Shared User Interfaces for Dynamic Collaboration in Network-centric Command Centers

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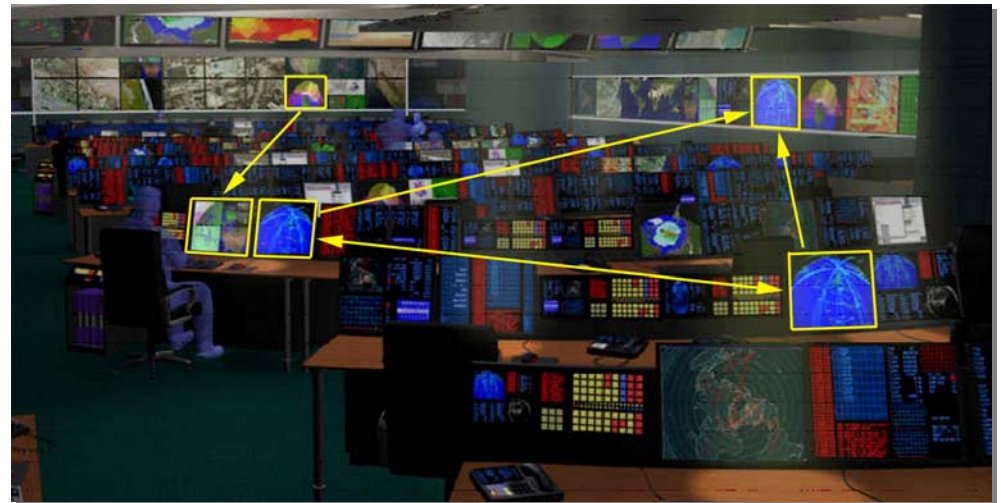**John Standard**
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Bedford, MA

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Overview

- **Background**

- **Design Approach**

- **Interaction Concepts**

- **Prototype System Architecture**

- **Summary**

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Background

- Information sharing in current command centers revolves largely around *video* sharing

- Sponsor CONOPS moving towards a distributed, collaborative mode of operations
  - *Virtual* command centers comprised of dispersed analysts and decision-makers supporting dynamic, changing needs
  - Structured and agile, ad hoc collaboration
  - Operational pictures tailored to mission requirements

- Teams must share tailored mission data to accomplish inter-dependent serial/parallel tasks
  - Across collocated or distributed teams
  - Synchronously or asynchronously
  - From individual workstations to "knowledge walls" for shared viewing
 - From command centers to the tactical edge

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Objective

- Explore and develop concepts for using multiple human/machine interface technologies together in a command center in a constructive, synergistic way

  - Share data between systems and displays to build collaborative pictures of the battlespace

  - Use large "knowledge walls" as a canvas for shared situation awareness

- How can we embed capabilities for such information-sharing within C2 mission applications and operational environments?

  - What should we share and how should we share it?

  - How can we create and share composite, multi-source data pictures?

  - What are effective human/computer interaction metaphors for shared pictures?

