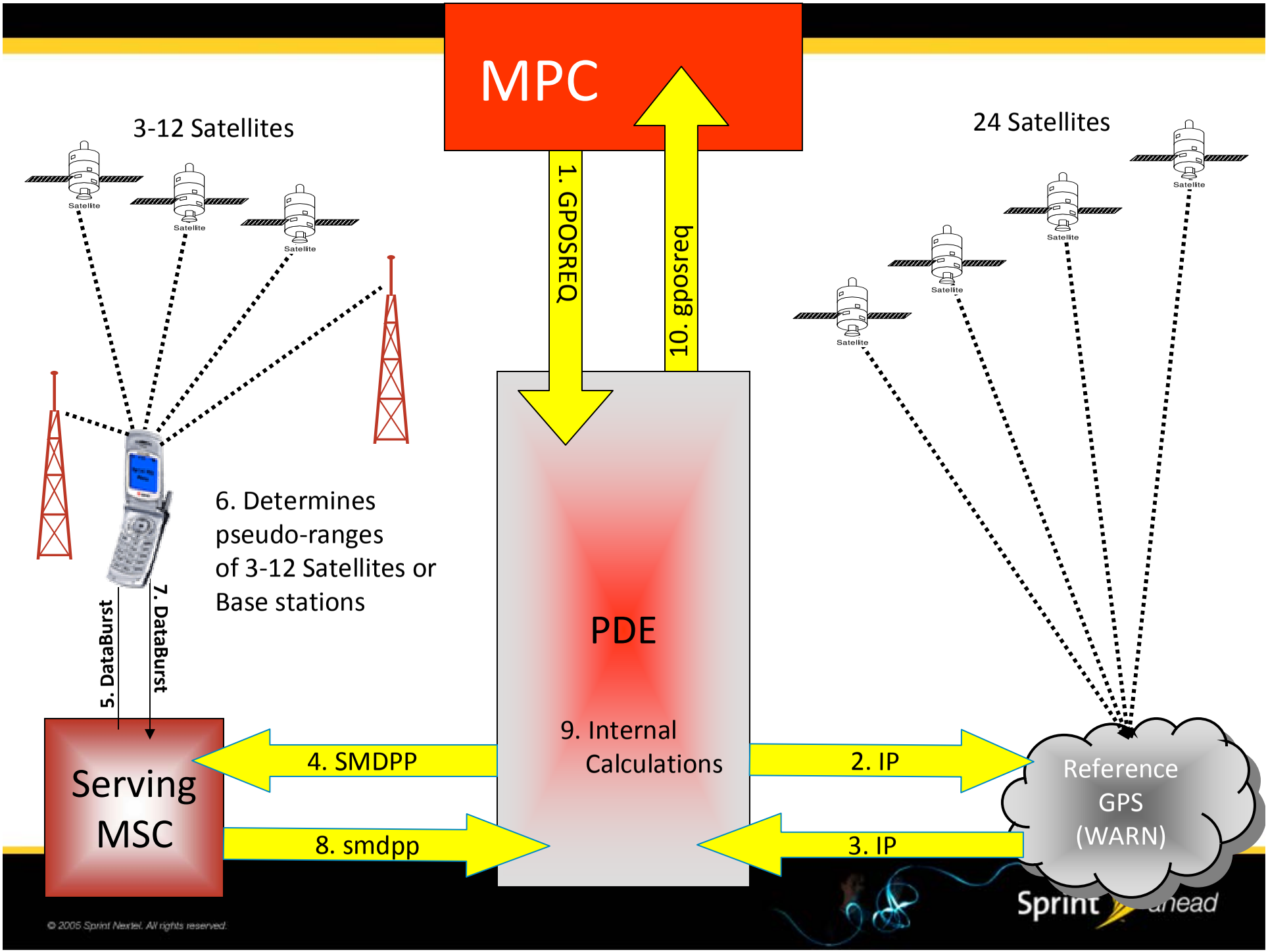
Sprint ahead


MPC
3-12 Satellites
24 Satellites
Satellite
1. GPOSREQ
10. gposreq
6. Determines pseudo-ranges of 3-12 Satellites or Base stations
5. DataBurst
7. DataBurst
PDE
9. Internal Calculations
Serving MSC
4. SMDPP
8. smdpp
2. IP
3. IP
Reference GPS (WARN)
Sprint
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Location Technologies Within the Sprint Network

