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Synergetic Human-System Integration for Reliable and Efficient C2 Operations

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Outline

I. Problem statement
II. Introduction
III. System Overview
IV. Technique Description
V. System Implementation
VI. Conclusion

I. Problem Statement

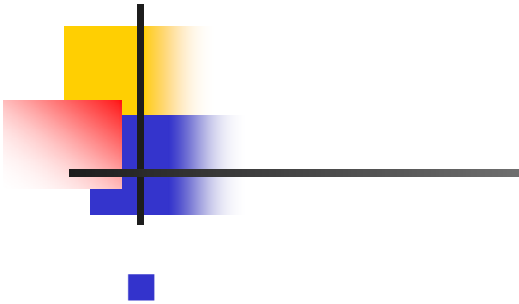
I. Problem Statement

1. Synergetic integrations of

- humans with autonomous systems (software agents),
- active and passive sensors, and
- data fusion engines

2. A cohesive human-in-the-loop system of
information
- gathering,
- analysis,
- management,
and
- decision making

Tasks crucial to future military command and control (C2) capabilities.



II. INTRODUCTION

II. INTRODUCTION (1)

Ways to share information

- **Poorly chosen technology solutions for information exchange between human and automated systems are more detrimental than the lack of information**

  e.g., a poorly defined flow of a large amount of information overloads the decision maker

- **Relationship between humans and computer systems in C2 operations should be mutually complementary, rather than reliance of one to the other**

  the automated systems should do is to extend and enhance the human's capabilities, in other words, to free human hands from tedious tasks and assist humans to do what they can do the best

Maximizing the overall system's capability (both human and computer)

II. INTRODUCTION (2)

Ways to share information

- **Surveillance System Human-Computer Integration (SSHCI)**

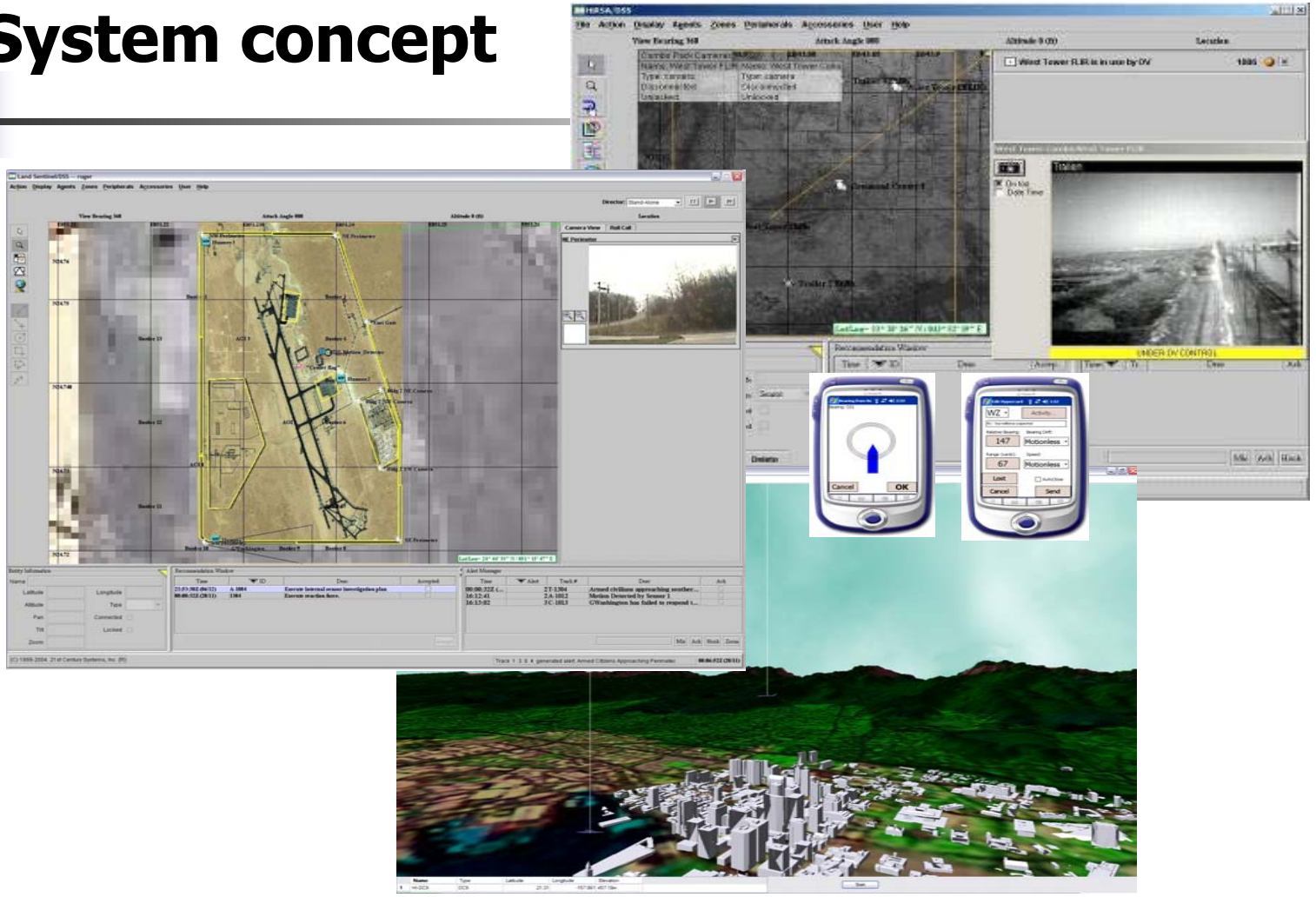
  A synergetic integration of humans and computers in a mutual, complementary, and human-in-the-loop configuration

