Understanding and Improving Knowledge Transactions in Command and Control

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Command and Control Domain

Common tasks:

- Gather, process, analyze information
- Develop and maintain Situation Awareness
- Develop, execute, and monitor complex & interrelated plans
- Manage / coordinate resources
- Make high-stakes / time-critical decisions
- Communicate / disseminate / coordinate

Complicating factors:

- Often don't have / can't get all needed information
- Available information sometimes conflicting or ambiguous
- Often must collaborate with others on tasks
- Often must provide information to others / use others' information to complete tasks
- Tasks / efforts are often distributed; may be synchronous or asynchronous

It's all about information exchange…

Command and Control personnel must gather and use information from others

- People or systems

Command and Control personnel must convey information to others

- Plans
- Intentions
- Orders / Decisions
- Information for use by others

We refer to these exchanges of complex, structured information (specifically, *value-added information*) as "*Knowledge Transactions*"

# Relevant Lessons Learned from Previous Efforts

Tactical Decision Making Under Stress (TADMUS)

Research efforts conducted to extend and apply developments in decision theory, HCI, and training to support time-critical, high-stakes tactical decision making.

- **Based on Naturalistic Decision Making**
- **Tools introduced new HCI concepts and methods**
- **Validated in realistic CIC team environments**

Lessons Learned: **By designing systems based on an understanding of decision makers' cognitive processes and information requirements we can achieve:**

- **Significant *improvements in Situation Awareness***
- **Significant *reductions in decision error***
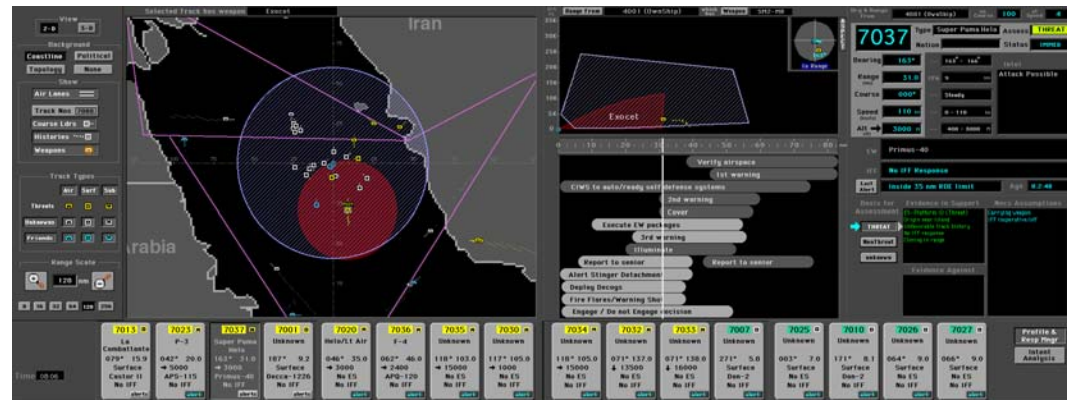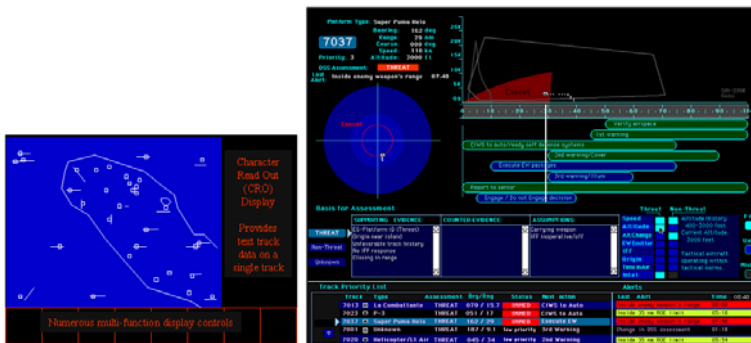
Response Planner & Manager

Design effort to extend TADMUS concepts and develop interface to facilitate response / action management in time-critical tactical decision making situations.

*Lessons Learned:* **Experts have very different information requirements and decision support needs.**