  - How can we make effective use of a knowledge wall canvas?
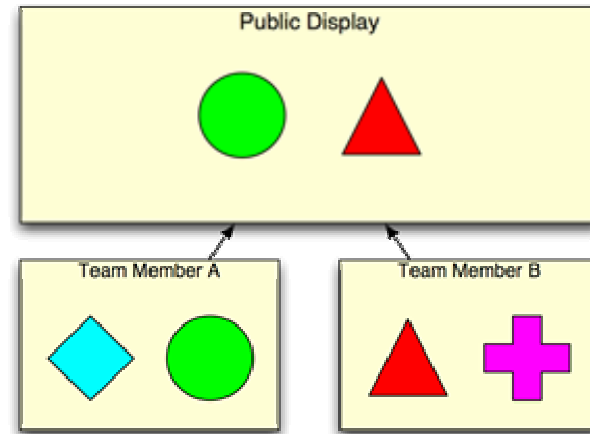
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Command Center Information-Sharing
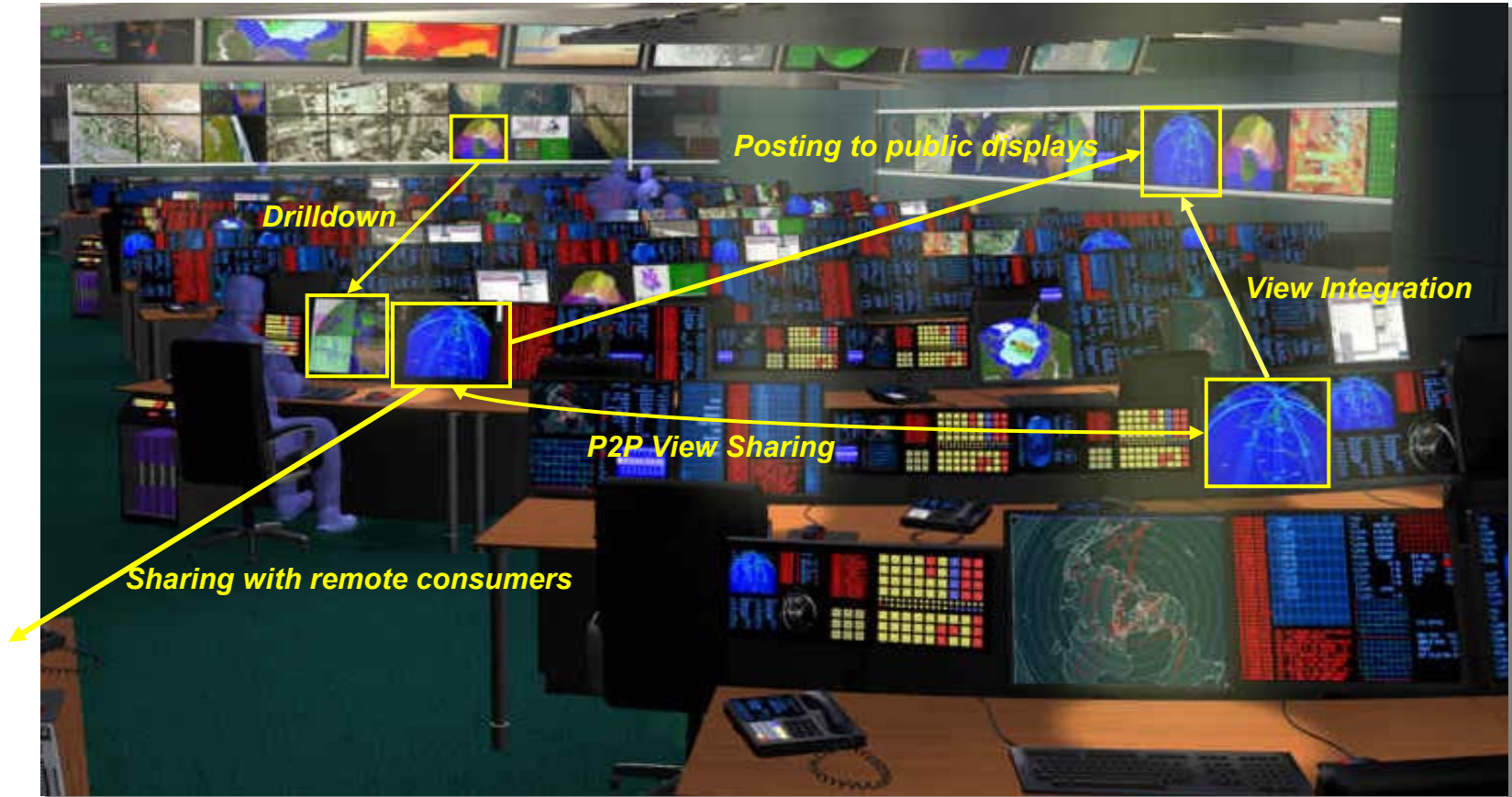
How can we move beyond the video switch?