- **AGPS**
  - Offers best accuracy
  - Requires 3 Satellite View to obtain an assisted GPS based fix

- **Hybrid**
  - Hybrid uses portions of GPS data combined with AFLT to calculate fix and must be a total of at least 3 measurements (SVs and/or RF pilots)

- **AFLT**
  - AFLT is impacted by cell density in the area and the ability of the handset to hear adjacent cells.
  - AFLT must have at least 3 unique RF pilots to properly triangulate

- **Mixed Mode**
  - If AFLT or Hybrid is not available, we utilize "Mixed Mode" which is only 1 or 2 total measurements with any combination of SVs or RF pilots.

- Location is an "estimate." Error in location determination depends upon the ability of the system to obtain clear GPS and/or RF cell tower data.

- The ability to obtain clean data depends upon the external environment.

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Performance of These Technologies

Performance today using Live Call and Location Accuracy Manager (LAM) Data

Accuracy Analysis (compliance obligations at 50m/150m)

GPS only	90.1% / 99.3 %
Hybrid	52.0% / 85.0%
AFLT	41.0% / 73.0%

Notes:

1. Performance shown as % calls meeting current compliance obligations.
2. Hybrid and AFLT as a "stand-alone" technologies do not meet benchmarks.
3. Hybrid positioning technology uses both satellite and triangulation. Location calculations are performed in a network based platform.
4. All data based upon one days' worth of live e911 calls.

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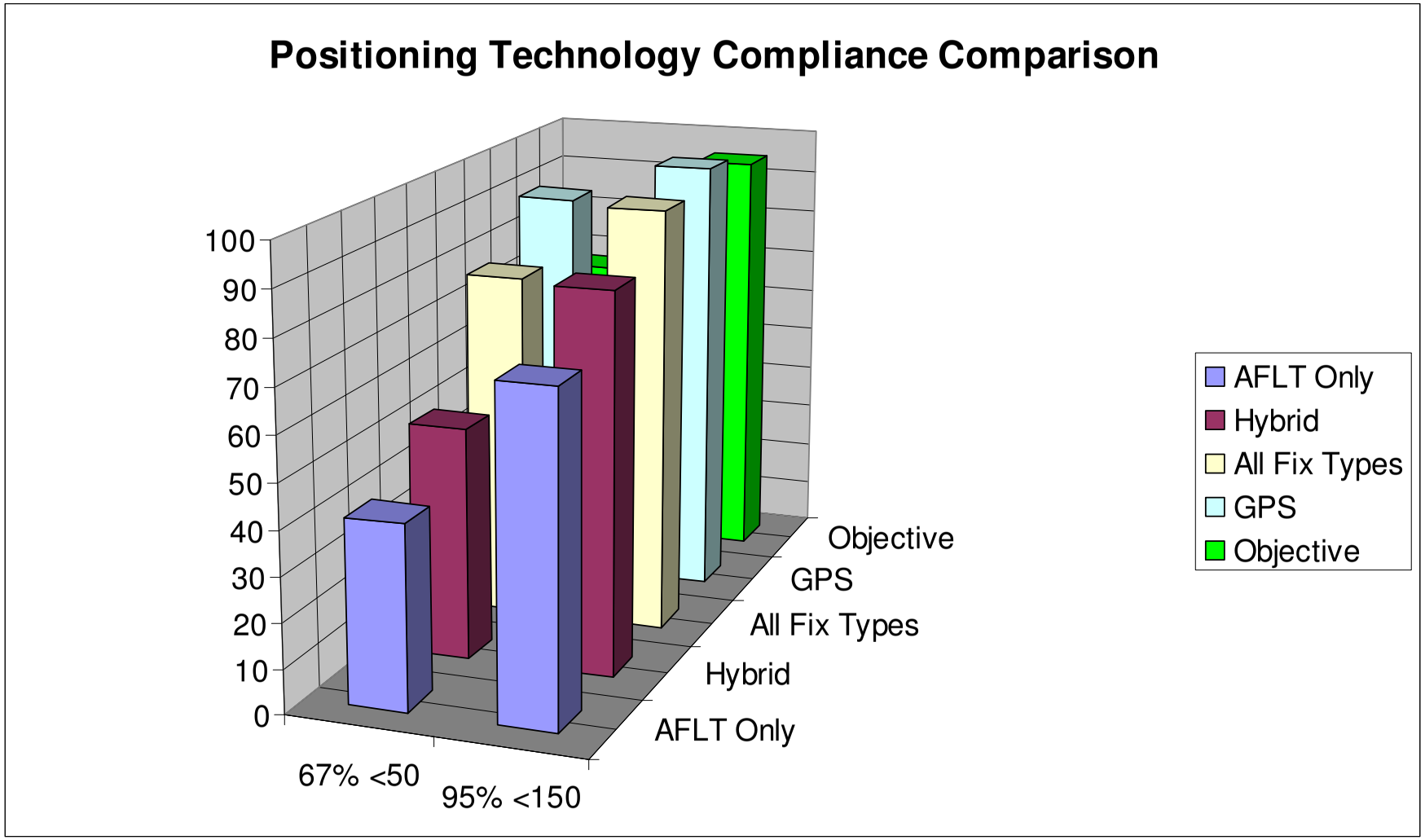
Performance Comparison



