

PERFORMANCE ANALYSIS OF AN INTEGRATED GPS/LORAN-C TRACKING SYSTEM

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Overview

- Background
- Evaluation System Description
- Performance Assessment
- Summary









Background

- The U.S. Congress Has Authorized \$140M Over Several Years to Enhance the Loran-C System
- The Performance of the Evolving New System is Being Evaluated for Potential Use
 - Aviation, Maritime, and Land Applications
- The Volpe Center Has Over the Past 15 Years Developed a Tracking and Situation Display Technology
- The FAA, Directing the Loran-C Enhancement Project, Has Asked the Volpe Center to Use its Tracking Technology to Evaluate Loran-C in Land - Particularly Urban - Environments
- **Project Objective:** Assess Ability of Enhanced Loran to Mitigate Loss of GPS in Land and Maritime Applications

Tracking & Display Technology: AIS and VIPS at U.S. Naval Station, Rota, Spain

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Escorted by law enforcement patrol boats equipped with the Vessel Identification and Positioning System (VIPS)



TRACKING & DISPLAY Technology

PORT SECURITY

Democratic National Convention

Boston, MA July 2004





Vehicle Tracking with GPS/Loran



Transponder Components

- Reelektronika Loradd Integrated GPS/Loran/WAAS Receiver
- Locus SatMate 1030 Loran with H-field Antenna and Rate Gyro
- µBlox Dead Reckoning System
 - Odometer, Rate Gyro, Trained with own GPS
- Starlink NDGPS (Nationwide Differential GPS)
- Nextel or Verizon (Boston, NYC, White Sands) Digital Data Link to Command Center for Land Tests
 - Marine Band for Maritime (Boston)
- Currently Recording:
 - 4 GPS
 - 2 Loran
 - 1 Integrated GPS/Loran
 - 1 WAAS
 - 1 DGPS
 - 1 DR (Odometer/Rate Gyro)

Performance Assessment - NYC

- GPS is Known to Perform Poorly in "Urban Canyon" Environment – Wall Street Area is Exceptionally Difficult
 - Signal Blockage, Multipath

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- Loran Has Some Conductivity and Signal Penetration Advantages, but also is Plagued by Multipath
- Preliminary Test Runs in Boston Confirmed the Multipath Problem
 - Decision to Add Dead Reckoning Capability



(photo courtesy ublox AG)

All 3 Systems Work Well Here



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Loran Offset Affected by Orientation



Middle of "Urban Canyon"



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Somewhere in Brooklyn



Dead Reckoning and GPS-Aiding in the Urban Canyon





"Open Tunnel" Near U.N. Bldg.



Observations on NYC Testing

• Three Representative Systems Involved: GPS, Loran, DR

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- Two Are Needed at a Minimum even THREE Are Not Good Everywhere
- The DR System Used Performs Much Worse in Situations (Relatively Few) Where it Continues to Use "Bad" GPS
- DR Can Locate Intersections in Wall St. Area, if Disconnected from GPS (up to About 20 min. after GPS is Lost)
- Loran, With ASF Corrections, Can Work in Normal Areas
- In a Jamming Environment, Loran Can Mitigate GPS Loss in Many Urban Areas
- In Some Areas (e.g., Near UN), Loran Can Hold Fix Longer Than GPS – But in the Volpe Tests, DR Also Performed Well
 - Time the Evaluated DR System Operates without GPS is a Factor



Performance Assessment - WSMR

- Jamming Will Deny Users the GPS Signal for Hours
- Loran Performance in Mitigating the GPS Loss is of Interest
- Dead Reckoning Performance Also of Interest







Range Rd 7 – DR Drift 1 km









Latitude vs. Time, GPS & DR Day 1





GPS HDOP (4 Sources) Day 1





Latitude vs. Time, Day 2 (1) 2 GPS; (2) 1 GPS, 1 Loran





Latitude vs. Time, Day 2 Different Loran Types, 1 Rx









Latitude vs. Time, Full Day2 (1) 3 GPS; (2) 3 GPS; Loran (red)



NOTE: Yellow (up) & Blue (down) Plots Shifted



SNR vs. Time; ECD vs. Time, Day 2

SNR





TDs, S1 – S4 (1); Master TOA (2); Day 2

TDs from Secondaries

Master TOA





Observations on WSMR Testing

- No Observed Loran-C Anomalies of Any Kind, Under Jamming or Not Under Jamming (GPS Band)
 - No Surprise, But Reassuring
- GPS-Dependent DR is Not Reliable Under Jamming
- Some Statistics:
- Up to 20 Data Messages per Second, All 7 Sources
- Loran Signal Quality "Bad" < 1% of the Entire Time, for the Chain Master and the Key Secondaries
- GPS Signal Quality (GGA) "Good" 1.1%, 44.2%, and 31.4% of the Entire Time (Includes Non-Jam Time)



Prognosis/Summary: e-Loran is a Likely Answer

- The Integrated GPS/Loran-C System is a Valuable Tool
- A Dead Reckoning (DR) System Was Also Examined
 - Uses GPS for "Training"
 - Extended GPS Outages (BOTH in NYC and in NM) Can Make DR Positioning Unstable
 - Next NYC Trip to Look at Video "Truth" Reference
- Loran-C Performance in GPS Jamming Environment: Remained on Lock – No Discernable Performance Degradations (Expected)
- When Loran Design Details are Fully Implemented in a Production Receiver, Performance Should be Even Better

DISCLAIMER:

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