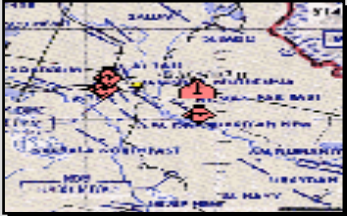**MITRE**

Shared User Interfaces
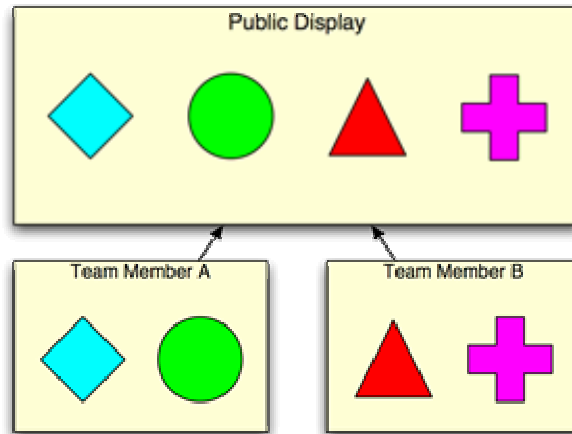
Full Shared Displays:
Share everything

Abstracted Shared Displays:
Share what's needed

- Team performance better using abstracted shared displays vs. full shared displays in simulated air defense task (Bolstad, 1999; 2000)

    – Accuracy and coordination improved in high workload conditions

- CTA techniques used to derive shared information requirements

- Can abstracted shared displays improve collaborative decision-making in the C2 domain?

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Shared Picture Concepts

Approach	Benefits	Limitations
Pixels	- Minimal requirements on receiving end: just a screen - Straightforward to implement: video cables and switches - Fewer security challenges	- View cannot be reformatted for different target devices - View cannot be modified - View cannot be integrated with others

Data
 	
`<Threat>`
`  <name>`
`    SAM-21`
`  </name>`
`  …`
	- View can be integrated with others on the receiving end - Potential bandwidth savings - View can be reformatted for different target devices - Role-based data filtering	- Recipients of shared picture must understand data format - Challenges with transport across security boundaries

Recipe
 	
`<feed>`
`  <src>COT:smulgund</src>`
`  <src>AirPicture:seth</src>`
`  <src>GroundPic:joe</src>`
`</feed>`
	- View can be integrated with others on the receiving end - View can be reformatted for different target devices - Can encode transformations and filters as part of the feed - Can be generalized to similar future scenarios	- Recipients of shared picture must understand data format - Challenges with transport across security boundaries - Receiver must interpret data view

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Mission Scenario: Course of Action Development

i. Mission analysis briefing development

ii. Mission analysis briefing to Commander

iii. COA options development

iv. COA options briefing to Commander

v. COA coordination between command centers

vi. COA recommendation briefing

Storybuilding **vs.** *Storytelling*

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Storybuilding vs. Storytelling

Storybuilding	Storytelling
• Knowledge wall is the canvas for shared situation awareness • Interactively build an understanding of the mission • Information and analyses developed by Crisis Action Team members posted to the wall as they are developed • Individual command center occupants can "drill down" into information on KW screens • "Information manager" can mediate what is posted to the KW	• Focus audience's attention on just one or two displays on the knowledge wall • Guide audience through a preconstructed narrative • Minimize distractions and extraneous information displays • Briefer mediates interaction with knowledge wall

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Approach to Knowledge Wall Layout

- Organize entire wall into a <u>small</u> number of individual compartments of related information

- Arrange information across and within compartments to provide either a vertical or horizontal flow

- Short columns of text aligned along vertical margins

- Minimize or eliminate artifacts of computer interfaces (scrollbars, window widgets, etc.)

