Increasing Location Accuracy with Network Augmented GPS for Mine Countermeasures

16 September 2008

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**Motivation/Objective**

Higher accuracy GPS positioning to meet Mine Countermeasure (MCM) requirements

- Lower latency GPS orbit & clock data available at GPSOC [every 15 minutes]
- Communicate augmentation data directly to users
- Improved accuracy for:
  - Remote mine geolocation
  - Navigation
  - Mine/object avoidance
  - Situational awareness
Benefits of Precision GPS Ephemeris Web Services for Augmented GPS

ZAOD provides high accuracy, improved integrity GPS solutions
**Talon NAMATH SOA**

**SOA Components**
- GPSIS Schema
- Sub Mgmt
- ZDGPS Msg Gen
- ZNAV Msg Gen
- TBD Msg Gen
- NCES Alerts
- Mission Effects

**Services Adapter Layer**
- J2EE
- Web
- JRE WS
- TBD WS
- TBD WS
- TBD WS

**Current**
- Message Scheduler
- Message Publisher

**Future**
- TBD WS
- TBD WS
- TBD WS

**Organizational role**
- JICO
- JRE
- ADSI
- ISR
- Naval Operations
- Ground Forces

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MCM Science and Technology

Addressing Capability Gaps in Maneuver and Capacity

LCS-based MIW Mission Modules using unmanned vehicle technologies

Advanced Sonars and Processing for detection of buried mines

Cooperative, netted UUVs for mine hunting

Wide area surveillance of the nearshore battlespace for IPB

Rapid, overt reconnaissance of BZ/SZ/VSW for mines/obstacles

Standoff Assault Breaching Sys for Mine & Obstacle Destruction
Mine Counter Measure (MCM)
Benefits of PGE TCS

- NAVSYS is under contract to ONR
  - PGE TCS Web Services are being extended to support MCM precision marking & navigation
- PGE Services will integrate with standard GPS User Equipment in use by the Navy
  - DAGR/MRC JV5 BFT for AAV
  - KN-4073B for COBRA
- MCM operation cost & time savings achieved
  - Improved target location error & increased navigation accuracy MCM allows use of narrower lanes which reduces number of weapons used for breaching mine fields
Three Phase Program

Phase 1 FY07
- Prototyping
- Architecture
  - MCM PGE System Design
  - MCM PGE TCS Build & Test
  - Message Prototyping, Test & Selection

Phase 2 FY08
- Implementation
  - Design, Build & Test Development System
  - Design Demo System
  - Design Ops System
  - End to End Test of Development System at NAVSYS & NSWCDD

Phase 3 FY09
- Demonstrations
  - Refine Design, Build & Test Demo System
  - Demo DAGR/BFT on AAV & KN-4073 on MH-53E w/ COBRA
  - Complete Preliminary Operational System Design
PGE TCS with MCM Web Services

SOA Components
- GPSIS Schema
- Subscription Mgt

Services Adapter Layer
- GPSIS Loader
- MCM Web App

Message Scheduler
- ZWAGE 153
- ZDGPS XML
- ZNav 153

Message Publisher
- PGE UDP

EPLRS Wireless Network
- KN-4073B
- Surrogate Mission Computer

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**MCM TCS Subscription Services**

1. **Shipboard Planner establishes subscription schedule**
   - Planner logs into Navy TCS and subscribes to MCM Web Service
   - TCS initiates message transmission through SIPRNET

4. **MCM Messages routed to PGE Client on Platform using IP/UDP over tactical data link**
   - PGE Client formats messages for input to GPS UE through standard serial interfaces

2. **NAVY**

3. **EPLRS**

5. **Tactical Common Data Link**

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System Topography

Web Browser based Client: User Enters Subscription Information

PGE Client
- ZMessage Handler
- LADGPS Creation
- Integrity Calculation
- KN Interface Handling

Application Server
- Master Executor
- Message Scheduler
- Subscription Management
- Message Publisher
- GPSIS Schema Loader

Database Server
- Database

GPS UE

UDP

HTTP/SOAP

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**Architectural Design with NCES**

**Application Components**

- Master Executor
- ZMessage Creator Services
- Subscription Mgt
- Data Abstraction
- PGE Client Status Web Service
- GPSIS Schema Loader
- SQL Server

**SOA based J2EE Application Bus**

**NCES Core Services**

- Discovery / UDDI
- Messaging / JMS
- Security / JAAS

**Legacy and Specialized Data Adapters**

- PGE UDP Adapter
- JRE Web Service
- Compression / Binary XML
- JREAP

**Subscriber**

- Web Browser

**GPSIS FTP Loader**

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DAGR (SW 984-3006-005) PGENAV

Results Without & With PGE (ZDGPS)

