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Savannah, GA

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

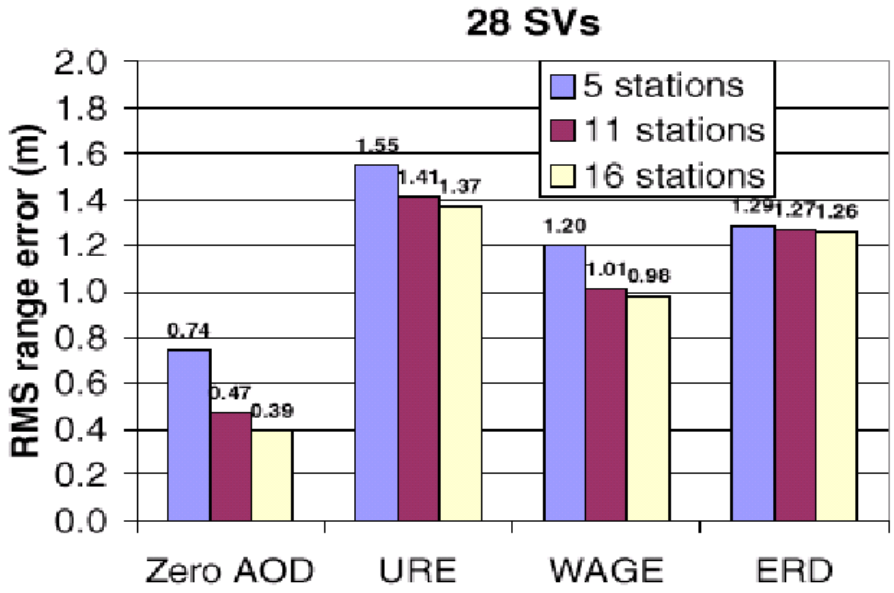
Lower latency GPS orbit & clock data available at GPSOC [every 15 minutes]

Communicate augmentation data directly to users

Improved accuracy for:

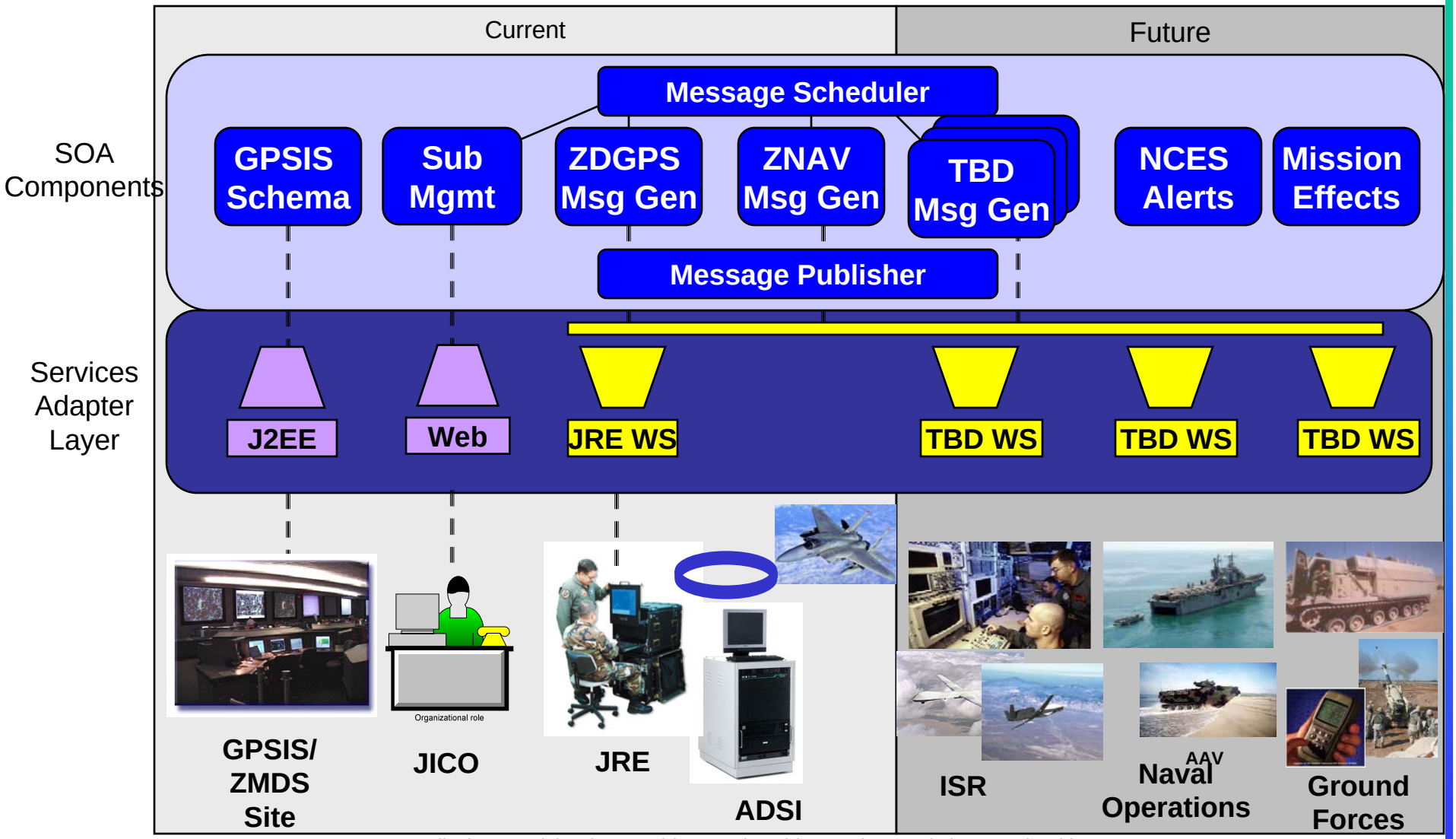
- **Remote mine geolocation**
- **Navigation**
- **Mine/object avoidance**
- **Situational awareness**