- Use "white space" instead of separator lines to avoid clutter

- Minimize display of flashing, animated elements where possible. Any motion should be smooth and slow

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Phase I Layout (Mission Analysis)

Overview of mission objectives, based on warning order from CJCS

Current state of development of mission analysis components

Task timeline view customized for knowledge wall

FBV-type COP display customized for knowledge wall

FBV drilldowns

Phase II-IV Layouts

Phase II: Mission Analysis Briefing

- View is reduced to a briefing area and the live COP display

- Minimizes potential distractions and focuses viewer's attention on briefing content and associated visuals
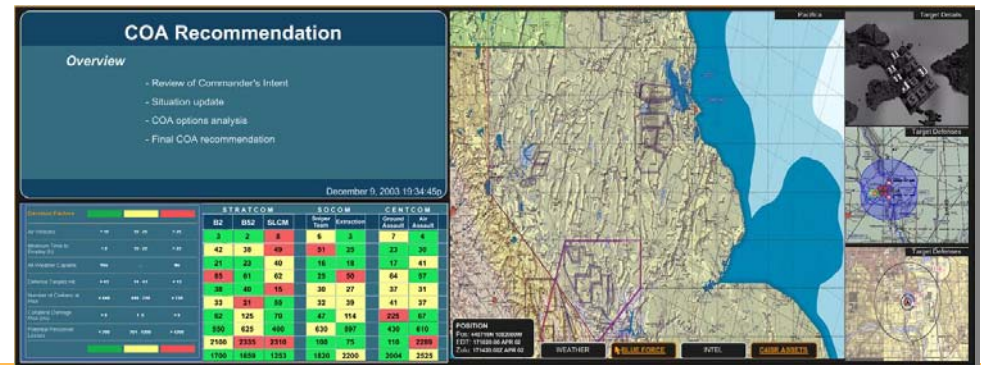

Phase III: COA Options Development

- Wall content organized to provide high-level real-time awareness of COA options evolution
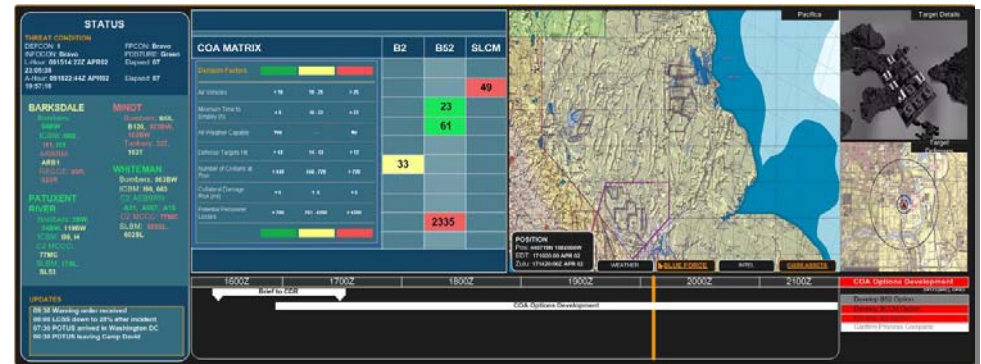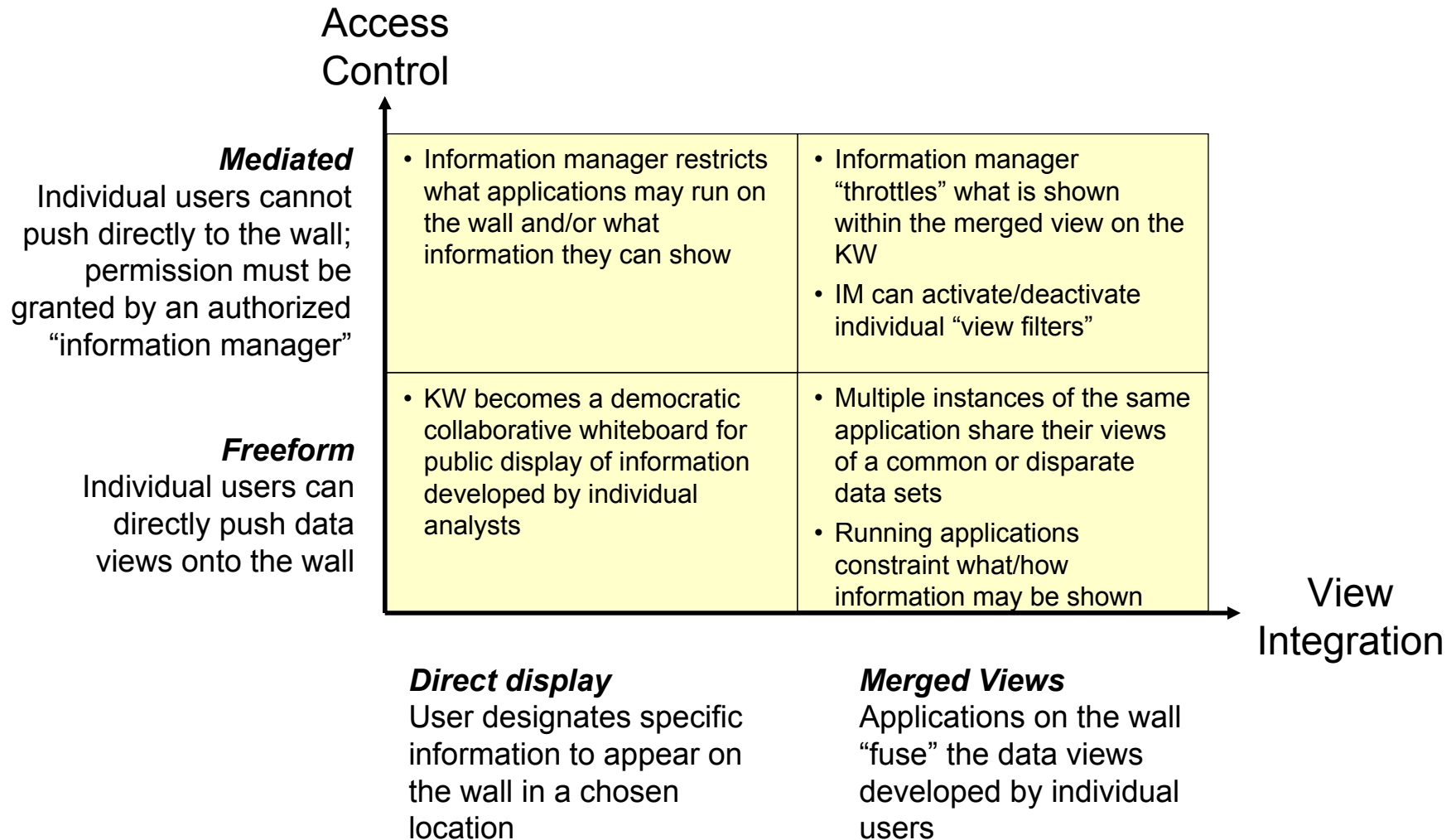