– **Varies with responsibilities and assigned tasks**

– **One data set / design does not meet the needs of all users**

Decision-Centered Design
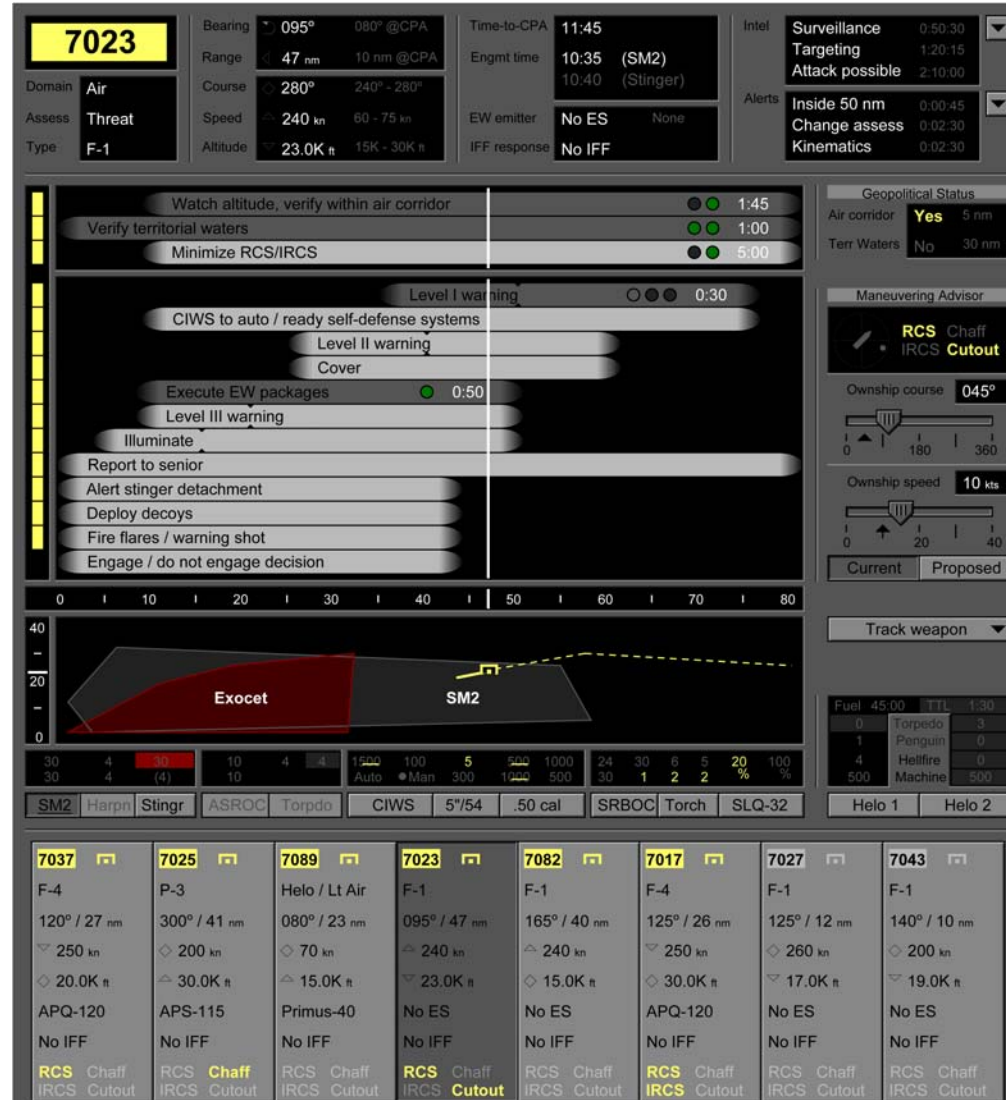
Project to design next-generation Command Centers and information systems using a decision-centered / user-centered approach
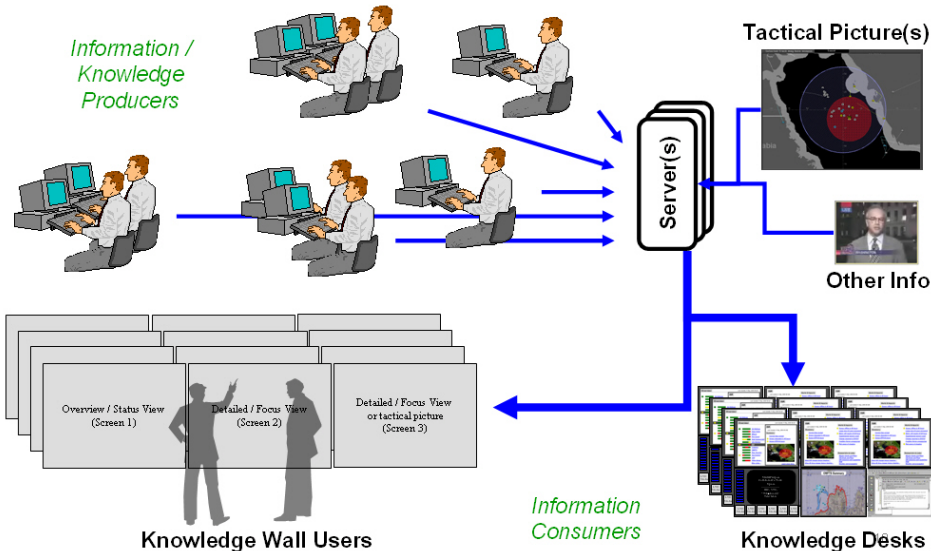
Lessons Learned: **Clear requirements emerge :**

- **Users need "value added" information vice raw data**

- **Users need help managing / using huge amount of data of varying relevance / validity**