  Incorporates multiple sets of agent-based functional modules, 2D/3D visualizations, and human-agent interaction interfaces

Application: **Anti-Terrorism/Force Protection (ATFP)**

II. INTRODUCTION (3)

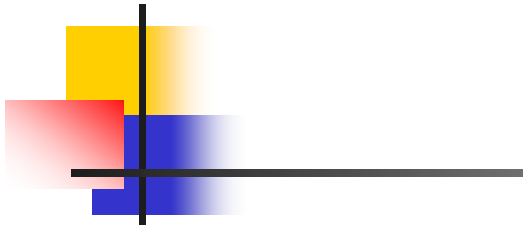
- System concept



I. INTRODUCTION (4)

Sentinel Net:

- **A tailored semantic knowledge representation model**
- **A smart-media communication scheme**
- **A simple, versatile, extendable, and rapid human-computer interaction mechanism**
  - holstered pocket PC with wireless connectivity
  - dynamical data structure (DDS) and
  - signal package (SP) scheme.
  - central tracker keeps a log of all SPs and transactions for reliable and extensive monitoring operations.



III. SYSTEM OVERVIEW

III. SYSTEM OVERVIEW (1)

Major Concepts

1. ***Complementary Human-System Functions***

- For an effective C2 operation, sensors, geospatial databases, force locators, and automated reasoning systems in commanding centers should be operating on a common network

- Include decision support tools for environmental prediction, event reporting, pre-mission planning and post-mission analysis, impact and consequence management, etc.

Bring humans and computer systems together

III. SYSTEM OVERVIEW (2)

Major Concepts (cont.)

2. ***Humans in the Loop Systems***

Common Operation Picture (COP) and Shared Tactical Picture (STP)

"**open loop**" - human operators or commanders make decisions on reacting to the events according to collected sensory data and other environmental information displayed in the COP and STP.

"**closed loop**" - human operators and commanders actively seek for and extend with control and management of the sensory devices and means of verifying current information and acquiring new information in the COP and STP, while reacting to the environmental situations.

Two-way information flow:

(1) from sensors and sentries to the C2 center

(2) from C2 centers to the sensors and sentries.

Major Concepts (Cont.)

3. ***Knowledge Augmentations***

"Shared information does not automatically, if ever, lead to shared understanding," [Kau05]

Ability to transfer knowledge reduces the amount of processing and information required at each stage of the information pathways.

Seize the initiative faster than the opponents

III. SYSTEM OVERVIEW (4)

Major Concepts (Cont.)

