GPS Privacy Jammers and RFI at Newark

Navigation Team AJP-652 Results

Presented to: Public Distribution

By: AJP-652

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Federal Aviation Administration

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 function 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.

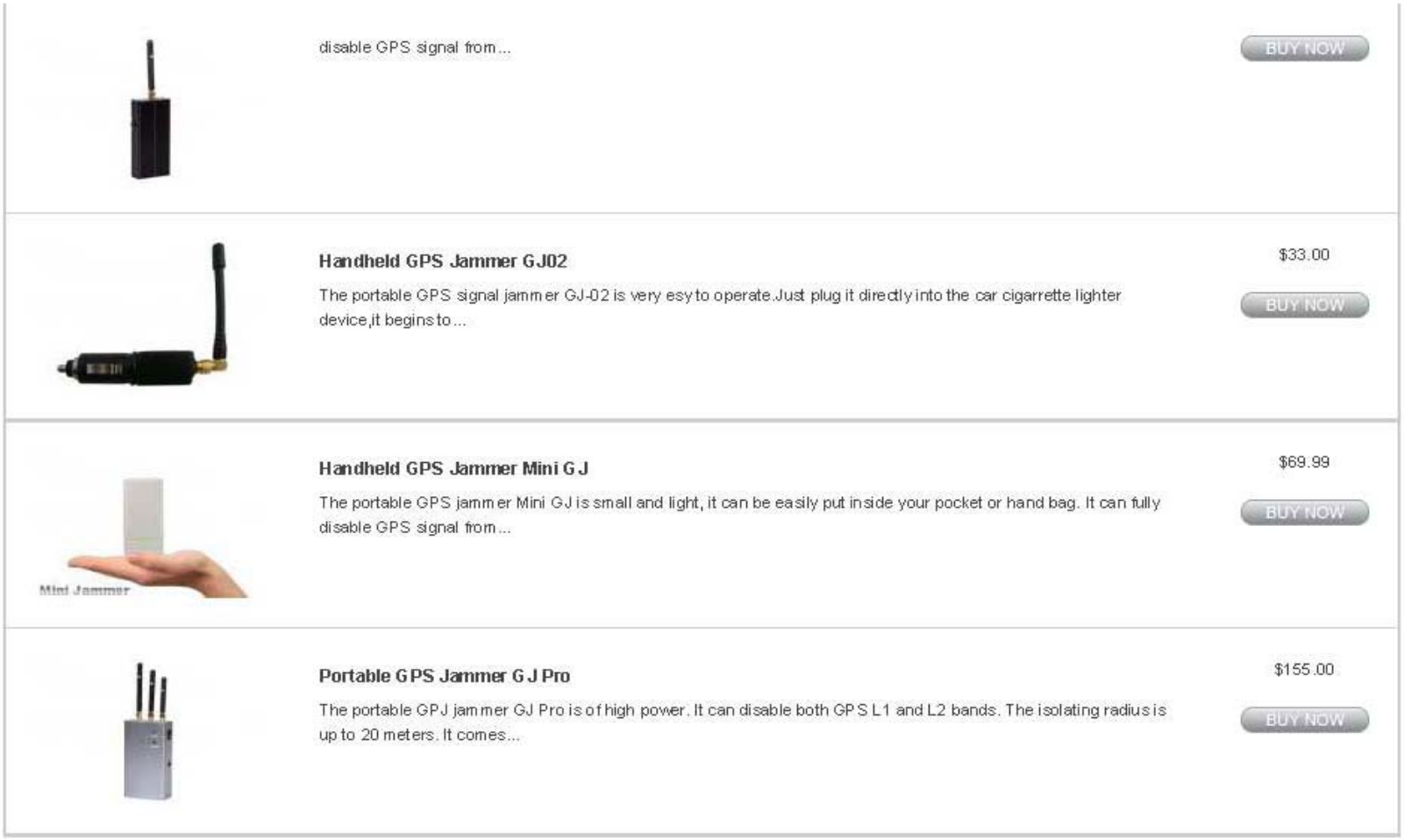
- **March 19th, 2010**
  - Zeta Deploys Specialized DF Equipment to GBAS Shelter as a second RFI station
- **March 23rd, 2010 (4 days)**
  - AJP-652 Deploys an expanded multi-day RFI Stakeout @ EWR – Same Contributors
  - GPS RFI Source Identified and Confirmed (NJTP)
- **April 14th, 2010 (2 days)**
  - 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

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



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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

EWR GPS/GBAS RFI Working Group

Addressing the RFI at Newark

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
  - 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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