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TECHNICAL REPORT 1882
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Knowledge Web Concept and Tools: Use, Utility, and Usability During the Global 2001 War Game

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ADMINISTRATIVE INFORMATION

This report was prepared as part of SSC San Diego's ongoing Command 21 project, sponsored by the Office of Naval Research, Cognitive and Neural Science Technology Division, with Gerald S. Malecki as program officer. Dr. Jeffrey G. Morrison is the Command 21 principal investigator. One goal of the Command 21 project is the development and operational evaluation of the evolving concept known as the *Knowledge Web* for use in advanced military command centers ashore and at sea. This report describes a major operational evaluation in the continuing efforts directed toward this goal.

Released by
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Under authority of
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EXECUTIVE SUMMARY

OBJECTIVE

The Space and Naval Warfare Systems Center, San Diego (SSC San Diego) Command 21 project is directed at supporting the needs of senior decision-makers and support staff in military command centers. As part of that effort, the Knowledge Web (K-Web) concept and technologies were developed to support shared situation awareness (SA), to facilitate group interaction, and to augment the decision-making capabilities of senior staff.

The K-Web concept was first tested using a prototype shared display, called the Knowledge Wall (K-Wall) at the Global 2000 war game. This prototype was evaluated against 14 user requirements that were identified with a previous cognitive task analysis of potential K-Web users. The K-Web products and tools met most of these requirements with great success. The results of the Global 2000 evaluation laid the foundation for continued development of the K-Web products and tools. New user requirements and suggestions for improved features were addressed with both hardware and software design changes. Prototypes of these revised designs were implemented in the Joint Command Center of the Naval War College (NWC) for the Global 2001 war game. Global 2001 afforded an invaluable opportunity to observe the redesigned K-Web products and tools undergoing extensive real-time usage in an operationally realistic setting, for which it was intended.

A usage, utility, and usability evaluation of the K-Web products and tools was conducted unobtrusively during the game using automated data collection methods and trained observers. The collected data lent to the assessment of whether:

- Revised features and functionality of the K-Web information products and support tools, and modifications to the display hardware, meet the information integration, cognitive support, and collaboration needs identified by the previous Global 2000 usage evaluation.
- New and revised K-Web design solutions support other previously identified user requirements.
- Additional K-Web user needs exist.
- Ergonomic problems related to the K-Web products and tools exist.
- Users prefer the K-Web products and tools to other information tools they have used.

RESULTS

We found that:

- The revised "Summary Page" design was successful at providing users with high-level summarized views of the operational picture and a means to easily navigate the K-Web to obtain more detailed information. The improved layout and change alerting functionality provided in the revised design of the Summary Page proved useful to the information producers.
    - Information consumers accessed over 31 Summary Pages per hour over the course of the exercise.
    - Information producers included "change alerting diamonds" on over 50% of the Summary Pages they created.

- The K-Web displays, and the "Knowledge Wall" and "Knowledge Desks" were successful at supporting information integration and situation awareness for information consumers and producers.
    - The revised Overview Page allowed information consumers to monitor status across all operational areas simultaneously and quickly access information; consumers accessed information from deteriorating areas more than twice as quickly as those that were improving or unchanged.
    - Consumer comments and behaviors reflected that they used these displays as one of their primary tools for acquiring SA and becoming apprised of the concerns of other players.
- The newly designed support software used to produce Summary Pages (*SumMaker*) and to control the display of information on the Knowledge Wall and Knowledge Desk (*Knowledge Web Viewer*) were a success.
    - Interviews with information consumers and producers revealed that they found these tools both useful and easy to use.
    - However, a need for improved alerting and feedback between information producers and consumers related to content and usage of information products was identified.

RECOMMENDATIONS

The data and observations collected during the Global 2001 war game provided important feedback pointing to specific needs that must be met by future Command 21 research and development efforts. Specifically, we recommend that future K-Web technology designs provide:

- Improved mechanisms for dissemination of K-Web business rules to support optimal usage of the K-Web by information providers and consumers.
- Enhanced cognitive tools to support attention management and change detection, including those that tailor change alerting to meet the needs of different users.
- Efficient and effective methods for providing feedback between information consumers and providers related to both the usage and content of K-Web information products.
- Integrated training to promote a better understanding of K-Web tool capabilities by information producers and consumers.

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1. INTRODUCTION

1.1. BACKGROUND

As technology increases the speed and ease of information exchange, the problems associated with information production, consumption, and management also increase. Effective command-level decision-making requires a high level of situation awareness (SA). To support improved SA, information must be made available in a format that is meaningful and useful for application to real-world problems; to do so means that the *information must be transformed into knowledge*. How can information technology be designed to best facilitate information production, consumption, and management? The Space and Naval Warfare Systems Center, San Diego (SSC San Diego) is currently working to address this question through the Command 21 project, an ONR-sponsored effort directed at supporting the needs of senior decision-makers and their support staff in military command centers.

1.1.1. The Knowledge Web Concept

A current focus of the Command 21 effort is the development of a concept referred to as the Knowledge Web (K-Web). The K-Web concept utilizes Web-based technologies to share operationally relevant information. In a K-Web, available data are processed, formatted, and stored by "information producers" in such a way that it represents meaningful knowledge to the "information consumers." The "users" of the K-Web, therefore include both information producers and consumers.