4. ***Integrative System of Systems***

A large set of system components interaction with each other to serve as a corporative construct for any specific application

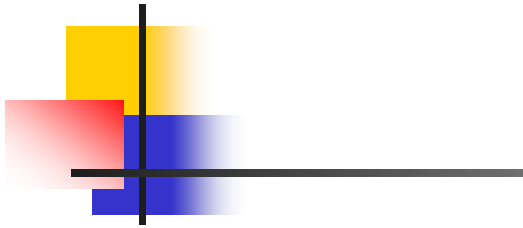
Merging of many different descriptions of the same point-of-contact into a single point-of-contact

Minimize the negative effects of either a wrong or a missed data

Key Functional Components

- Much of the situation awareness (SA) task aboard submarines is made very difficult by incomplete, confusing and partially correct (and partially incorrect!) information from the various resources.

- To model friends, foes and the environment, and to provide functional, timely and relevant advice to CO, XO, OOD, Sonar Supervisor and others, we need to make use of theories suitable for modeling information and structuring information in the presence of incomplete, partially correct data and under conditions of time and mission stress.



IV. TECHNIQUE DESCRIPTION

Key Functional Components

1. Knowledge Representation

- **Representation framework -**
  - a common data dictionary, and
  - a belief network used

  low-level sensor classification, and higher level semantic and synonym-set representation

- **Semantic Distance -**
  - For different problem spaces, different semantic distance and belief functions should be used.

IV. Technique Description (2)

Key Functional Components (Cont.)

2. Knowledge Communication

- **Organization**
  - **in groups according to geospatial zones or threat types.**
- **Encode**
  - **different threat patterns and**
  - **causal relations in different zone identities.**

Military personnel can manage the system with little or no special training (as long as the person knows how to connect to network and to generate some kind of text input using a software like a word processor).

IV. Technique Description (3)

Key Functional Components (Cont.)

2. Knowledge Communication

- ***Operations***
  - **data-driven.**
- **Collaboration between**
  - **users (humans) and the computer system (agents)**
  - **humans and the SSC central tracker.**

Once a DDS transaction event takes place, a human-system collaboration process starts

IV. Technique Description (4)

Key Functional Components (Cont.)

3. *Knowledge Engine*

- ***Data Acquisition***
  - **Can be addressed (push/pull) from the multiple, heterogeneous resources.**
  - **Can be fed, or acquired by the system, in multiple channels ranging from**
    - sources of intelligence resources,
    - surveillance sensors, and
    - HUMINT originated from the pocket PCs of the on-ship observers in charge of each zone.

IV. Technique Description (5)

Key Functional Components (Cont.)

3. Knowledge Engine

Functions of the engine include

queuing,
prioritization,
mapping,
evaluation, and
directions of linking.

The sensory and watch-stander observations from the multiple sources are gathered in a buffer/queue, prioritized, and then sent to the inference agent.

The threat/attack detection inference engine associates the real-time data with the knowledge stored in the system to identify a possible terror attack and trigger an alarm/reaction.

The inference engine performs a sequence of operations such as look-up with respect to the events reported, and invokes activities specified by the pre-set models (e.g., look up other events according to the current situation).

IV. Technique Description (6)

Key Functional Components (Cont.)

3. *Knowledge Engine*

- ***Inference Engine***
  - **a necessary component of information integration and decision support**
  - **utilizes KR for reasoning and evidence integration.**
  - **resides in the SNAAP, and**
  - **allows for common use cases and force protection plan inheritance from other like protection plans.**

IV. Technique Description (7)

Key Functional Components (Cont.)

3. *Knowledge Engine*

- **The inference engine of Sentinel Net is designed to perform, in a sequence of, two pattern matching operations for**
  - alignment,
  - correlation,
  - association, and
  - integration of multiple reports from different sentries and automated sensory devices with disparate information of observed objective situations.

to provide a more efficient threat/solution matrix and increase the force protection efficacy overall.

IV. Technique Description (8)

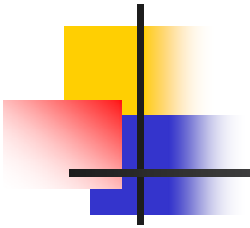
Key Functional Components (Cont.)

3. *Knowledge Engine*

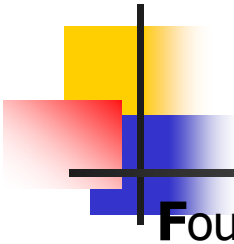
- ***Characterization***

Main characteristics of the knowledge engine of the Sentinel Net system include:

- Easy to operate: For system set up, the users only need to know how to enter text into DDSs (will have templates) and one only needs to push a button to trigger the system.
- Easy to modify: Operations can be done either off-line or on-line.
- Easy to expand: Sentinel Net renders a nice separation from the system control engine. Knowledge and Inference rules are not hard-coded in software.
- Easy to enhance and comprehend: A natural language interface provides the ability for user to participate in the system building activities by creating the DDS, communicating the contents, and fusing the data in the inference engine.