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Position Determination Technologies

- Each position determination technology has different strengths and weaknesses and often is applicable in different environments. The matrix below depicts this.

Technology	Strength	Weakness
AGPS	Most Accurate	Requires SVs. Performance may be hindered in urban canyons, indoors, or other locations with limited views of the sky
AFLT	Can provide fixes in locations where no SV is available but cell density is high	Challenged in areas with low cell site density. Accuracy less reliable and can be significantly diminished in circumstances similar to those that cause issues for GPS (e.g., indoors).
UTDOA	Accuracy questionable, but better than cell sector	Requires hardware at each base station. Not interoperable with current systems.
NMR	Accuracy questionable, but better than cell sector	Requires extensive calibration. Uses RF Fingerprinting technology.
Hybrid	Works in areas where some SV is available and cell density is sufficient. Accuracy is a function on number of SVs and Cell density.	Not applicable everywhere. Accuracy not within the benchmarks.

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External Limitations on Performance

- The ability to obtain the location of a radio transmitting device is limited in all technologies to the number of available data points and the quality of those data points.
- The number of available data points will be restricted in the GPS system by the number of SVs available. This can be limited indoors, under heavy forest, or from building shadow.
- The number of available data points for network based systems will be limited by the number of available RF channels (i.e., base stations). This can also be effected indoors and by building shadow.
- Whether TDOA, AFLT or GPS, the accuracy of location will be effected by multipath, reflection and other factors that cause the transmitted signal to appear farther or closer than its actual position.
- The time allowed to obtain location data also impacts the quality of the information. Because handsets are required to obtain location in a matter of seconds, they cannot take the time to acquire weaker satellite signals, for example, making their calculations more vulnerable.

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Location Accuracy Monitor

- Sprint Nextel has deployed 1400 Location Accuracy Devices (LADs) that are placed in Sprint vehicles to sample the network.
- LADs have phone equivalent devices coupled with GPS Ground Truth receivers to obtain location as units drive the network.
- Reporting tools compare actual ground truths against reported locations to calculate location error which equates to accuracy.
- Using these reporting tools, LAD data can be analyzed at the national, state, or county level. Significant time is required, however, to collect sufficient data points for a statistically valid sample. This time increases as the geographic area decreases.
- Using interpolation, Sprint Nextel can apply these findings to our live call data to determine estimated accuracy at various levels.

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County Performance Measured by LAM

The following is a sample of system performance as measured in five counties by the LAM.

County	State	% @ 50m	% @ 150m	total # of test points	AFLT	Hybrid	GPS	% AFLT	% Hybrid	% GPS
Lake	IL	96.80%	99.70%	1591	9	21	1559	0.57%	1.32%	97.99%
Clay	MO	93.30%	98.50%	1442	27	60	1346	1.87%	4.16%	93.34%
Chatham	GA	82.50%	97.10%	1517	106	154	1252	6.99%	10.15%	82.53%
New York	NY	76.90%	96.50%	1088	32	161	891	2.94%	14.80%	81.89%
Davis	UT	74.30%	95.00%	1686	47	237	1392	2.79%	14.06%	82.56%

This data confirms that performance degrades as reliance on AFLT and hybrid fixes increase. Counties with significant AFLT data may fail one or both of the benchmarks.