Prior to the K-Web's initial implementation, specific user information needs were determined through a series of structured interviews conducted with Joint Operational Center senior staff (Moore & Averett, 1999; Smallman, Oonk, & Moore, 2001). Interviews focused on decision-makers' information requirements in the context of an operational mission. Analyses of the responses led to the identification of 14 critical user requirements that a tactical/operational information system (e.g., a K-Web) must meet. These user requirements are shown in Table 1.

Table 1. The 14 K-Web user requirements.

Information System User Requirement		K-Web Prototype Design Capability / Feature
General	Shared SA	Shared display
	Integrated Information	Co-located Summary Pages
Format	Intuitive Graphical Interface	Graphical presentation when possible
	Consistency	Consistent format Summary Pages
Content	Tactical Focus	Ability to view multiple tactical displays
	Supplemental Information	Summary Pages on peripheral displays
	Mission Goals and Objectives	Text document
	Anchor Desk Output	Summary Pages with links to more info
	Connectivity/Collaboration	Collaboration tools (*IWS*)
	Cognitive Support	Limited output from nonintegrated cognitive support tools
Feature	Flexible Configuration	Any pages viewable in any display
	Drill-Down	Multiple scalable views, links to more info
	Info Age and Reliability	–
	Tactical Overlays	Various software for tactical graphic presentation

Based on these 14 user requirements, a number of prototype K-Web tools have been developed to facilitate the production, formatting, dissemination, and Web-based presentation of information so that it is easily shared and understood. These tools allow information products to be created and continually updated by information producers. Information products, which are stored in shared locations accessible to information consumers via a standard Web browser, comprise the K-Web. Other K-Web tools allow consumers to easily access and flexibly configure the display of the information products on large or multi-monitor display systems. A schematic of the K-Web concept is shown in Figure 1. Following sections describe the major products of the K-Web and the hardware and software tools used to create them.

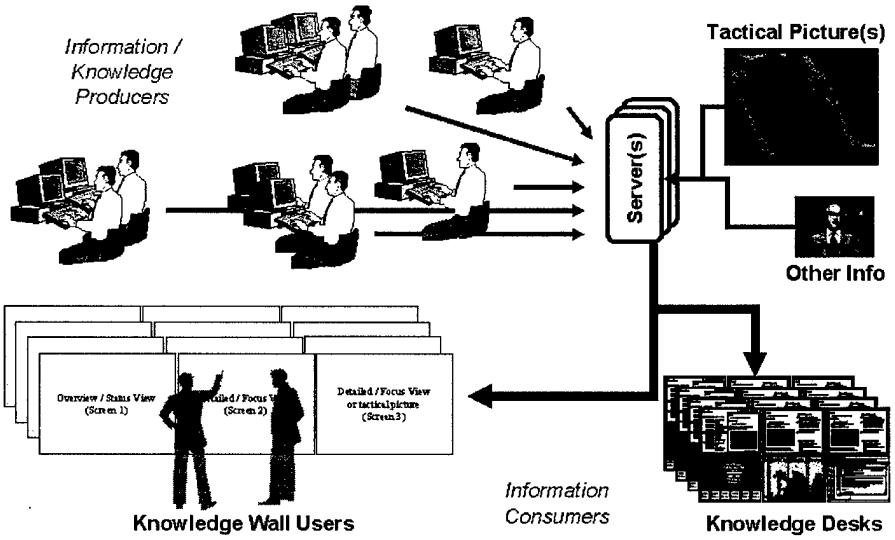


Figure 1. Concept diagram of the K-Web.

1.1.2. Knowledge Web Summary Pages

Summary Pages, created by the various information producers, are the "entry points" to the K-Web. They function as high-level views of the operational picture consisting of single-page distillations of current status and events, critical updates, related information, relevant graphics, etc. These pages are designed to enable users to rapidly gain SA of the overall mission status through a consistent and intuitive graphical format. Consistency in the placement of information on displays conforms to human factors principles for information presentation and allows users to scan for information efficiently and integrate information from multiple sources (see Mayhew, 1992; Wickens, 1992). Consistent formatting also allows users to rapidly acquire and integrate information from multiple Summary Pages and to prioritize knowledge retrieval from the K-Web. An example Summary Page is shown in Figure 2. Summary Page features include:

- Color-coded operational status information across three time periods: Today (within 24 hours), Tomorrow (24 to 48 hours), and Long-Range (more than 48 hours) and three colors: Green (least critical), Yellow (moderately critical), Red (most critical).
- Alerts, impacts, and links to status-related information.
- A "focus area" for a picture or other document related to the operational situation.
- A time stamp indicating when the Summary Page was last updated.

Most items/elements on the Summary Pages can be linked to additional information (using hyper-links) to initiate drill-down to more detailed information. Information producers may link to Web pages (including other Summary Pages), *MS Office* documents, graphics, and many other types of information.