Phase IV: COA Options Briefing

- Summary of COA Options, briefing area, and live COP View

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System-to-System Interaction

- Initial focus on interactions between the knowledge wall and other systems

- Pushing information or data views (not pixels) from one display to another

  - Exploit capabilities of larger displays for public presentation

  - Provide complex data views to systems with limited input capabilities

- Pulling information from public displays to a personal display

  - Identify information of interest on the knowledge wall and reproduce on personal display

  - Use near-to-eye displays to read detailed information more comfortably

  - Avoid obscuring general shared view on public display

  - Enables role-based access to drilldown information

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Pushing Information to the Wall

Access Control

Mediated
Individual users cannot push directly to the wall; permission must be granted by an authorized "information manager"

Freeform
Individual users can directly push data views onto the wall

• Information manager restricts what applications may run on the wall and/or what information they can show	• Information manager "throttles" what is shown within the merged view on the KW • IM can activate/deactivate individual "view filters"
• KW becomes a democratic collaborative whiteboard for public display of information developed by individual analysts	• Multiple instances of the same application share their views of a common or disparate data sets • Running applications constraint what/how information may be shown

View Integration

Direct display
User designates specific information to appear on the wall in a chosen location

Merged Views
Applications on the wall "fuse" the data views developed by individual users

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View Integration Example

Software Architecture Drivers

- Make it lightweight and adaptable to new/existing applications

- Move control and data messages between publishers and subscribers

- Provide services that perform some common function surrounding the collaboration
  - Presence information
  - Registry of publishers and subscribers
  - Archive of past transactions
  - Support control console for remote management of public displays