Benefits of Precision GPS Ephemeris Web Services for Augmented GPS



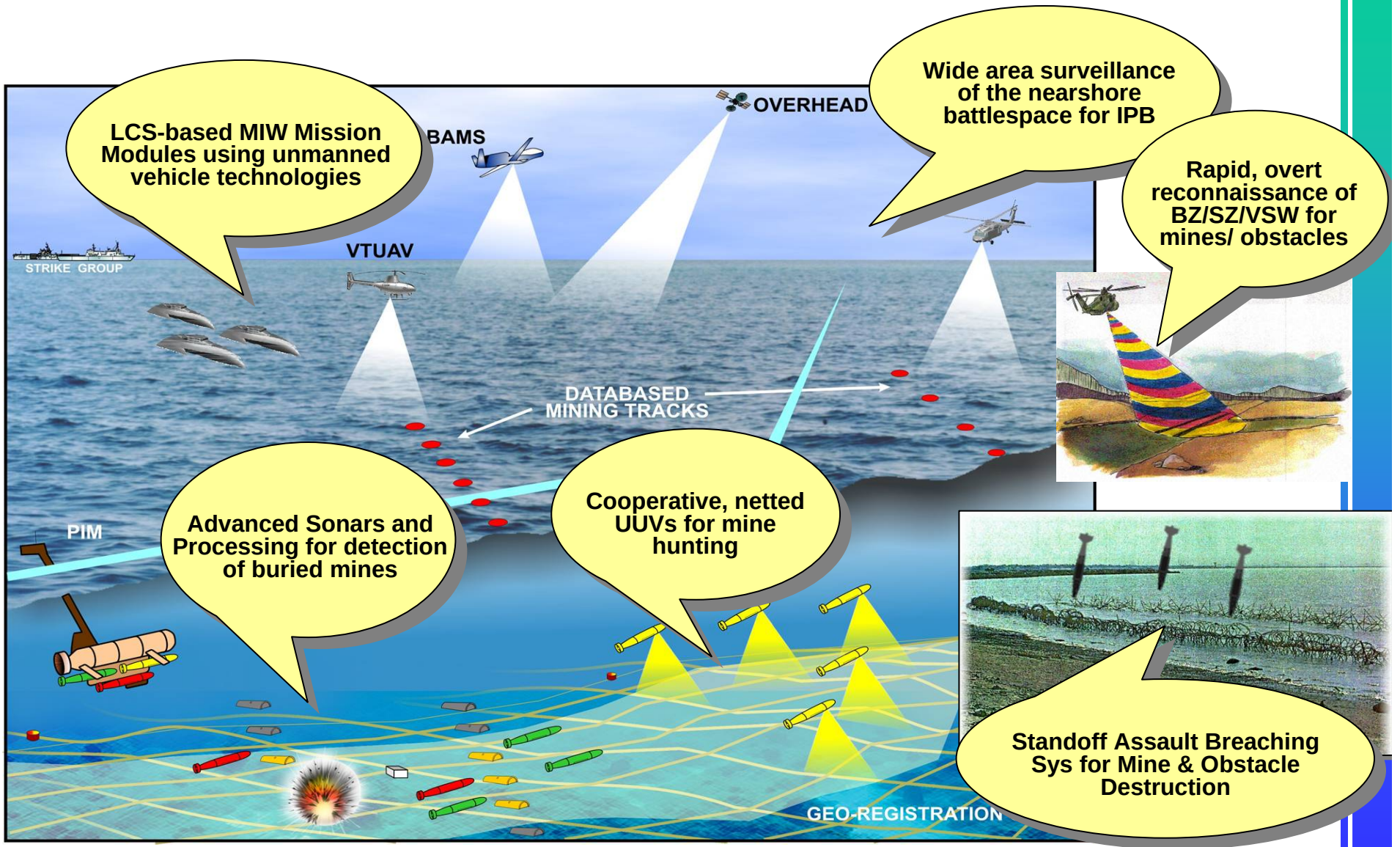
ZAOD provides high accuracy, improved integrity GPS solutions

Talon NAMATH SOA



MCM Science and Technology

Addressing Capability Gaps in Maneuver and Capacity



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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

MCM Precision GPS Ephemeris Distribution System Demo

GPS

MH-53 w/COBRA & GPS/INS Sensors

Worldwide AF & NGA Real-Time GPS Tracking Sites

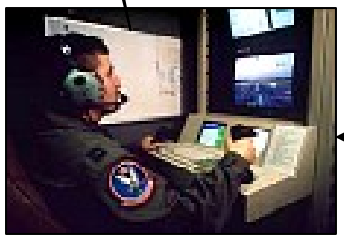
AAV with DAGR GPS Receiver

RF COM LINK

AF GPS Operations Center (GPSOC)

SIPRNET

SINCGARS or EPLRS COM LINK



SIPRNET

MCM Tactical Control Station [NAVSYS or NSWCDD]

Communication Station

GPSOC Provides Updated GPS Satellite Nav Message Every 15 Minutes for Improved Positioning Accuracy

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

Services Adapter Layer

GPSIS Schema

Subscription Mgt

Message Scheduler

ZWAGE 153

ZDGPS XML

ZNav 153

Message Publisher

GPSIS Loader

MCM Web App

PGE UDP

EPLRS Wireless Network

KN-4073B

GPSIS FTP Site

Comm Officer

Surrogate Mission Computer

DAGR

MRC JV5 BFT

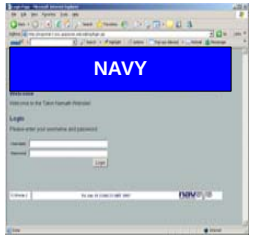
MCM TCS Subscription Services

1

Organizational role

Shipboard Planner establishes subscription schedule

2



Planner logs into Navy TCS and subscribes to MCM Web Service

3

TCS initiates message transmission through SIPRNET

SIPRNET

EPLRS

AAV

4

MCM Messages routed to PGE Client on Platform using IP/UDP over tactical data link

