GPS Privacy
Jammers and
RFI at Newark

Navigation Team
AJP-652 Results

Presented to: Public Distribution
By: AJP-652
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Briefing Outline

• Background – Why is the Navigation Team (AJP-652) working this issue
  – Observations/Timeline
• GPS Jammers
• Working Group and Mitigations for GBAS
• Continuing Efforts
• Airborne Testing
• Summary
Ground Based Augmentation System (GBAS) and RFI Requirements

- Full Category I Non-Federal GBAS system design approval was completed in September 2009.
  - Honeywell SLS-4000 is the first approved GBAS.
    - The EWR station was commissioned, but is not available for use.
    - Newark (EWR) was to be the first operational GBAS in the National Airspace System (NAS).
- The SLS-4000 is required to detect RFI, which is covered via action of several monitors and tests, and these functions are operating properly.
  - The SLS-4000 safety case required that the station alarm until maintenance verified the RFI issues were resolved.
  - The probability of RFI occurring was considered very low.
  - The SLS-4000 is not required to operate when interference within the protected Aeronautical Radio Navigation Service (ARNS) GPS band exceeds the design mask levels.
Trigger Event

- November 23, 2009 during installation testing the EWR GBAS went into alarm.
  - GPS Receiver satellite tracking was interrupted.
    - Had not been observed in 10+ years at the Memphis GBAS
  - Observed carrier to noise (CN$_0$) measurements were not consistent with normal RF environment.
    - RFI monitor had triggered.
  - Data from the SLS-4000 RFI monitors and an independent AJP-652 GNSS monitor (GBPM) system alarms confirmed strong RFI events.
  - Many other events are being observed.
    - RFI Jamming events occur up to multiple times per day.
EWR GPS/GBAS RFI Background

- **October 27, 2009 (2 days)**
  - AJP-652 Installs EWR GBAS Monitor at Newark Airport – in advance of GBAS SIS
- **November 23, 2009**
  - The EWR GBAS Shuts down due to Excessive RFI (1) – Source Unknown
- **December 2, 2009**
  - FAA AJP-652 provides EWR data to FAA Spectrum Engineering (SE) for support
- **December 10, 2009 (2 days)**
  - FAA AJP-652 Deploys an event monitor to begin EWR RFI data collection
    - Significant RFI is brief in duration, concentrated in weekdays, long gaps present.
- **January 13, 2010**
  - The EWR GBAS Shuts down due to Excessive RFI (2) – Source Unknown
- **January 20, 2010 (2 days)**
  - FAA AJP-652 Deploys Specialized RFI Detection and Characterizing Equipment to EWR, supported by an FAA contractor Snapshot system (Building 80)
    - Snapshot system Captures 1st wideband event (no shutdown)
- **February 17, 2010 (3 days)**
  - AJP-652 Coordinates a multi-organization, multi-day RFI Stakeout @ EWR
    - Multiple Spectrum, GPS, DF equipment, and vehicles.
    - GPS RFI instances and detected bearings were varied and intermittent
- **March 11, 2010**
  - The EWR GBAS Shuts down due to Excessive RFI (3) – Source Unknown
EWR GPS/GBAS RFI Background Cont.

- **March 19th, 2010**
  - Zeta Deploys Specialized DF Equipment to GBAS Shelter as a second RFI station

- **March 23rd, 2010 (4 days)**
  - AJP-652 Deploys an expanded multi-day RFI Stakeout @ EWR – Same Contributors
  - GPS RFI Source Identified and Confirmed (NJTP)

- **April 14th, 2010 (2 days)**
  - FAA AJP-652 Performs Stakeout on NJTP, with FCC and FAA SE – RFI Observed

- **April 29th, 2010 (2 days)**
  - FCC, FAA Spectrum, and AJP-652 on NJTP for a pursuit Stakeout.
  - Jammer Vehicle is Pursued and Device surrendered - Source Stopped?

- **May 7th, 2010**
  - The PANYNJ GBAS Shuts down due to Excessive RFI (4), More RFI sources present

- **May 20, 2010**
  - AJP-652 Performs GBAS Antenna RFI Environment Optical Survey – NJTP

- **May 26, 2010**
  - AJP-652 Begins EWR GBAS RFI Working Group Meetings for Mitigations Research

- **June 15, 2010**
  - Prototype RFI software installed, designed to recover from RFI events
  - Multiple stronger events in Aug-Dec caused alarms in this new software baseline

- **Revised Prototype SLS-4000 Software Installed December 2010**
  - Recovers from stronger events, service is interrupted during jamming events, multiple instances
  - Operational outages is being evaluated; an “Out of Service” NOTAM was issued for the GBAS
Transient GPS RFI on NJTP