V. SYSTEM IMPLEMENTATION



Software Architecture

Four major functional blocks:

1. Network environment

- The linked DDSs, the set-up, activation, access, and utilization of the system will all be done through message communication in the network.

2. System control agent assembly

- The system control agents coordinate the creation, modification, access, and activation of the sentry entities.
- There are different types of agents, each responds to a specific task, such as access control, event inference, parameter adaptation, etc.

Software Architecture (Cont.)

Four major functional blocks:

3. Agent communication

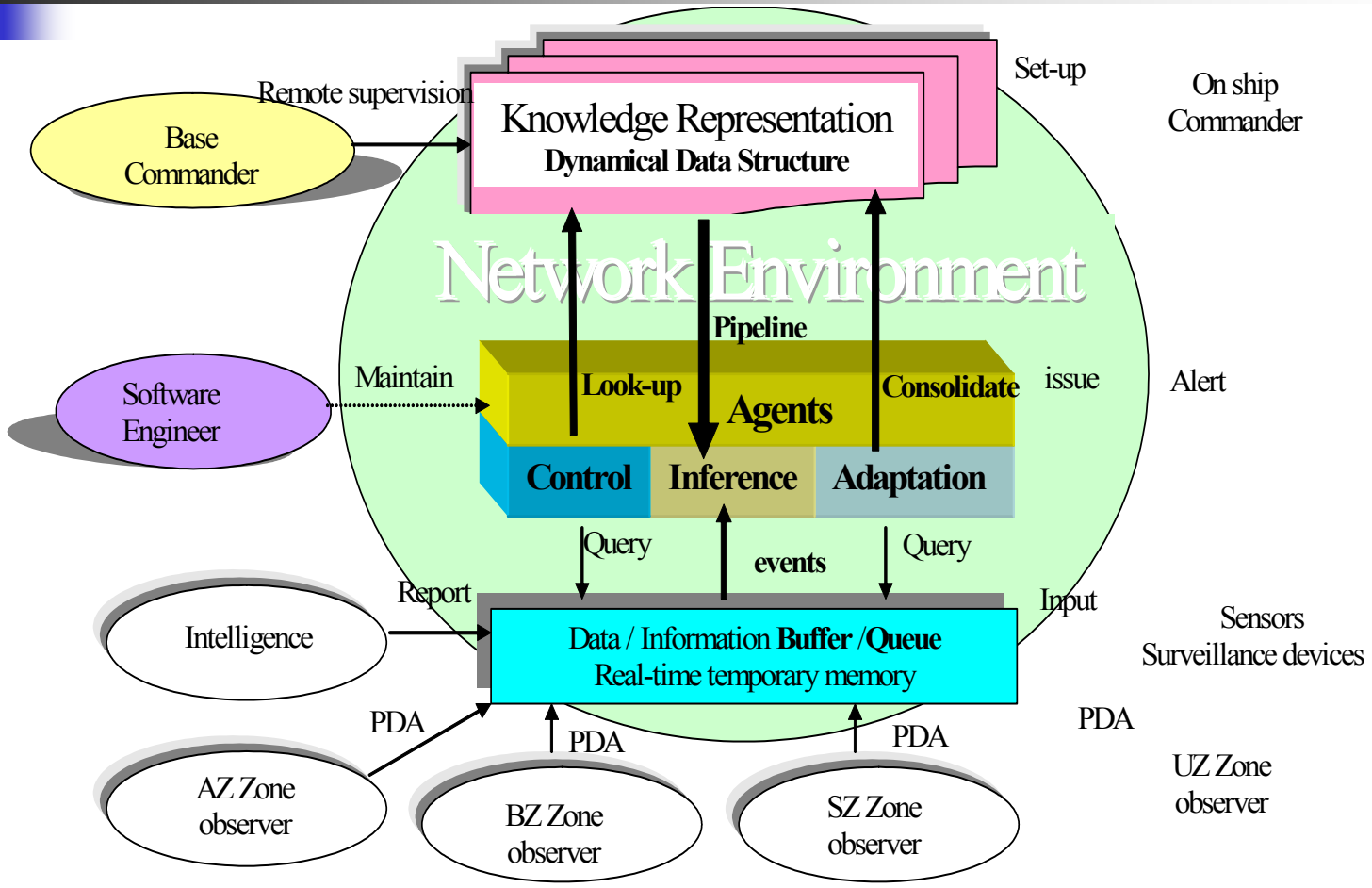
- Agents in the system communicate using smart DDS organized in stacks according to zone categorization.
- The DDSs can be created, organized, accessed, and modified through operations that can be performed either remotely (via network) or locally.