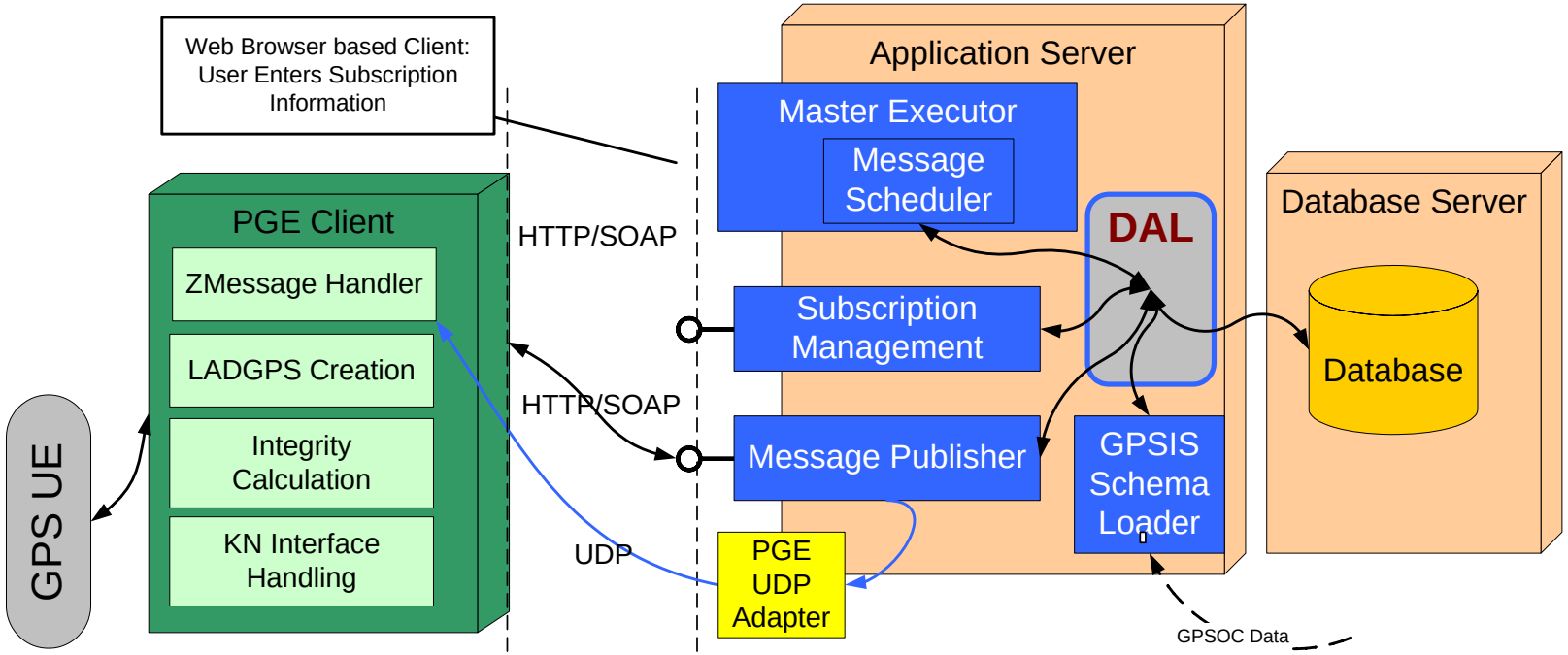
5

PGE Client formats messages for input to GPS UE through standard serial interfaces