- **Regular "information disconnects" occur between peers and other echelons**

- **Different "customers" need different levels of detail / fidelity / depth of information**
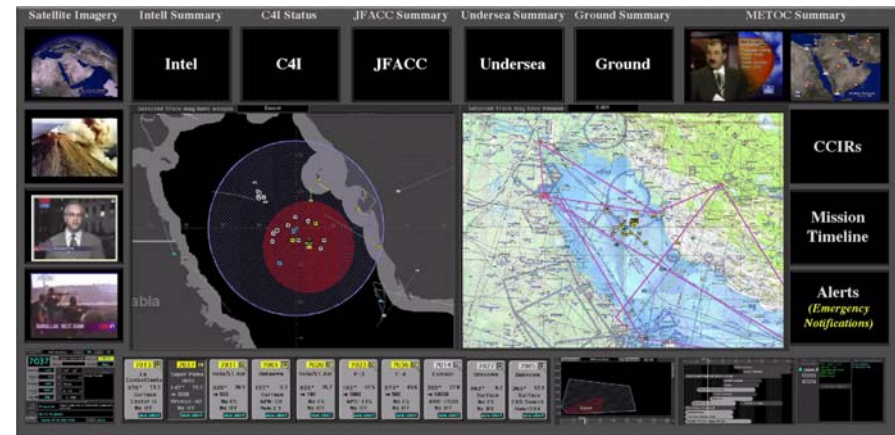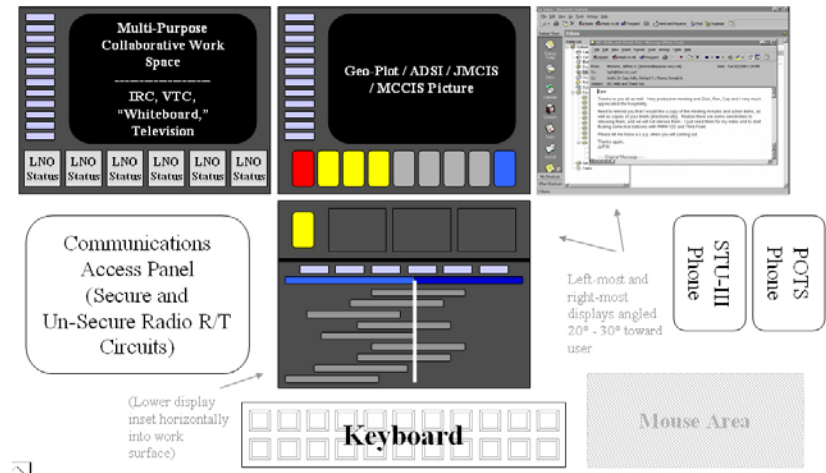
Command 21 (previous years)

Research and development efforts to extend and apply a concept known as "Knowledge Web" to CJTF-level knowledge management.

- **Concept of Operations and Business Rules**
- **Information production, management, and display tools**

Information / Knowledge Producers

Knowledge Wall Users

Overview / Status View (Screen 1)

Detailed / Focus View (Screen 2)

Detailed / Focus View or tactical picture (Screen 3)

Server(s)

Tactical Picture(s)

Other Info

Information Consumers

Knowledge Desks

***Lessons Learned:* Use at Global 2000 and 2001 war games confirmed:**

- **K-Web use significantly increased speed of command and shared SA**
- **K-Web use reduced / eliminated need for traditional briefs / meetings**
- **Cross-echelon and cross-function linking and use is an important and much used aspect of the Knowledge Web concept**
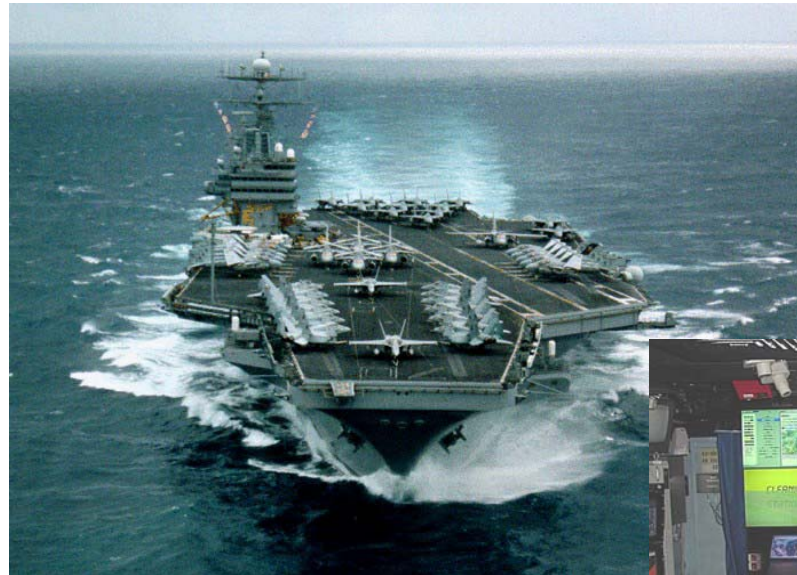- **When displays optimized for one type of user, was found less useful for others…**

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Global 2000 & 2001
Knowledge Walls

K-Web concepts, tools, and technologies validated in war gaming and at-sea use.