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Live Call Data

- The following slides place live call data on maps for typical mid-sized towns.
- While only a "snap shot" in time, this mapping demonstrates usage patterns to some degree.
- Current technology cannot determine whether a call is being made indoors or outdoors. These maps, however, appear to confirm that most wireless calls continue to be generated from roads or other outdoor locations.

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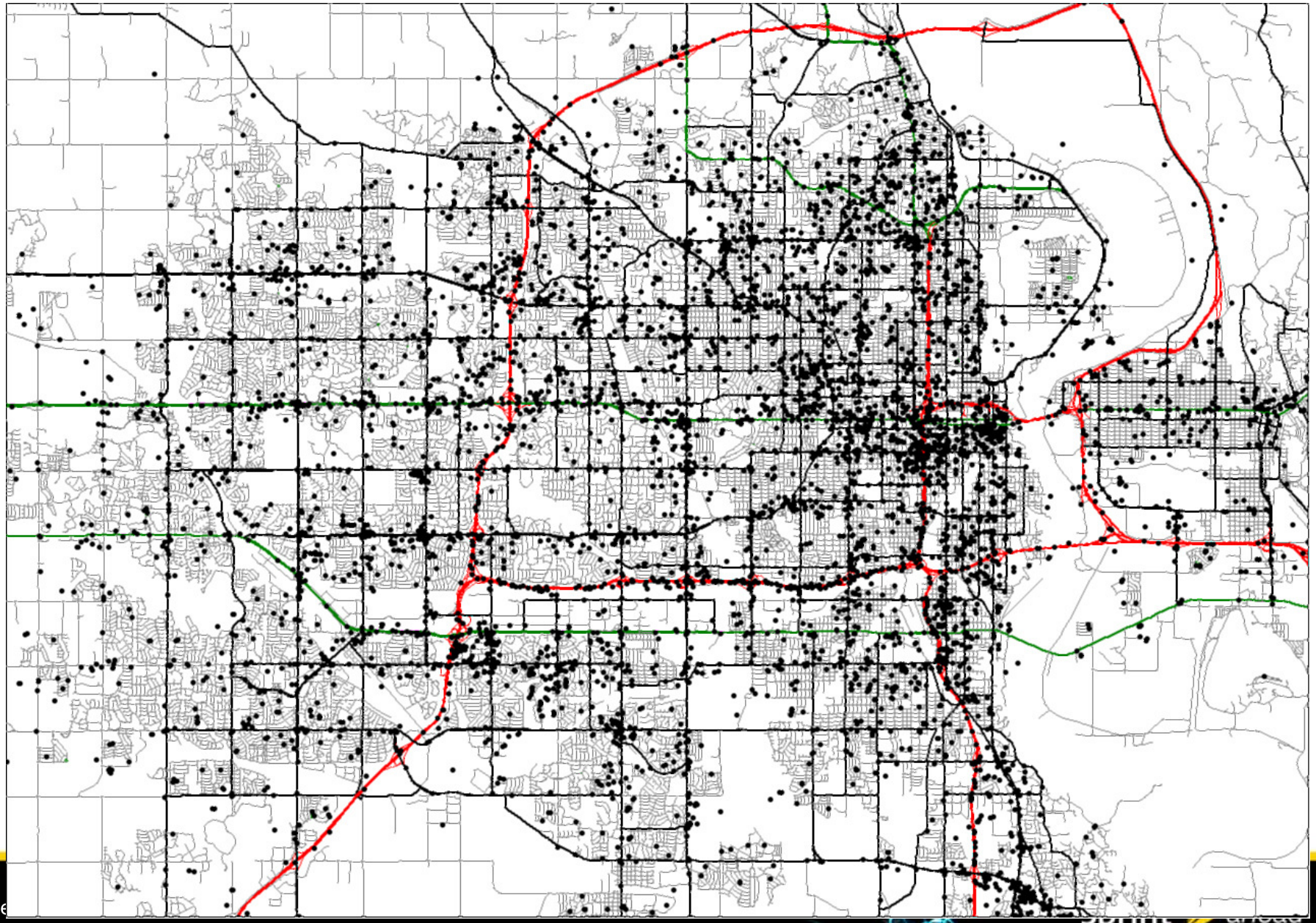
Omaha, NE – 1 month of live e911 PDE positions