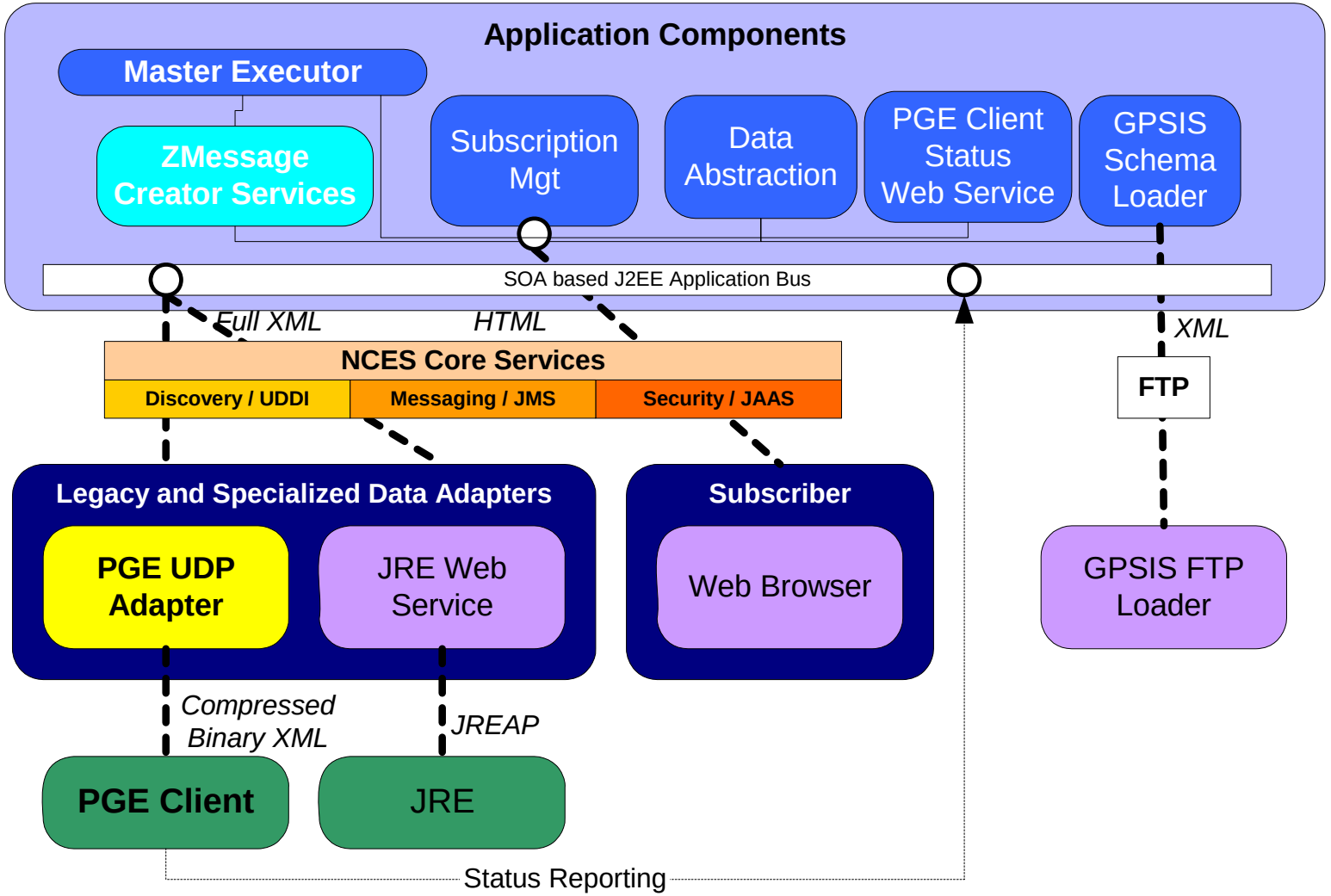
Tactical Common Data Link

COBRA Payload

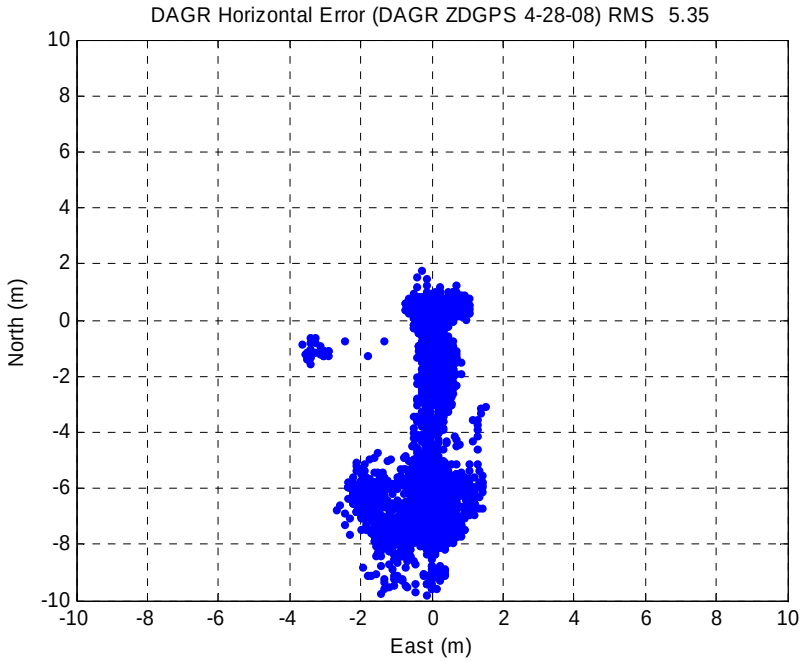
System Topography



Architectural Design with NCES

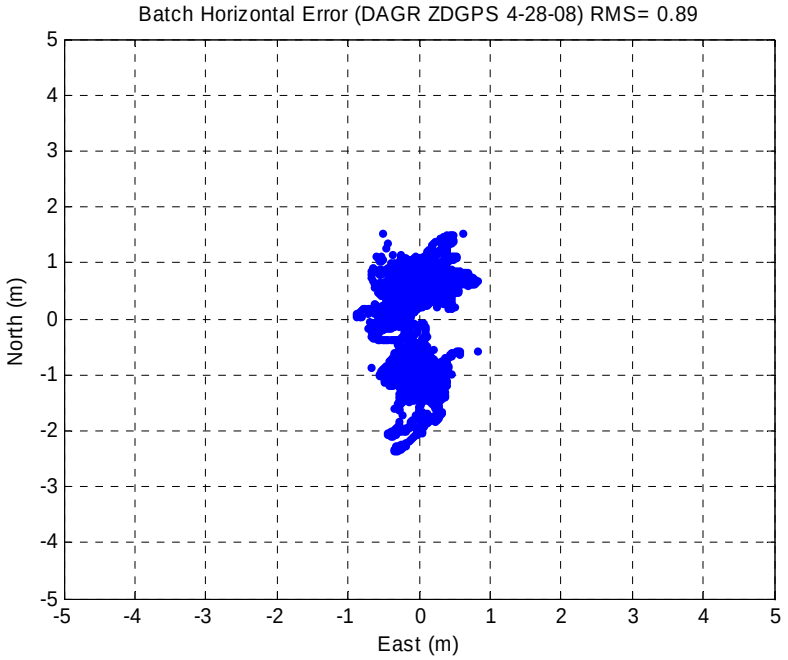


DAGR (SW 984-3006-005) PGENAV Results Without & With PGE (ZDGPS)



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

Error Sources	Spec* DAGR	Proposal** DAGR	DAGR PGE NAV w/o ZDGPS	DAGR PGENAV w/ ZDGPS
ZAOD (m)		0.47		
Ionosphere (m)		0.10		
Tropo (m)		0.10		
Multipath and Noise (m)				
URE (m)	2.25			
UEE (m)	2.59			
UERE (m)	3.43	1.30		
HDOP (SS-GPS-300***)	0.98	0.98		
VDOP (SS-GPS-300***)	1.58	1.58		
DRMS (m)	3.36	1.27	5.35	0.89
Vertical RMS (m)	5.42	2.05	5.72	0.83