- **Carrier Group Three / USS Carl Vinson used K-Web and K-Wall derivative during Operation Enduring Freedom.**
- **14 Functional areas - 500+ Unique Users / Day**

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Evolution of Data to Information to Knowledge: METOC Example

Data: Text-based weather product
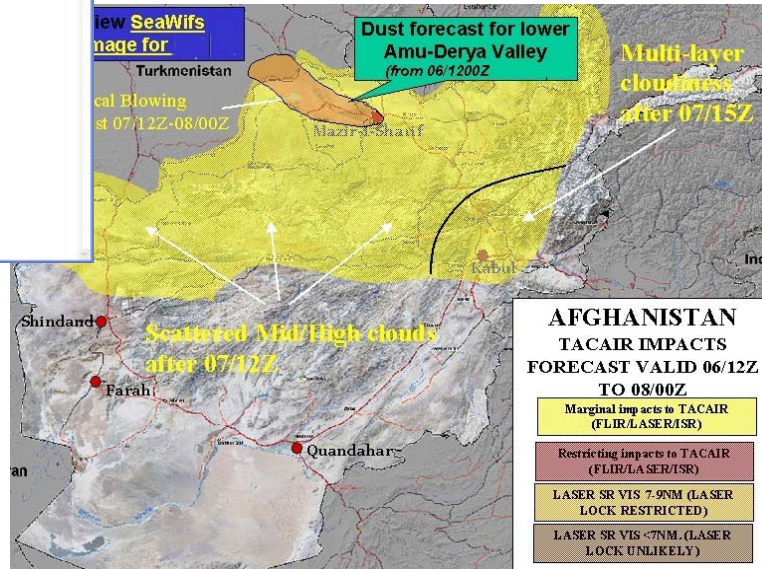
Information: raw and semi-processed data represented graphically

Knowledge: weather data and info translated into usable, understandable *Knowledge* of value to planners and pilots
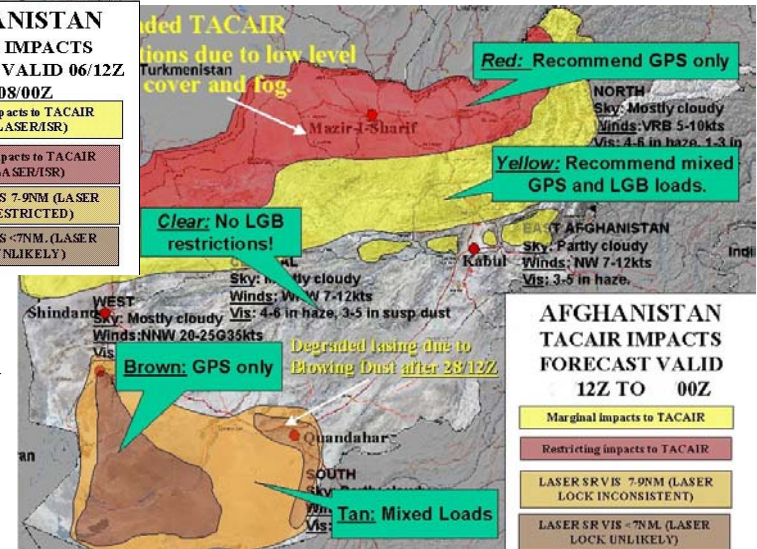
Degraded TACAIR conditions due to low level cloud cover and fog.

Turkmenistan

Mazir-I-Sharif

Red: Recommend GPS only

NORTH
Sky: Mostly cloudy
Winds: VRB 5-10kts
Vis: 4-6 in haze, 1-3 in

Yellow: Recommend mixed GPS and LGB loads.

Clear: No LGB restrictions!

EAST AFGHANISTAN
Sky: Partly cloudy
Winds: NW 7-12kts
Vis: 3-5 in haze.

Kabul

CENTRAL
Sky: Mostly cloudy
Winds: WNW 7-12kts
Vis: 4-6 in haze, 3-5 in susp dust

WEST
Shindand
Sky: Mostly cloudy
Winds: NNW 20-25G35kts
Vis:

Brown: GPS only

Degraded lasing due to Blowing Dust after 28/12Z

AFGHANISTAN TACAIR IMPACTS FORECAST VALID 12Z TO 00Z

Quandahar

SOUTH
Sky: Partly cloudy
Win
Vis:

Tan: Mixed Loads

| Marginal impacts to TACAIR |
| Restricting impacts to TACAIR |
| LASER SR VIS (LASER LOCK INCONSISTENT) |
| LASER SR VIS (LASER LOCK UNLIKELY) |

Turkmenistan

India

Knowledge Web Technologies
Future Naval Capabilities

Pacific Science & Engineering

Development and transition efforts to quickly deploy K-Web concepts and technologies to fleet users.