- Support long-term strategy towards
  - Federation
  - Disconnected operation
  - Adaptation of multiple wire protocols

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Potential Options

- Custom web services glue

- CORBA

- Distributed objects (RMI, .NET Remoting)

- Java Messaging Service (JMS)
  - Provides much of the needed infrastructure
  - Open-source tools available
  - Supports migration to Enterprise Service Bus (ESB)
  - Simple message distribution
    - Straightforward protocol to publish a message to a JMS queue
    - Messages are characterized by a position in a topic hierarchy
    - A client subscribes to a topic and receives all messages that are placed into that topic
    - Guaranteed message delivery

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System Architecture

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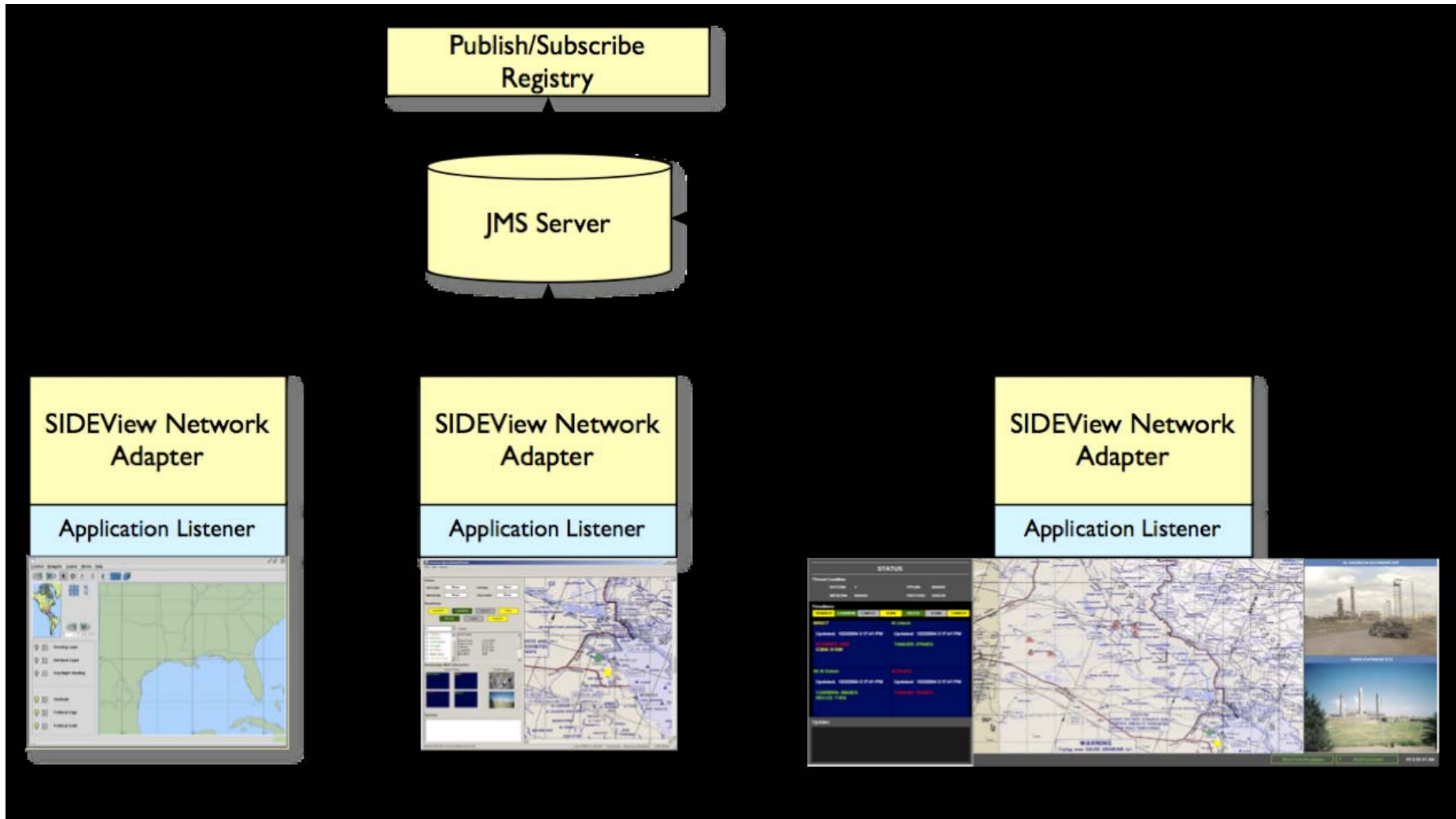
Application Adapter