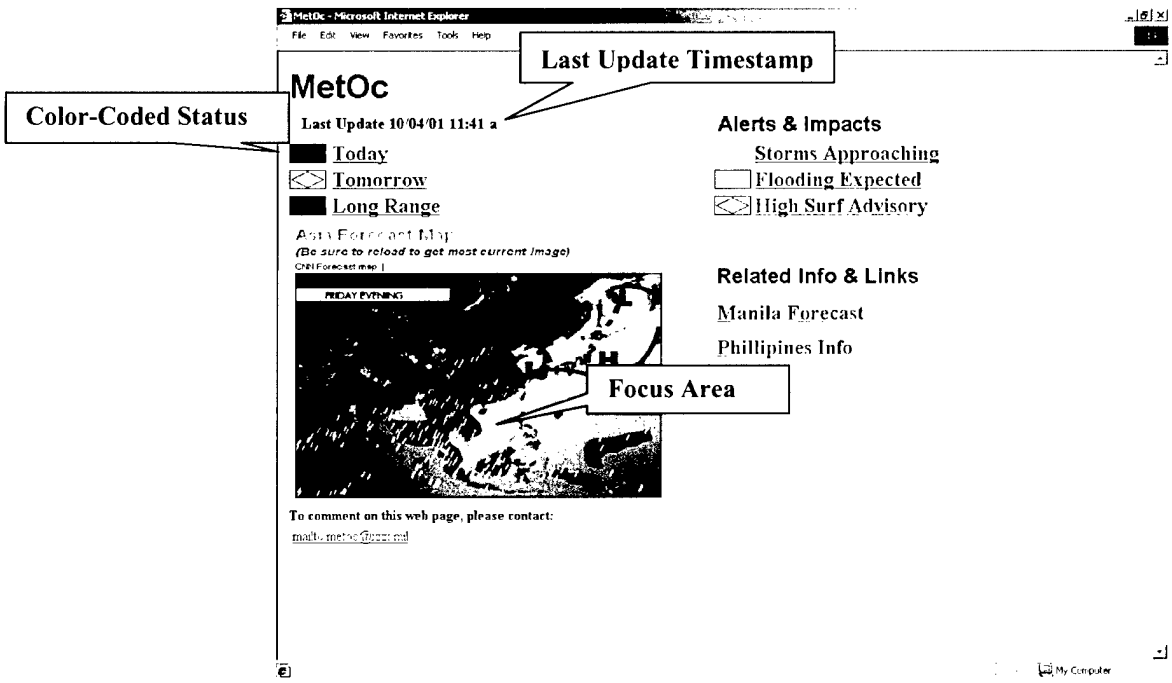


Figure 2. Example Summary Page.

1.1.3. Knowledge Web Viewer Hardware

Hardware displays used to access the K-Web are called Knowledge Web Viewers (KWVs). Specifically, the Knowledge Wall (K-Wall) used at Global 2001 is a wall-sized shared display consisting of contiguous display windows that bring together information from multiple sources. The idea behind the K-Wall is that providing a processed and fused presentation of the "information space" on a single large display should support cognitive processes such as data integration, pattern recognition, event memory, and distributed cognition among information consumers. The K-Wall is intended to be large enough to provide a shared operational picture to multiple personnel, to promote shared SA, and to provide focus for collaboration among its users (Bolstad & Endsley, 1999). Smaller single-user displays called Knowledge Desks (K-Desks) also facilitate K-Web information consumption, but have the added purpose of information production.

1.1.4. Knowledge Web Software Tools

Several K-Web software tools have been developed that enable:

- Information producers to easily create and disseminate the K-Web information products.
- Information consumers to easily access and configure the display of these products.

These tools were developed using an iterative design process, involving (1) the identification of core information requirements via structured interviews with subject matter experts (Moore & Averett, 1999; Smallman et al., 2001), (2) development of basic design requirements and storyboard concepts by human–computer interface designers, (3) review of these concepts by subject matter experts and selected fleet representatives to determine how well they met the identified needs, (4) reevaluation and reworking of these concepts until they met with approval with regard to function and features and (5) development via rapid prototyping. This process yielded K-Web tools that are

easy to learn and feature easy-to-use interfaces that facilitate rapid production, dissemination, and access of information and knowledge-based products. Features that are familiar to most users, such as "point-and-click" and "drag-and-drop," are used where possible, while unnecessary features and functions are suppressed or removed. The K-Web tool set includes the following software:

The *SumMaker* Software

Information producers can create and update Summary Pages using the Summary Maker (*SumMaker*) software (Averett & Moore, 2000; Averett & Moore, 2001). This software was developed to operationalize the information template approach adopted by the Command 21 K-Web effort. The *SumMaker* template-based information products, and the *SumMaker* tool itself, were judged extremely valuable during use at the Global 2000 war game and aboard ship.

Using *SumMaker*, information producers with no knowledge of publishing HTML can create Web content. They can easily indicate status information (shape and color) using pull-down menus and can add hyperlinks to most fields of the template. Once published, the HTML-based Summary Pages are made available on the K-Web using standard Web-hosting software (e.g., Microsoft's *Internet Information Server*). Because of *SumMaker*'s inherent flexibility to display or link to virtually any kind of information product, *SumMaker* affords the user the ability to provide all relevant information associated with each of the template information requirements. The *SumMaker* Summary Page template is shown in Figure 3.

