Workshop on GPS Protection and Receiver Performance

Motorola Solutions, Inc.

Greg Buchwald

June 20th, 2014

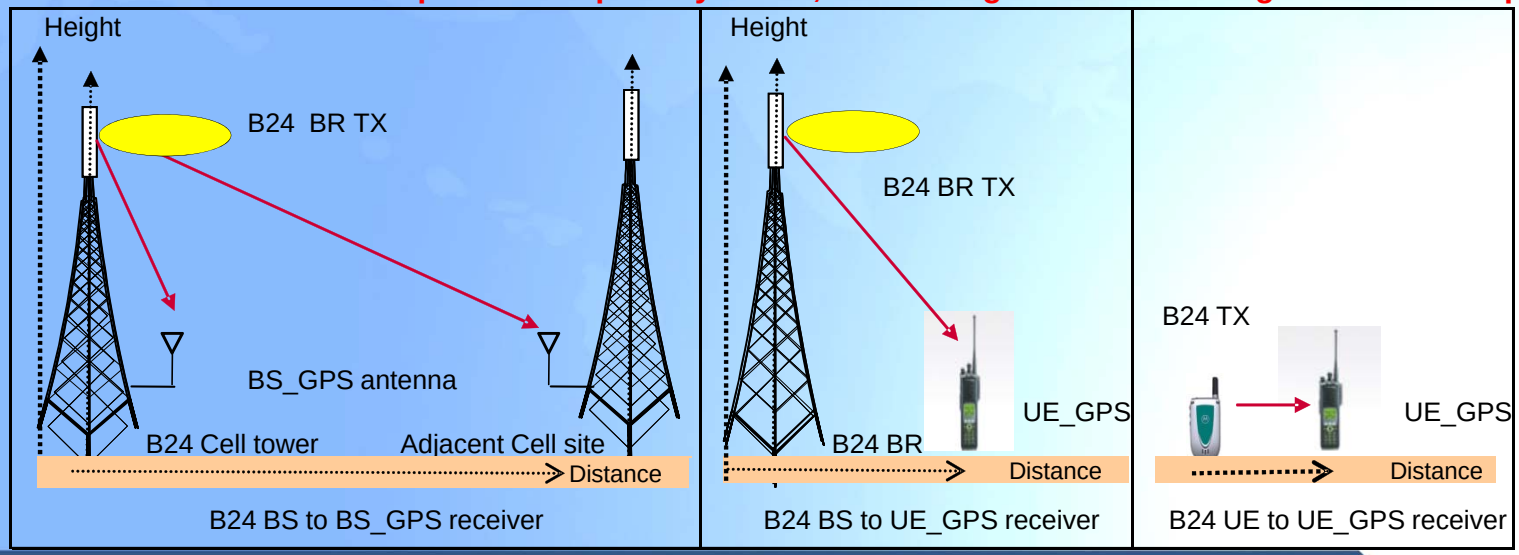
GPS Disruption of Service Impact Upon Public Safety and Associated Services

- Subscriber Units (Handheld Subscriber Units, Accessories, Surveillance, CAD)
  - Disillusion of location accuracy – Examples:
    - Officer-down location: Response / backup support delay impact
    - Traffic stop location: may be extremely important during escalated situations
    - “Ankle bracelet” tracking disrupted; a-priori knowledge of outage areas may be exploited
    - E911 calls / reporting – response delays; location inaccuracies or outages
    - Potential impact to location stamping of voice, data and video recordings used as evidence

- Base Station
  - Present Day Concern: Simulcast Systems
    - Accurate timing important to self-interference mitigation: Immediate alarm sent to dispatch or control point if tracked and locked satellites drops below threshold level
    - Continued interference and loss of timing may cause site disablement; differential multi-site timing degradation over time determines severity and eventual outage.

Primary Interference Scenarios

1) OOBE into GPS receiver – can only be corrected at L-band transmitter
   - B24 proponent added sufficient filtering to mitigate (2011)
2) GPS receiver **blocking** – can only be fixed at receiver
   - Function of GPS receiver design and,
   - Distance between Band 24 BR and Victim Receiver
     - **Inter-Modulation Product-induced Interference.**
     - **LNA compression is primary cause; RX filtering and reasonable guard-bands help alleviate issues**



Motorola Solutions Subscriber GPS Evolution

Device Under Test (Test Results: GPS @ -142dBm/2MHz LTE Terrestrial L-band Signal)	Max LTE Level; RX Input	Bore Site	Live Sky Results
Gen 2006 PS GPS Microphone Accessory, Filtered LTE@1550MHz; Radiated w/GPS @ -142dBm	-36dBm	~1000 meters	-
Gen 2007 Professional / Commercial Radio HH; Filtered LTE@1550MHz; Radiated w/GPS @ -142dBm	-37dBm	1100 meters	-
Gen 2009 PS HH; Filtered LTE @1550MHz; Radiated w/GPS @ -142dBm	-35dBm	850 meters	610 meters
Latest Gen PS HH; Filtered LTE @1550MHz; Radiated w/GPS @ -142dBm	-22dBm	190 meters	26 meters

- "Long hanging fruit" improvements have been made as have moderate cost-added improvements.
- Already have a small "hit" to GPS sensitivity; additional filtering escalates losses rapidly, temperature coefficient issues arise, practical limitations become paramount
- Deployed PS systems last many years; design-to specifications for L-band adjacent services must be known well in advance of system deployment.

Motorola Solutions Infrastructure: Consistent Upgrade

Test Results: GPS @ -142dBm/2MHz LTE Terrestrial L-band Signal

Device Under Test	LTE Level; RX Input	Distance A; Bore-sight	Distance B; -20dB
Third Party Receiver w/ External GPS Antenna / Standard LNA; Radiated Test	-47dBm	3800 meters	380 meters
Third Party Receiver w/External GPS Standard Antenna / LNA + 16dB Line Loss; Radiated Test	-35dBm	850 meters	85 meters
Third Party Receiver w/External GPS High Rejection (BPF) Antenna / LNA + 16dB Line Loss; Radiated Test	-35dBm	4 meters	<1
GTR Site Controller / GPS Reference w/External GPS RX in Head; Radiated Test (High Rejection GPS RX Head)	-22dBm	2 meters	<1 meters

Mitigation Methods

- **Replace External Antenna / LNA equipment utilizing high OOBE rejection SAW filters (added filters) and well-designed distributed gain**
  - Downside: Additional Noise Figure; loss of RX Sensitivity (~2dB)
- Add additional filtering between Antenna / LNA and receiver
  - Downside: Antenna-mounted LNA 1dB IM spec must be sufficient; generally more $$$

Cost: All require site visit, upgraded equipment purchase; equipment procurement and, for MSI-Approved equipment an Internal Qualification Process

In Summary:

- Proactive steps have already been taken to improve performance of GPS-enabled MSI Astro Public Safety products:
  - Since 2011, forward-looking steps have already been taken to improve performance of GPS-enabled Public Safety product offerings with future rational terrestrial L-band spectrum use taken into consideration
  - However, considerable legacy equipment exists; long equipment life-cycles are common in PS
- Reasonable band-plans for eventual terrestrial use of L-band must be developed consistent with realizable GPS receiver performance expectations. Sufficient Guard-bands, UL/DL choice, etc.
- GPS is critical to Public Safety but, as civilian devices, they generally only utilize the narrow BW Coarse Acquisition (CA) code
  - Defense, Aviation, and Precision Agriculture utilize information extracted from the full 20MHz channel.
  - If their needs are met, so will those of Public Safety (but not vice-versa)