– **K-Webs used in support of Operation Iraqi Freedom**

Lessons Learned: **Wider-scale fleet use reveals:**

– **Users configure, format, and use K-Webs very differently depending on user group and intended audience**

– **Differences can cause confusion among consumers**

– **Bandwidth issues highlight need to focus / filter information to consumers**

Basis for Assessment / DeClutter

Cluttered
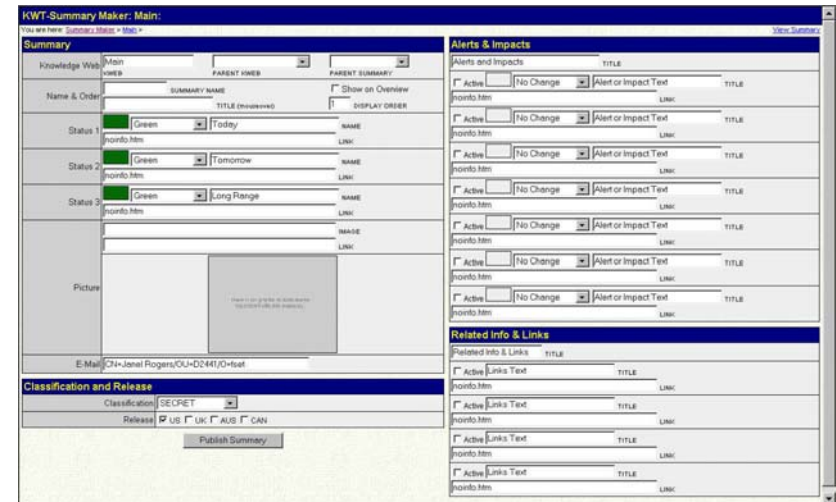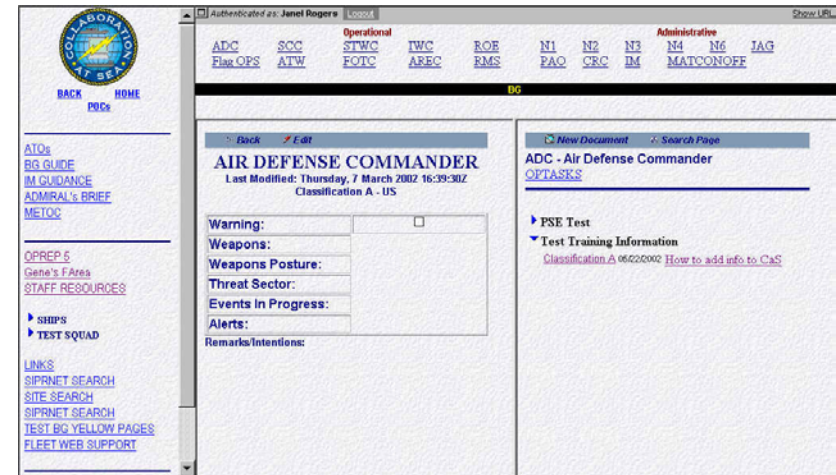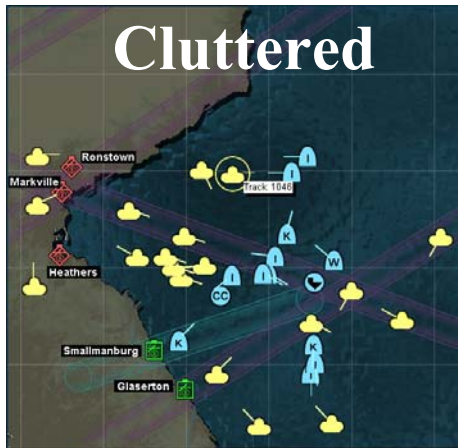
Decluttered

Research conducted to develop context-sensitive models to aid in rapid assessment of tracks, combine with technologies to declutter displays.

- **Based on Naturalistic Decision Making and Marshall's Hybrid Schema DM model**
- **Research exploring new HCI concepts and methods**
- **Concepts validated; improved response times and SA, decreased workload**
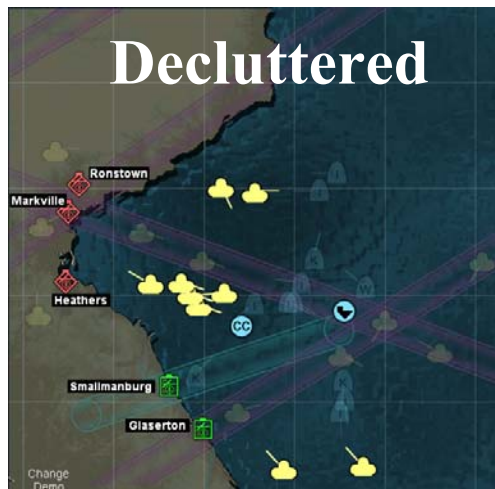
***Lessons Learned:* Powerful concept and emerging technologies; concepts and techniques might be applied to other information domains (non-tactical displays) to declutter complex information sets (i.e., the Web).**

Present Focus of Command 21 Project

Ever-growing Requirement for Information vice Data!