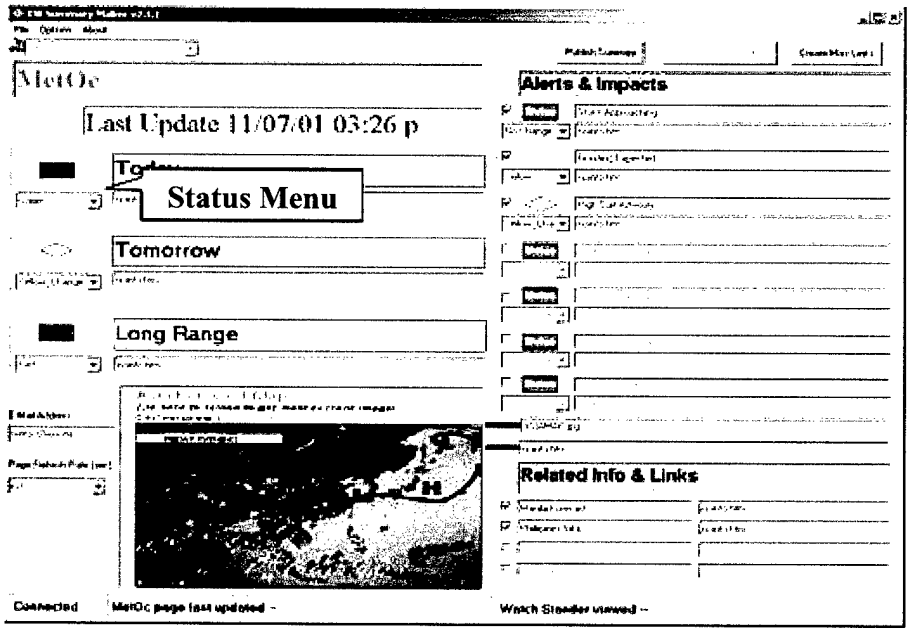


Figure 3. The revised *SumMaker* interface.

The *TacGraph* Software

The *TacGraph* tool (Bank & Moore, 2000; Quinn, Bank, & Moore, 2001), allows information producers to create interactive tactical pictures that also provide value-added information and hyperlinks to other documents. An advantage of *TacGraph* over currently used tools is that it enables multi-layered tactical graphics to be published in HTML format and later edited as needed (see Figure 4). This allows graphics-based information products to be quickly and easily developed,

saving considerable time over the older, less efficient process of creating single-use, single-layered custom tactical graphics with a combination of nonintegrated applications (e.g., tactical software, various photo/art/drawing applications, and *MS PowerPoint*).

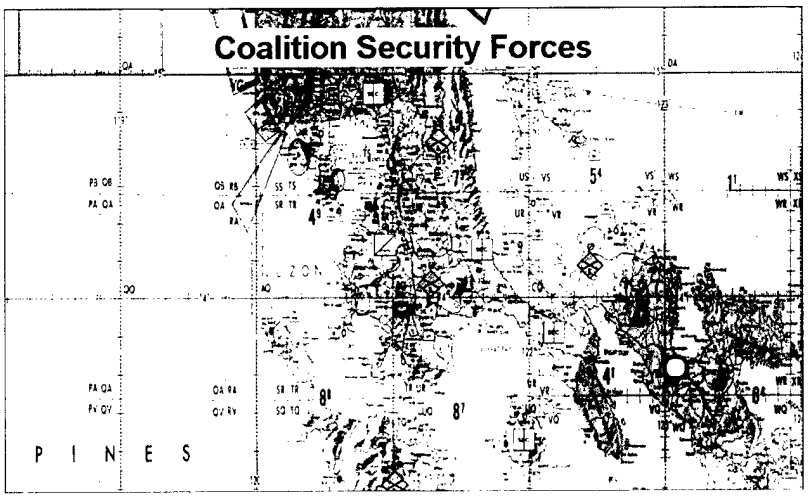


Figure 4. Example output created with the *TacGraph* tool.

The *Knowledge Web Viewer* Software

Information consumers can easily access and configure the display of K-Web information products using *Knowledge Web Viewer* (*KWV*) software (Moore & Averett, 2000). *KWV* software is a special-purpose Web browser that enables display and control of multiple browser windows on multiple monitors and facilitates navigation and display of information and knowledge residing in the K-Web. It also affords display of non-Web content, such as *MS Office* software and products. *KWV* software features a simplified set of familiar Web browsing controls that allow easy and rapid access to K-Web content. The software can be run on single-display computer systems but is optimized for multi-display systems (up to six monitors). Figure 5 shows the *KWV* software running on two displays. *KWV* software may be used on wall-sized shared displays, (called K-Walls), as well as on smaller, desk-sized units, referred to as Knowledge Desks (K-Desks). Both display types were implemented during Global 2001.