*Performance Spec for the NAVSTAR GPS DAGR, 29 Sep 2004, pp 127-128

** Section 4.1.2 of submitted proposal

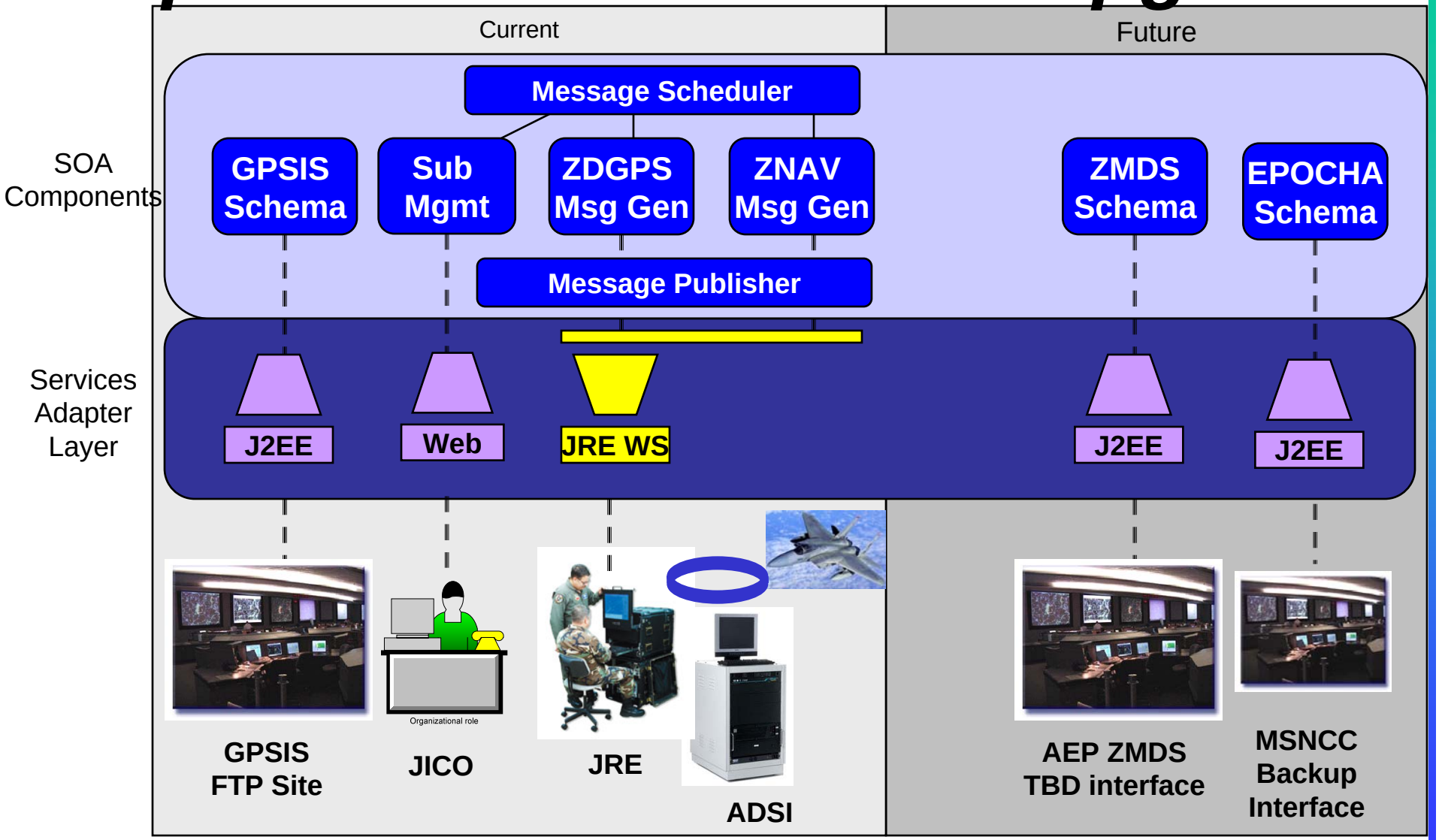
*** SS-GPS-300 nominal constellation

NAVSEA WARFARE CENTERS
DAHLGREN

NSWCDD/NGA EPOCHA

- 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



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
- EPOCHA: 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