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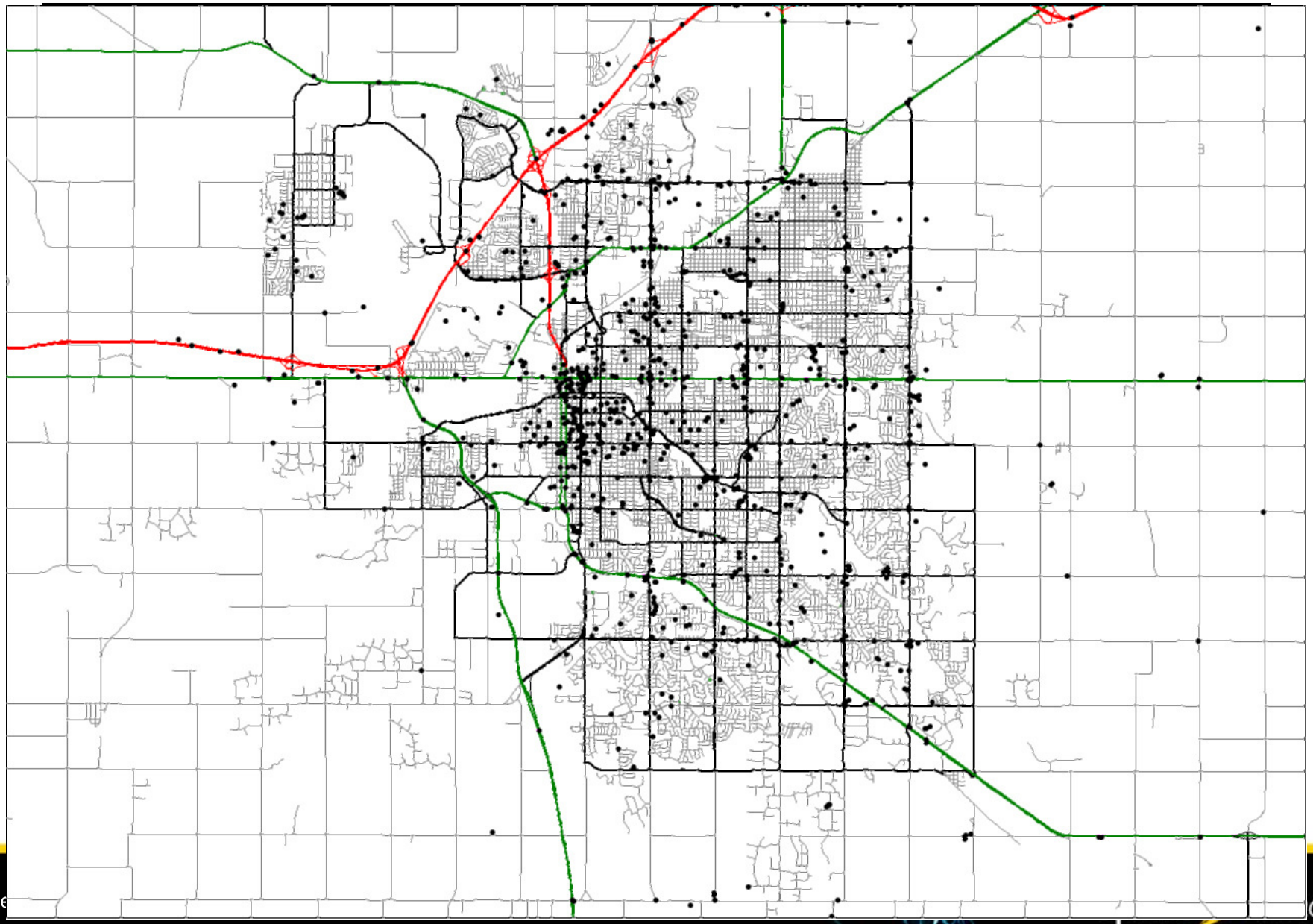
Lincoln, NE – 1 month of live e911 PDE positions



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Challenges of Integrating PDE Solutions into Existing Systems

- Interfaces do not exist to simply add and integrate PDE systems into existing architectures.
- Interfaces and triggers would be needed at the MSC, MLC, and often at the RF layer.
- Interfaces are required to stream data from RF infrastructure to secondary PDE. There are no defined standards between vendors on these interfaces.
- Today there is no "standard" way to get additional PDE location back into GMLC / MLC. This would have be to implemented as a vendor specific feature.
- Logic has to be deployed in each vendors solution to decide what PDE location would be sent to the PSAP.

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