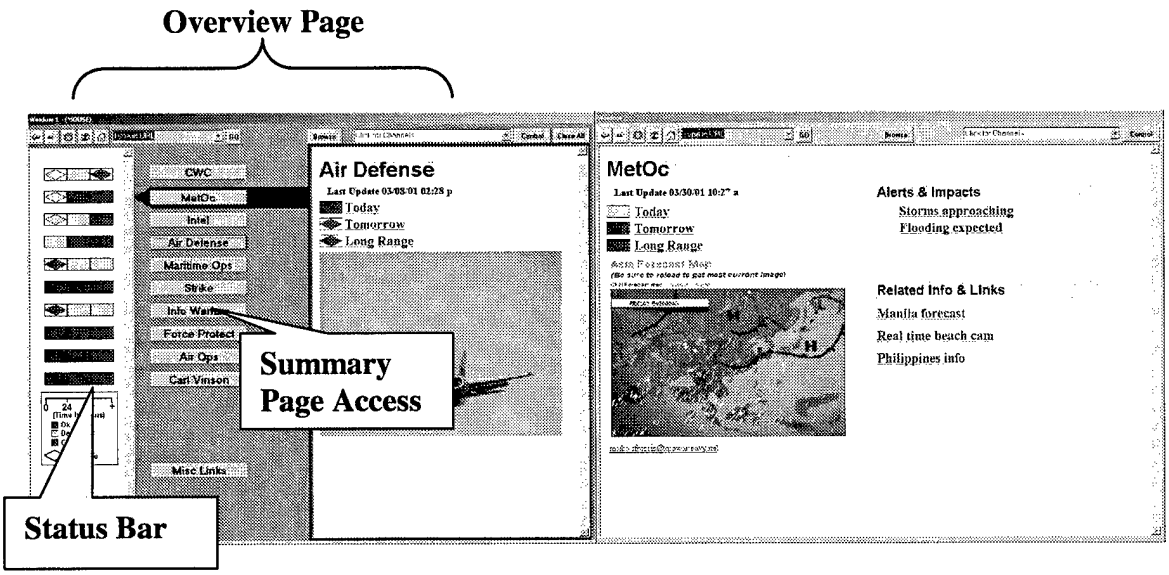


Figure 5. The Knowledge Web Viewer (two windows).

The *KWV* "Overview Page," shown on the left screen in Figure 5, is both a shared SA tool and a K-Web navigation tool. In order to enhance shared SA, the Overview Page combines the color-coded status information from all Summary Pages into a comprehensive status bar display. This enables consumers to view and quickly integrate information "at a glance" and thus maintain SA regarding mission status. Navigation features of the Overview Page allow users to easily access information in the K-Web. These features include:

- *Easy access to Summary Pages.* Each button on the Overview Page is associated with one of the primary operational cells that publish information to the K-Web. These buttons allow users to easily access a high-level status summary associated with each functional area by left-clicking with the mouse on the appropriate button. If users want to see further information, they can easily display the entire Summary Page (and drill down as desired) on any other *KWV* window by right-clicking on one of the buttons.
- *Text Color Change.* The color of the button text indicates which operational cells have published information since the *KWV* user last accessed that Summary Page.

1.1.5. Knowledge Web Use Evaluation at Global 2000

The first in-depth evaluation of the K-Web concept and tools was at the Global 2000 war game—at the Naval War College (NWC) and onboard USS *Coronado* (AGF 11). Specifically, K-Wall prototypes were installed for use by senior staff (the Commander Joint Task Force [CJTF] staff at the NWC and the Commander in Chief [CINC] staff on *Coronado*). Information producers in each of 13 "functional areas" (the operational cells designated to provide information to the CJTF staff) were provided with *SumMaker* software, which allowed them to create Summary Pages for display on the K-Wall. K-Wall users could then manipulate the information presented on the K-Wall by using the *KWV* software.

The Global 2000 K-Web evaluation concluded that the K-Web successfully supported most user requirements and that users preferred it to other tools that were available to them (Oonk, Smallman, & Moore, 2001). The K-Web Summary Pages provided consumers with an integrated summary of

the operational picture and enabled them to navigate the K-Web in order to access further detailed information. Several additional requirements, however, were identified as needing to be addressed by future technology designs. These included:

- Cognitive tools to support attention management and change detection, including tools facilitating navigation to changed pages in the K-Web.
- Tools and improved business processes to support multi-tiered collaboration, including feedback and guidance from information consumers to information producers regarding the content and use of K-Web products.
- Improved text visibility.
- Information integration *across* functional areas.
- Information age and source information on the Summary Pages.

As a result of this evaluation, changes to the design of the K-Web information products and tools were made to meet these requirements. These changes are outlined below.

1.2. REVISED KNOWLEDGE WEB PRODUCTS AND TOOLS

To address the requirements of K-Web users identified by the Global 2000 use evaluation, several revisions were made to the design of the K-Web information products and tools.

1.2.1. Revised Summary Page Design

The primary K-Web information products used during both Global 2000 and Global 2001 were Summary Pages. Figure 6 shows the Summary Page design that was used in Global 2000 and the revised Summary Page design implemented at Global 2001.

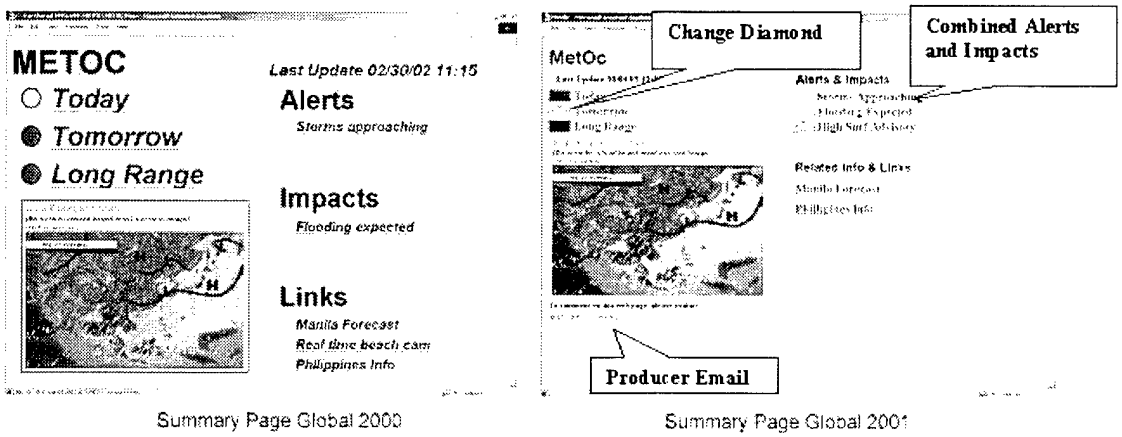


Figure 6. The Summary Page design used in Global 2000 (left) and the revised Summary Page design (right) used in Global 2001.