Military Command Centers:

– **Research conducted, lessons learned, and evolving needs of Navy have revealed requirement for tools to support:**

» **Improved Situation Awareness / Assessment**
- ◆ **Perception of Data Patterns**
- ◆ **Alerting / Attention Management**
- ◆ **Memory augmentation for Dynamic Events**
- ◆ **Situation-based Data Fusion**

» **Dynamic, synchronous and asynchronous collaboration**
- ◆ **Distributed Cognition**
- ◆ **Adaptive information flow and team structure**

» **Adaptive, real-time resource and action management and planning support**

Context is Key!

Tactical data (multiple views if possible!)
- **Map-based and highly graphical views / context**

Mission Summaries and Commander's Intent

Real-time info! (or close to it)

Alerts / Advisories / Recommendations
- **What isn't working according to plan?   &   What do we do to fix it?**

Impacts & Indications
- **"X" happened; how does it affect everything else?**

Plans (and alternate COAs)
- **Response & Timeline Management**

Effects Summaries
- **Various formats preferred**

Asset / Resource Management

Collaboration Tools (including VTC)

Operational Problem

Ineffective and inefficient information exchange

- **Ineffective: Decision makers aren't getting the information they need – incomplete picture, degraded SA**
- **Inefficient: Decision makers are getting information they don't need – increased workload**
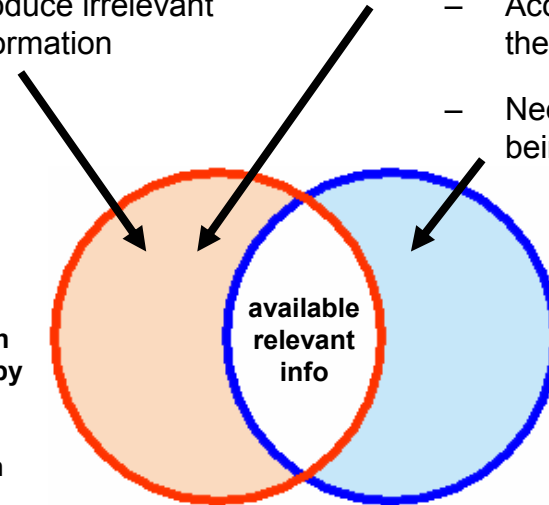- **Both may lead to suboptimal decision making**

Information Producers:

- Produce irrelevant information

Information Consumers:

- Access information they do not need
- Need information not being produced

information "pushed" by producers

information needed by consumers

available relevant info
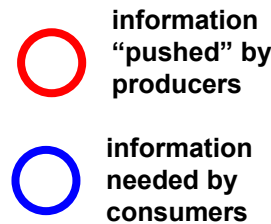
2 (of many) reasons:

- **Information producers often don't understand the decision maker's information requirements and intent**
- **Decision makers accessing information tailored to another decision maker's task and not necessarily their own (esp. in multi-echelon environments)**

The Challenge…
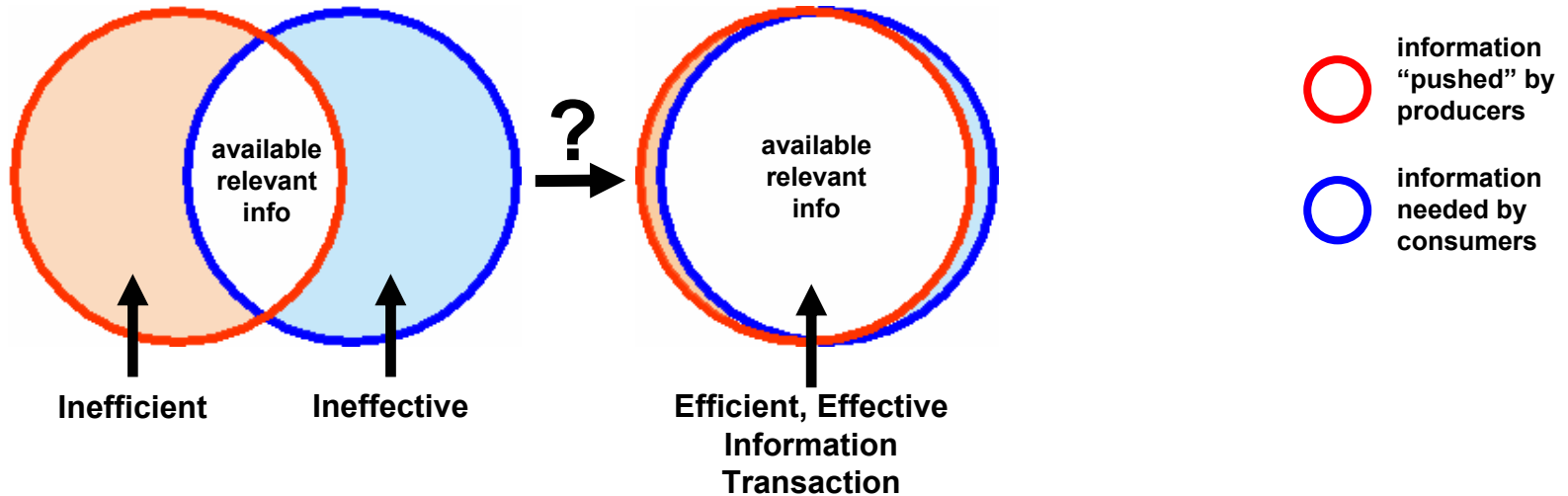
How do we increase the availability of *relevant* information?