4. Event Buffer /Queue

- The event buffer is organized as a data queue.
- The buffer receives event report and other surveillance information from multiple sensors, observers in every zone, and other information sources.
- There is an event control agent in the system agent assembly that is in charge of setting the event processing priorities and preliminary filtering for the events entering the queue.

V. SYSTEM IMPLEMENTATION (3)

Software Architecture



Agent technology

- **Intelligent agents provide**
  - qualification and quantification of information uncertainty,
  - utilities of particular decisions,
  - risk aversion,
  - Tradeoffs.

- **Special agents to**
  - coordinate,
  - Synchronize,
  - Arbitrate,
  - play human surrogate roles,
  - Communication exchanges.

Agent technology (Cont.)

Asynchronous and intelligent agents

- to support:

- prioritization, management, coordination of data fusion process,
- modeling adversarial and friendly behavior
- providing advices to decision makers (or software agents playing human roles).

The agents with data fusion ability are to learn and cooperate to process overwhelming combat information more accurately, systematically, and in a well-prioritized manner.

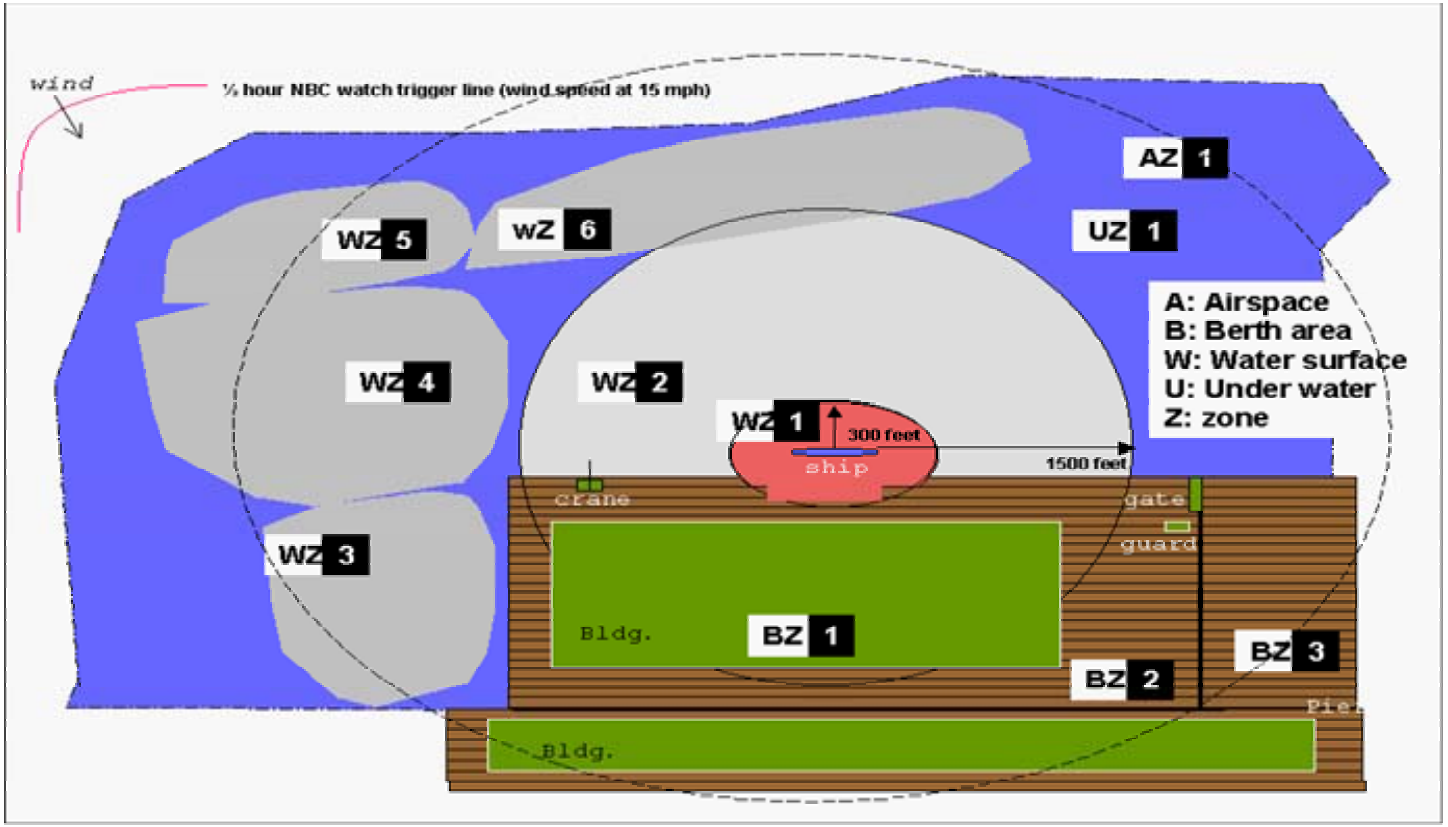
Distributed processes

Force Protection Zone Characterization

- Each zone is categorized by a security level (see Figure 3) such as:Figure 3 Zoning Illustration for a Berthed Ship
- Exclusion (Red) zone - a ship's stay out area
- Medium security zone (light gray) - vessels at minimum speed on a non-threatening course
- Surveillance zone (dark gray) area under surveillance - Size and shape of a surveillance zone may change due to time of day, weather, etc.