The changes made to the Summary Page design include:

- *Change alerting*. "New" information could be indicated on the Summary Pages by a change in shape (from a square to a diamond) of the color-coded status indicators. This design

implementation was intended to address the attention management and change detection needs of the Summary Page consumers.

- *Feedback to information producers from consumers.* The revised Summary Page layout included a field for the *SumMaker* user to provide an e-mail address, enabling the KWV users to contact them if necessary with input/feedback regarding their information product.
- *Combined layout.* The Alerts and Impacts areas were combined into a single area. These areas were combined to reduce the redundancy that was observed in the Summary Page content of these two areas during Global 2000.

1.2.2. Revised Knowledge Web Viewer Hardware Configurations

The initial KWV prototype, the K-Wall, consisted of two large central displays surrounded by 10 smaller peripheral monitors (see Figure 7). Although this design provided multiple users the ability to display information from multiple sources simultaneously, they found it difficult to read information on the small monitors. At Global 2001, a large three-monitor configuration replaced the K-Wall described above. In addition to the K-Wall, smaller, six-monitor K-Desks were provided to the various Component Commanders for use in information production and monitoring. Users viewing the smaller monitors were now seated close enough to permit easy viewing, unlike in the original K-Wall configuration used during Global 2000.

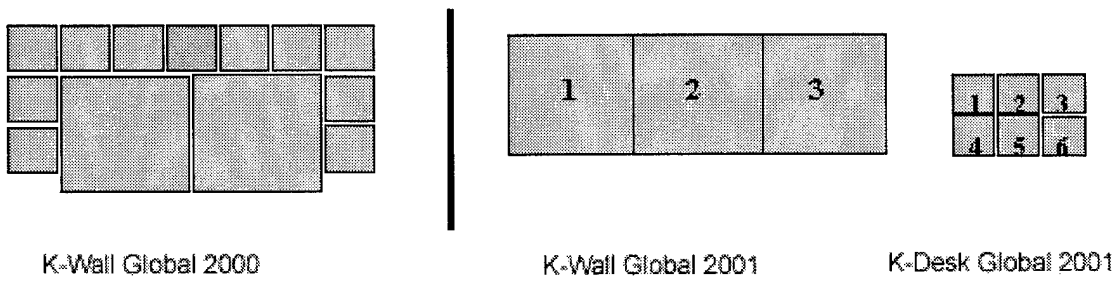
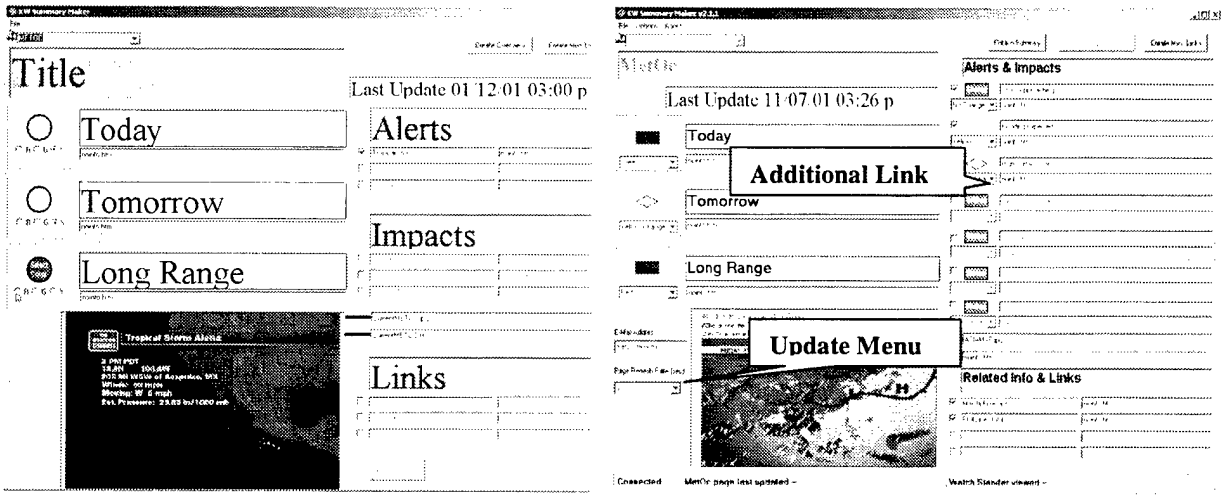


Figure 7. The KWV hardware implemented at the Global 2000 and 2001 war games.

1.2.3. Revised SumMaker Software Design

The *SumMaker* software (Averett & Moore, 2001) was revised to provide additional K-Web functionality and to support the Summary Page revisions described above (see Figure 8).



Global 2000 *SumMaker* **Global 2001 *SumMaker***

Figure 8. *SumMaker* templates.