◆ **The information producer must understand the information requirements of the consumer(s).**
- **Consumers & Producers must have a shared mental model including factors such as: Tasks, Objectives, Roles and Situation Awareness.**
- **Content must be produced that will support different levels of abstraction.**

◆ **Consumers need tools to help them tailor the information presented to what is needed in the current mission context.**

There are usually many potential consumers… (some known – some not)

Decision makers at different echelons have different goals, tasks, information requirements. Fleet users have indicated the need for *customized* information.[*]

- "One glove does not fit all – there needs to be tailorable information"
- "So many viewers….Who do you create content for?"
- "How do you….tailor information for different [decision makers]?"
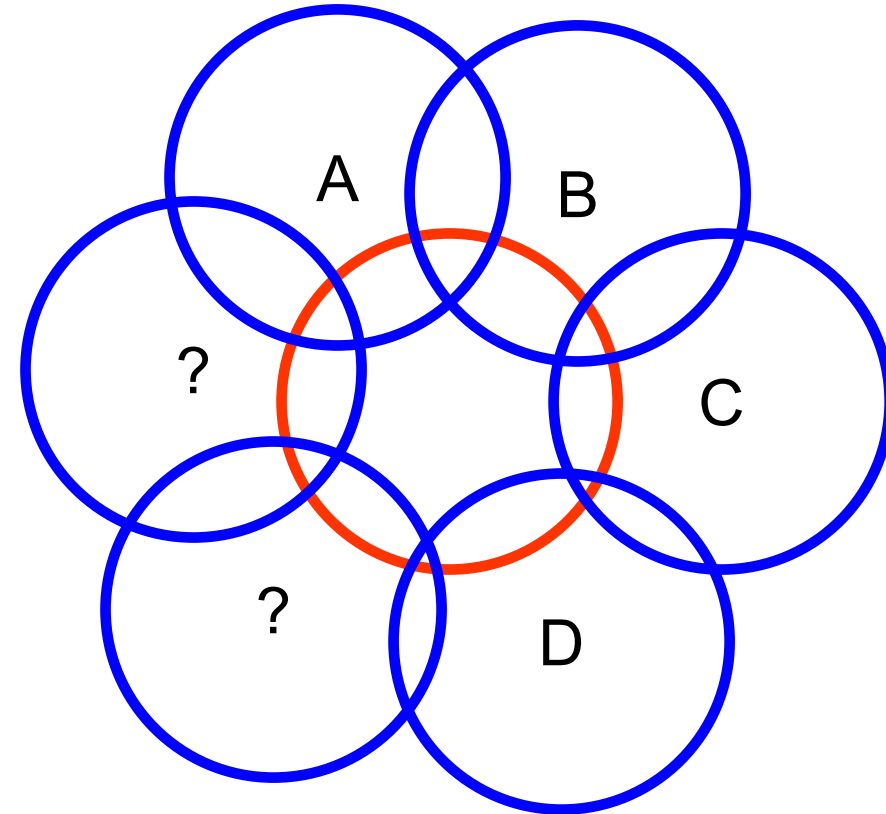
*quotes taken from K-web cognitive task analysis, Global 2000 and Global 2001 War Games, interviews with Carl Vinson K-Web users following Operation Enduring Freedom

○ information "pushed" by producers

○ information needed by consumers

The Challenge…

Develop models of how people can efficiently exchange information in at-sea / in-the-field environments.

Build tools using these models that facilitate efficient and effective Knowledge Transactions.