**Without PGE GPS**
- DRMS: 5.35 m
- Vertical RMS: 5.72 m

**With PGE GPS**
- DRMS: 0.89 m
- Vertical RMS: 0.83 m

Note Scale Difference
## DAGR Error Budgets & PGENAV

### Results

<table>
<thead>
<tr>
<th>Error Sources</th>
<th>Spec* DAGR</th>
<th>Proposal** DAGR</th>
<th>DAGR PGENAV w/o ZDGPS</th>
<th>DAGR PGENAV w/ ZDGPS</th>
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*Performance Spec for the NAVSTAR GPS DAGR, 29 Sep 2004, pp 127-128
** Section 4.1.2 of submitted proposal
*** SS-GPS-300 nominal constellation
• Estimation & Prediction of Orbits & Clocks to High Accuracy
  – Next generation of precise GPS orbit & clock estimation software being developed by NSWCDD for NGA
  – Current software (OMNIS) used by NGA operationally as DoD standard; NGA & AF tracking site positioning; WGS 84 definition
• Potential source for MCM PGE data (vs GPSIS ZAOD)
• Status
  – Non-real-time algorithms completed
  – Real-time systems scheduled for testing in spring 2009
• Post-processed user positioning results (OMNIS SW)
  – Decimeter-level accuracy demonstrated using NSWCDD dynamic precise point positioning software
Proposed ZMDS/EPOCHA Upgrades

SOA Components

Current

Message Scheduler

GPSIS Schema
Sub Mgmt
ZDGPS Msg Gen
ZNAV Msg Gen

Future

Message Publisher

ZMDS Schema
EPOCHA Schema

Services Adapter Layer

Current

JRE WS

Future

J2EE
J2EE

Organizational role

GPSIS FTP Site
JICO
JRE
ADSI

AEP ZMDS TBD interface
MSNCC Backup Interface

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Summary

• MCM PGE TCS architecture from legacy system
  • Extendable to new pub/sub services for fielded GPS UE
  • Customized TCS Web Services reduce development and integration costs in platforms needing GPS Augmentation

• PGE services provided by TCS can enable < 1 m accuracy for targeting, nav & weapons guidance

• GPS UE supported by MCM developed services
  • DAGR/MRC JV5 BFT (PGE Client SW runs on laptop)
  • KN-4073B GPS/Inertial (PGE Client SW on platform computer & in KN-4073B)
  • Other GPS Receivers IAW GPS ICD

• PGE has potential application for other assets
Backup
MCM PGE Program Objectives

• Provide system for high accuracy position for MCM assets
  • Enhanced GPS accuracy/integrity for COBRA navigation system
  • Precise GPS location to AAV DAGR for nav in safe maneuver space
• Implement appropriate NESI architecture for MCM operations
• Create PGE TCS development & test infrastructure
  • Robust architecture for extension for other applications
  • Easily reproduced for future developments to grow into ops capability
• Provide ForceNet capabilities through pub/sub service
  • Extends GPS accuracy corrections where and when needed
  • Message distribution increases accuracy of mission execution
• Integrate w/ platform nav systems for TRL 6 Demo for transition
  • DAGR/BFT end-to-end, accuracy improvement demo on AAV
  • KN-4073B (COBRA) end-to-end, accuracy demo on MH-53E
Acronyms

- AAV: Amphibious Assault Vehicle
- BFT: Blue Force Tracker
- COBRA: Coastal Battlefield Reconnaissance Analysis
- DAGR: Defense Advanced GPS Receiver
- EPLRS: Enhanced Position Locating Reporting System
- EPOCH: Estimation & Prediction of Orbits & Clocks to High Accuracy
- GPSIS: GPS Information Service
- GPSOC: GPS Operation Center
- GPS UE: GPS User Equipment
- MCM: Mine Countermeasure
- M-DACT: Mobile Data Automated Communications Terminal
- OMNIS: Orbit Mensuration and Navigation Improvement System
- PGE: Precision GPS Ephemeris
- TCS: Tactical Control Station
- UDP: User Datagram Protocol
- ZAOD: Zero Age of Data
- ZDGPS: Zero Age of Data Differential GPS
- ZNAV: Zero Age of Data Navigation Message
**PGE Importance to AAV**

- Troop Commander (TC) AAV has M-DACT
  - 1 M-DACT in every 3 vehicles
  - Lead Driver has M-DACT display in TC AAV

- **Importance:**
  - More accurate position within cleared lanes
  - Allows AAVs to safely maneuver wrt each other & waves

- **Benefits:**
  - More forces arrive on the beach during assaults
  - Faster transit to the beach during assaults
  - Reduction of losses of troops and AAVs
  - Fewer incidents of grounding on sand bars
PGE Importance to COBRA

- KN-4073B, Kearfott GPS/INS, integrated with COBRA
  - Provides nav, heading, attitude, velocity, position, Δθ, & ΔV
  - COBRA employs KN-4073B data to determine mine location
- Importance:
  - More accurate position of mine and obstacle locations
  - Allows better determination of safe maneuver space
- Benefits:
  - Minimum Overlapping Efficient Searches
  - Neutralization with high probability of kill
  - Well defined virtual lanes for safe transit
  - Minimizes sorties/weapons/darts to clear lanes
  - Decreased probability of landing accidents