Three new functions added to *SumMaker* were:

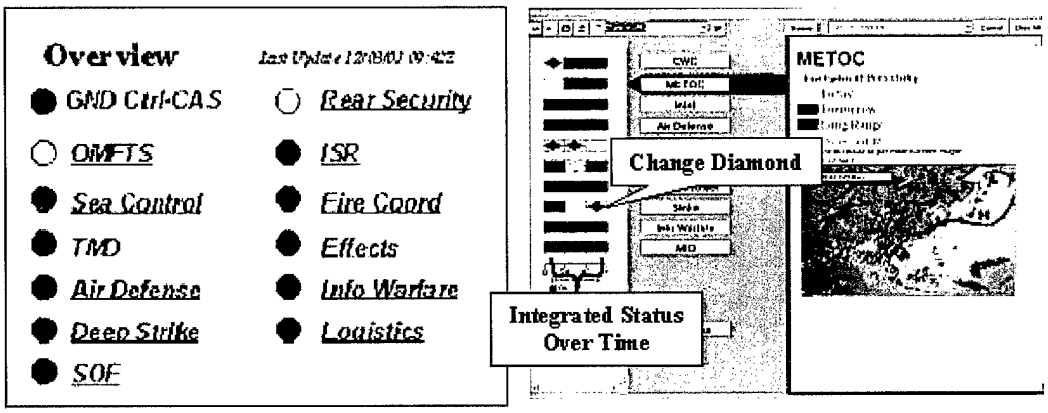
- *Feedback to information producers from KWV users.* The *SumMaker* software allowed its users to designate the operator of a particular KWV as a "primary watchstander." Feedback was provided to information producers when the watchstander viewed their Summary Pages using the *KWV* software. This feedback was provided in the form of a text time stamp on the *SumMaker* software interface. The purpose of providing this feedback to the information producers was twofold: (1) to give them information about access and use of their information products, and (2) to support the change alerting functionality (described in Section 1.2.4 below).
- *User-defined update rate.* Users of the *SumMaker* software could select, using a pull-down menu, the rate at which their Summary Pages would be updated (auto-refreshed) on the designated watchstander's KWV. This update rate can be set at various pre-assigned values (ranging from every minute to once every 3 hours) based on how often the information producer believes the watchstander needs to be updated. (Note that the Summary Pages are updated in the K-Web every time a *SumMaker* information producer publishes a new page or revised page. The user-defined update rate only applies to the auto-refreshing of the Summary Page if it is displayed continuously on a KWV).
- *Increased Link capacity.* Two additional fields enabled producers to link more information to the Summary Pages. One was added to "related Info and Links," and the other was added to the combined "Alerts and Impacts." The *SumMaker* template allowed for up to 15 links (one in each of the three status areas, a graphic, seven Alerts and Impacts, and four Related Information links).

1.2.4. Revised Knowledge Web Viewer Software Design

Several changes were also incorporated into the *KWV* software design (Moore & Averett, 2001). These changes were:

- *Dedicated Overview Page with support for Attention Management and Information Integration.* Users at Global 2000 had difficulty integrating high-level status information displayed

on the K-Wall and keeping track of changes in this information. Several features of the revised Overview Page on Window 1 (the top-left window of the K-Desks, the leftmost window on the K-Wall) are intended to alleviate these difficulties. The Overview Page is shown in Figure 9.



Global 2000 Overview Page Global 2001 Overview Page

Figure 9. Overview Page designs.

Revised features of the Overview Page include:

- *Improved overall status indicators (all areas, over time).* The left side of the Global 2001 Overview Page consists of a status bar that shows the status colors and shapes corresponding to those on the Summary Pages of the primary operational cells. The predicted status over three time periods—Today (24 hours), Tomorrow (24 to 48 hours), and Long-Range (beyond 48 hours) —is displayed in a single representation for each operational cell. The color (green, yellow, or red, in order of increasing criticality) and shape (square or diamond, in order of increasing recency) convey, respectively, the criticality and recency of the information associated with each time period. This was intended to allow KWV users to easily integrate information from these areas "at a glance."
- *Automatic indication of new/changed status information.* When an information producer indicates some change related to the predicted status of one of the primary functional areas (by changing the status indicator into a diamond on the Summary Page), this fact is automatically reflected on the Overview Page status bar by the presence of a diamond.

1.3. THE KNOWLEDGE WEB AT GLOBAL 2001

1.3.1. The Global 2001 War Game

The Global 2001 war game was played over a period of 2 weeks (16–27 July 2001). The 2-week period—10 working days—was composed of 1 day of training, 6 days of operational play (~37.5 hours of play, intermingled with "time jump" seminars), and 2½ days of post-exercise Executive Sessions. Game-play featured three operational phases: a pre-hostilities phase (Phase 1, ~19 hours of game-play), a hostilities phase (Phase 2, ~7.5 hours of game-play) and a post-hostilities phase (Phase 3, ~11 hours of game-play). The game's command structure was composed of a CJTF supported by

the five Functional Component Commands (FCCs).[1] (Throughout this report these areas will be encompassed by the term "operational cells.") CINC and Higher Authority (HA; the command at the Pentagon) roles were also role-played during the game. A mix of game personnel, War College umpires and facilitators, and mentors and observers from various commands and activities filled these roles.