Measures of Effectiveness:

- **Reduce production of unneeded information**

- **Reduce consumers' need to filter out irrelevant / unneeded information**

- **Reduce workload on producers and consumers (or at least, do not increase workloads)**

- **Demonstrate that system can meet the needs of many different consumers - each with their own requirements**

Command 21 (current year)

Ongoing research to determine what factors support efficient and effective information exchange in multi-echelon environments

- **Compares / establishes impact on Knowledge Transactions of sharing Mission, Task, and Information Requirements among distributed, multi-echelon team**

- **Work to be validated at Naval Postgraduate School and at next JFMCC war game at the Naval War College**
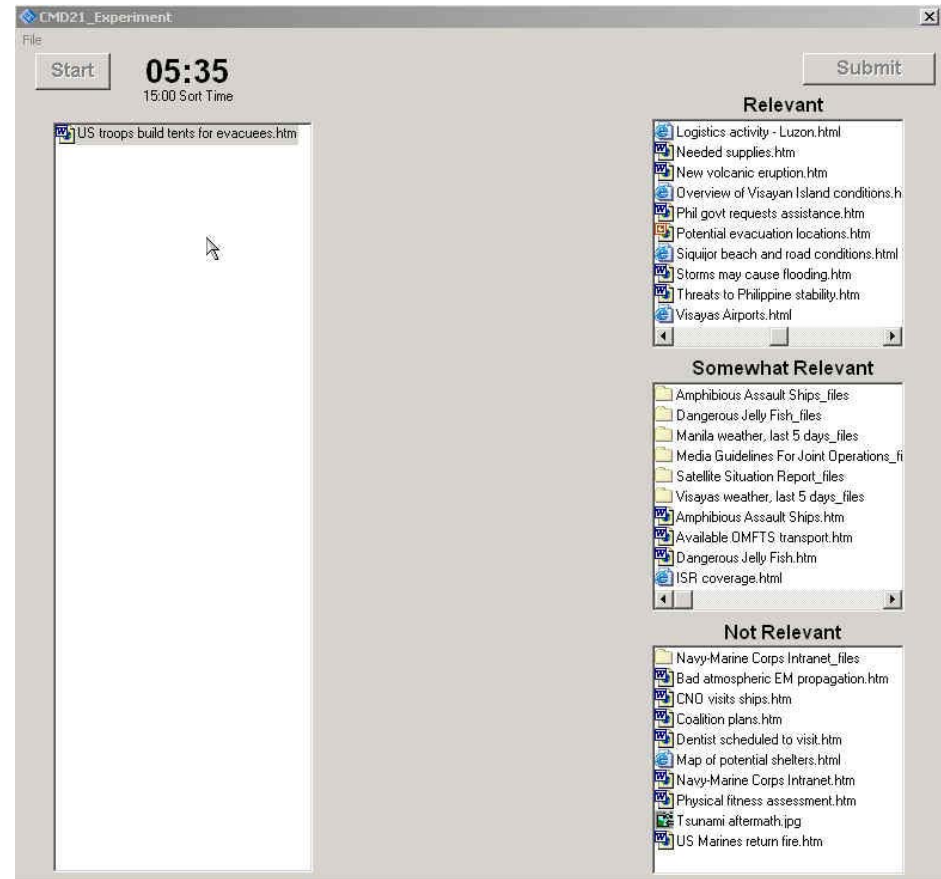
Experiment sorting interface

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Command 21 – Initial Findings

Overall, results suggest that:

- Sharing [Mission + Task] and [Mission + Task + Information Requirements] supported the best performance.
  - » In other words, knowing how the consumer is going to use the information provided to them is useful to producer.
- Sharing [Mission + Task] most helped producers decide **what to provide**.
- Sharing [Mission + Task + Information Requirements] most helped them decide **what *not* to provide**.
- Sharing [Task + Information Requirements] helped producers decide what *to* provide; had little effect on what *not* to provide.

Results being used to develop a "Context Interface" summarizing Mission, Task, and Information Requirements to help consumers and producers achieve a shared understanding

- Interface to be demonstrated at NPS this summer/fall

Future Areas of Research

Advanced structure / templates to facilitate rapid & consistent information production and exchange, and "story building"

Accommodating the needs of different users at different echelons of command

Knowledge Management of large stores of information and Knowledge Representation of fused, processed, filtered information

Representing change and implications within a store of information

Agents to off-load user of time-consuming knowledge management "administrative" tasks

Advanced, web-based change awareness and status alerting technologies

Advanced visualizations of information space to facilitate navigation & assimilation

Agents to tailor content to different classes of users and afford improved Bandwidth Management

Tools to facilitate integration of non-tactical and tactical data systems (integrated context)

Summary

The key to improved Command and Control is the efficient and effective exchange of information – especially value-added knowledge.

- **Context is critical**
- **Knowledge of Content Consumers is vital in effective exchange – particularly with distributed, asynchronous collaboration.**

Lessons learned from past, current, and future research are helping us facilitate such exchanges – in the form of improved Knowledge Transactions.

Improved Knowledge Transactions result in users having the right information, when they need it, in a form that is intuitive, easily understood, and readily applied.

For more information, please contact:

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