Distributed processes

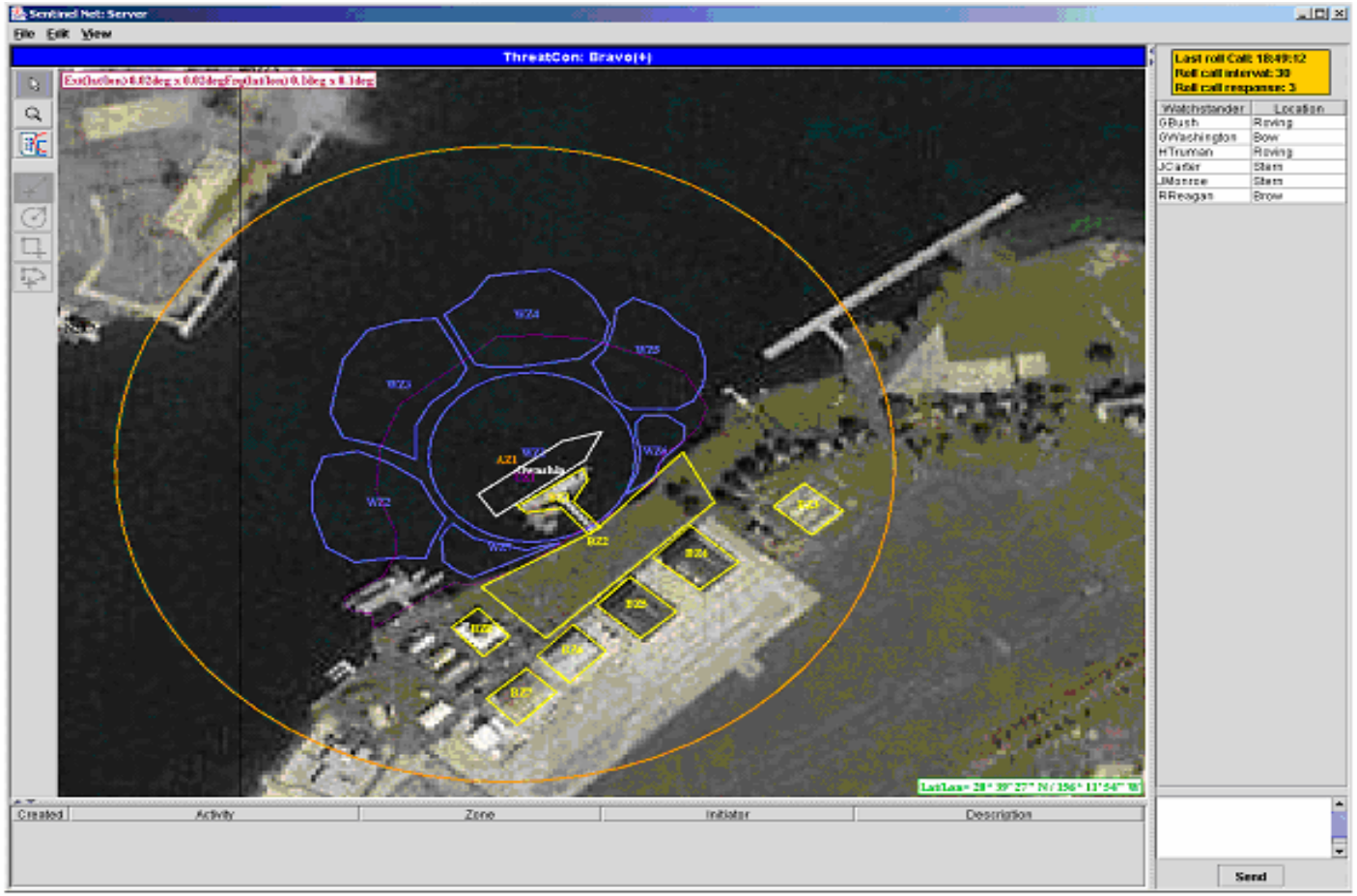
Force Protection Zone Characterization



V. SYSTEM IMPLEMENTATION (8)

Distributed processes

Example



V. SYSTEM IMPLEMENTATION (9)

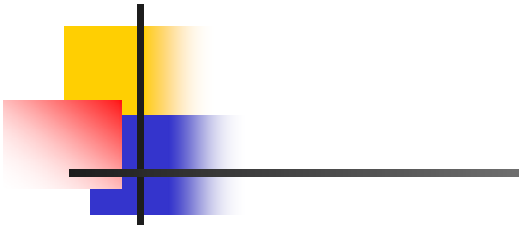
Augmented Human-Machine Interaction

- Graphics User Interface and Visualization
  - icons indicating current location of
    - sentries,
    - sensors,
    - SP incidences, and
    - WCA (Warning, Caution, and Alert).
- Visual feedback is crucial to discern patterns of attack and develop a course of action.
- Using data-driven inference engine to perform data fusion
  - aid the FP "Command Center" in making timely, accurate decisions in response to perceived threats.

V. SYSTEM IMPLEMENTATION (10)

Augmented Human-Machine Interaction (Cont.)

- Current Sentinel Net architecture lends itself well to additional sensor integration.
- Examples of sensors can be incorporated:
  - swimmer detection systems,
  - IR detection devices,
  - passive motion sensors and
  - land-based acoustic sensors.
- Ability to learn more aspects on how human and systems (sensors and inference engines) can interact most effectively and efficiently
  - with respect to the availabilities of more advanced sensory and automated systems



VI. CONCLUSION

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Benefits of the Technology and Extended Applications

- Synergistic integration of human operators and automated computer systems can more accurately emulate C2 processes
  - expand the operational field of efficiency and effectiveness in interaction and communication with the automated systems.
- Superior knowledge leads to superior tactics and overwhelming victory.
  - processing vast amounts of information and
  - helping speedy decisions.
- Concepts and technology also be applied to war in cyberspace
  - integrated network of humans and "intelligent" sensors.
  - includes threats to computers and network services.
- Codes for manipulation of computer, cable, satellite, or telecommunications services.
  - Again synchronized attack where the terrorist intent to disrupt the network to reduce communications and follow with physical attack to increase the level of terror and chaos.
- Inference engine collaborating with human operators closely can identify any potential attack pre-actively.

About 21CSI

- 21st Century Systems, Inc.® (21CSI®) is a pioneer in agent-based decision support systems for time- and mission-critical military applications
  - Woman-owned, founded in 1996
- Decision support tools across the spectrum of missions
  - Individual Soldier Situational Awareness
  - Distributed Warship Command and Control
  - Decision Under Uncertainty
  - Homeland Security/Force Protection Situational Awareness
  - Secure R&D Collaboration…*and others*
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  - Wireless PDAs
  - Laptops, desktops, to massive parallel computers

  …*and are Operating System independent*
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