- Adapter exposes an interface for a listener that must be provided by a client application

- Converts application data objects to XML for wire transport
  - JAXB data binding

- Contents of data messages defined by application
  - Populate specified metadata fields
  - Place other data into a payload field

- Control messages handle registration activity
  - What data am I interested in?
  - What data do I produce?
  - What data is available?

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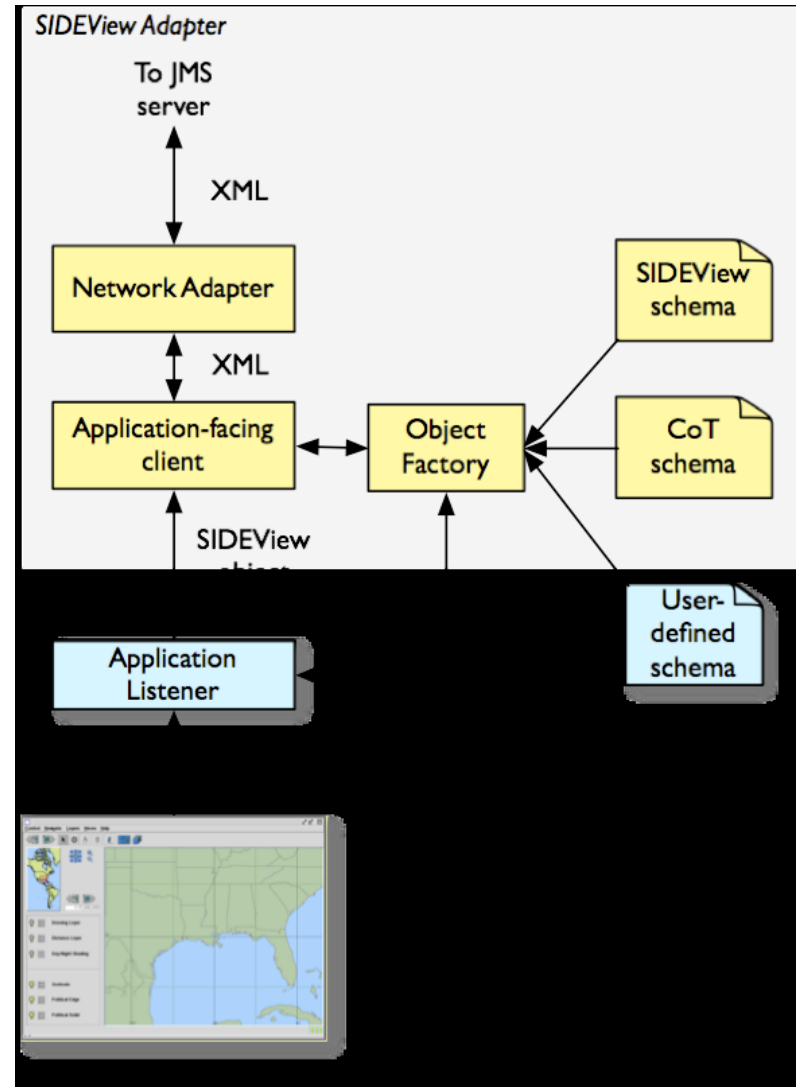
Summary

- Exploration of shared user interfaces for collaborative decision-making in command center environments: beyond the video switch

- Technology concept for supporting collaborative situation awareness through distributed messaging

Directions for Future Work

- Information assurance

  – How do we verify the integrity of a received message?

- Access control

  – How do we regulate who can see what pictures?

  – Moving pictures across security domains

- Picture aggregation and redistribution

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