Notional Pattern of Moderate Jammer
Cause of the RFI at Newark: Privacy Jammers

• Why are Jammers Used? – To mask user position from new GPS-based tracking systems
  – Employee tracking
  – Personal tracking
  – Rental cars
  – Prisoners ankle bracelet
  – Stolen vehicles - cars/trucks
  – Cell phones / Drug dealers
### Jammer Availability

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handheld GPS Jammer GJ02</td>
<td>$33.00</td>
<td>The portable GPS signal jammer GJ02 is very easy to operate. Just plug it directly into the car cigarette lighter device; it begins to disable GPS signal from...</td>
</tr>
<tr>
<td>Handheld GPS Jammer Mini GJ</td>
<td>$69.99</td>
<td>The portable GPS jammer Mini GJ is small and light. It can be easily put in a side pocket or hand bag. It can fully disable GPS signal from...</td>
</tr>
<tr>
<td>Portable GPS Jammer GJ Pro</td>
<td>$155.00</td>
<td>The portable GPS jammer GJ Pro is of high power. It can disable both GPS L1 and L2 bands. The interfering radius is up to 20 meters. It comes...</td>
</tr>
</tbody>
</table>

Displaying 1 to 4 (of 4 products)
Jammer Capabilities

- Jammers are designed to overwhelm GPS receivers by broadcasting directly on the GPS L1 frequency
  - The power required to achieve this varies by manufacturer.
  - The power of the models surveyed or tested exceed the necessary power AND far exceed the GPS interference mask published in SATNAV standards.
Difficult to Detect and Isolate
Weekly Meetings Began May 26th 2010

- Group’s Focus on Viable Impact Mitigation Techniques and Testing Opportunities specific to Newark GBAS.
- Any potential solutions were considered – many options were looked at and eliminated.
- Considered the fact the current GBAS location is the only verified site that satisfied all Part 77, and GBAS Performance stipulations.
- Would make use of existing data, and test specific data
  - Summary provided in this briefing
- Participant and Contributing Organizations
  - Diverse team composed of FAA, FAA contractor and university support, manufacturers, and service providers
RFI Mitigation Options Explored

• Three Areas for Change
  – Environment
    • Modify the surroundings to better protect the GBAS
  – Configuration
    • Modify the GBAS either in layout, software, or hardware
    • If Hardware or Software is considered, there would need to be considerations toward an SDA (System Design Approval) for operation in the NAS
  – Threat (FAA SE, FCC, and other agencies)
    • Focus on the threat source
      (Jammer Sales Websites, and Customers)
      Awareness material issued by the FCC in February 2011
    • Focus on Enforcement
    • Focus on the threat source (NJTP) and offenders
Potential Mitigations

• **Software modifications**
  – The team is working closely with Honeywell and their development of a more robust RFI solution.
    • Safe operation during RFI periods
    • Auto-recovery from RFI alarms
    • Maximize operational availability, determine acceptability of resulting service

• **Ground Configuration Modifications**
  – The working group determined a comprehensive set of potential mitigations for Newark.
  – Detailed briefing was provided to the PANYNJ to help with their decision process (November 2010).
    • Final decision will be based on cost and operational benefit.
Mitigation Summary

• RFI Mitigations are being assessed and developed for subsequent evaluation and approval.
  – Initial mitigations and margins determined were based on previous observations.
  – Most recent events present a trend of increasing power levels and frequency of occurrence.

• Until a bound can be put on the threat, money spent on gaining margin against a growing threat could be wasted.
  – Companies are competing by increasing jamming output power
    • Jamming implementations are not power-limited
  – Multiple jammers present at the same time will cause an aggregate impact
Continuing Efforts

- Coordination with FAA Spectrum Engineering to develop detection tools
  - Commercial system installed at Atlantic City for test
- Monitoring of GBAS performance at EWR as well as other target GBAS sites (Houston)
  - Real-time Availability Monitoring and event reporting
    [http://laas.tc.faa.gov/EWR_Availability.html](http://laas.tc.faa.gov/EWR_Availability.html)
  - Assess mitigation performance and threat growth
- Participate in DOT GPS RFI meetings
- Review of Government RFI flight testing
Summary

• GPS Privacy Jammers are proliferating, transmitting on GPS L1 frequency well above the specified satellite navigation mask power level.

• The SLS-4000 is required to detect RFI, which is covered via action of several monitors and tests, and these function are operating properly.

• The system modifications have been identified and are being implemented to reduce the operational impact of jammers at the ground station.

• Government Airborne RFI testing has occurred.
  – More SATNAV System level tests are needed.

• FAA Spectrum Engineering is working to develop and deploy detection equipment.
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