1.3.2. The Implementation of the Knowledge Web at Global 2001

K-Web information products and tools featuring the revised design features described above were implemented during the Global 2001 war game. Specifically, this implementation included:

- *A K-Web Web site*, installed on NWC Web server. This K-Web Web site/server acted as a repository for published K-Web products, and as a Web server so that game players could access K-Web content via a Web browser.
- *Revised SumMaker software,* installed on multiple production consoles. Information producers used these consoles to create Summary Pages and other information products stored in the K-Web. Summary Pages were created by each of the FCCs (JFACC, JFLCC, JFMCC, JSOTF, JSTC), the CINC staff, the CJTF staff, the HA staff, as well as various "supplemental operational areas" (including Intel and Blue's Red Assessment Team [BRAT]).
- *A three-monitor K-Wall,* installed in the Joint Command Center (JCC) at NWC. The display hardware consisted of three 58-inch diagonal SmartBoard rear projection displays. The K-Wall was intended to be used as a shared display by the CJTF staff, primarily for information consumption. Figure 10 shows the CJTF K-Wall. The *KWV* software was the primary display software used. Additional software applications/tools (e.g., *MS Office* software, tactical software) were also used and displayed on the K-Wall.

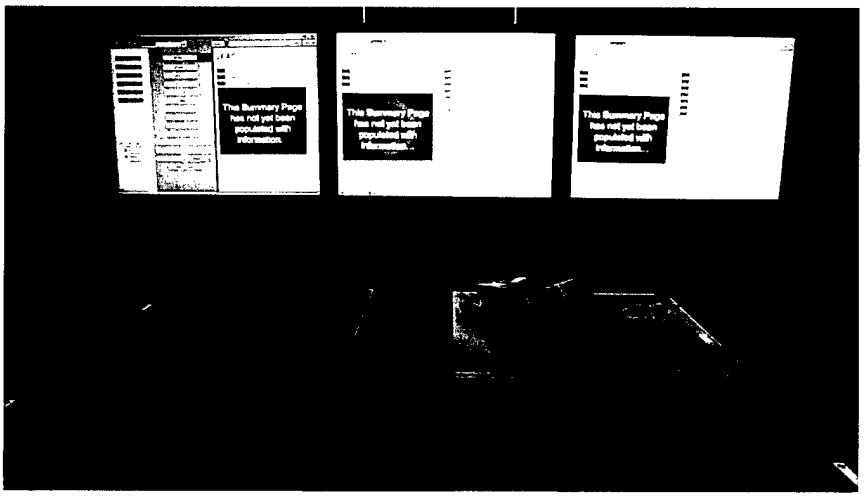


Figure 10. The CJTF K-Wall in the JCC at the NWC.

[1] Joint Forces Air Component Commander (JFACC), Joint Forces Land Component Commander (JFLCC), Joint Forces Maritime Component Commander (JFMCC), Joint Space Theatre Commander (JSTC), Joint Special Operations Task Force (JSOTF).

- *Five six-monitor K-Desks at the NWC,* for use in the CINC cell and the operational cells. These were intended to be used for both information production and consumption. Figure 11 shows an example K-Desk. The same software applications that were used on the K-Wall were available on the K-Desks. The display hardware consisted of K-Desk computer and six 15-inch diagonal flat-panel monitors.
- *One six-monitor K-Desk at the Pentagon,* for use by HA.

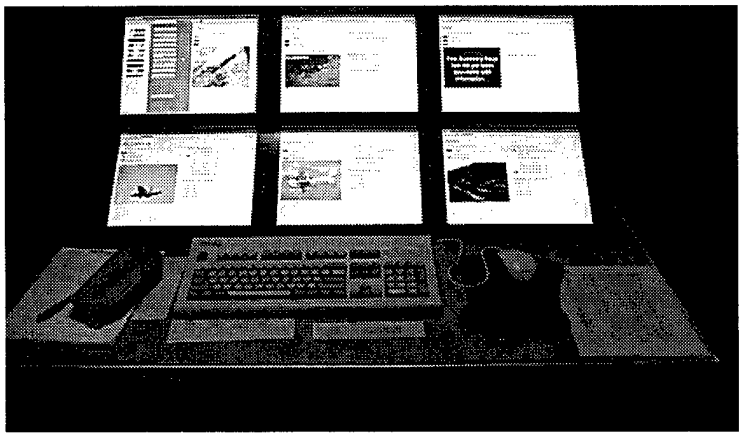


Figure 11. Example 6-monitor K-Desk.

1.3.3. Training and Business Process

Figure 12 illustrates the implementation of the K-Web tools within the Global 2001 command structure. During the game, a relatively small number of game participants had access to K-Desks and K-Walls. In Figure 12, an icon of a K-Desk or K-Wall indicates which cell had such a system.

A larger number of game participants had access to *SumMaker* and *TacGraph* software tools, which were used to produce information products that were stored in the K-Web on the Web server. All cells had access to these tools, as indicated by icons representing Summary Pages in the lower right-hand corner of each blue box in Figure 12.

Finally, *all* game participants had access to K-Web information products via their Web browsers (e.g., MS *Internet Explorer*). Furthermore, a "Commanders' Summaries" link in the NWC *War Game Information Grid System* (*WIGS*) (see section 2.2.3) provided easy access to K-Web content. Providing all game participants with access to K-Web content was intended to allow a more fully distributed set of knowledge/information products than more traditional means of information dissemination (i.e., up and down the chain of command). Information producers were told that every participant of the exercise could, and most likely would, access their information products. However, they were also instructed to create products with the Global 2001 command structure in mind.[2]

[2] Ideally, the K-Web should be populated with information products that can be tailored to the information requirements of *all users*.

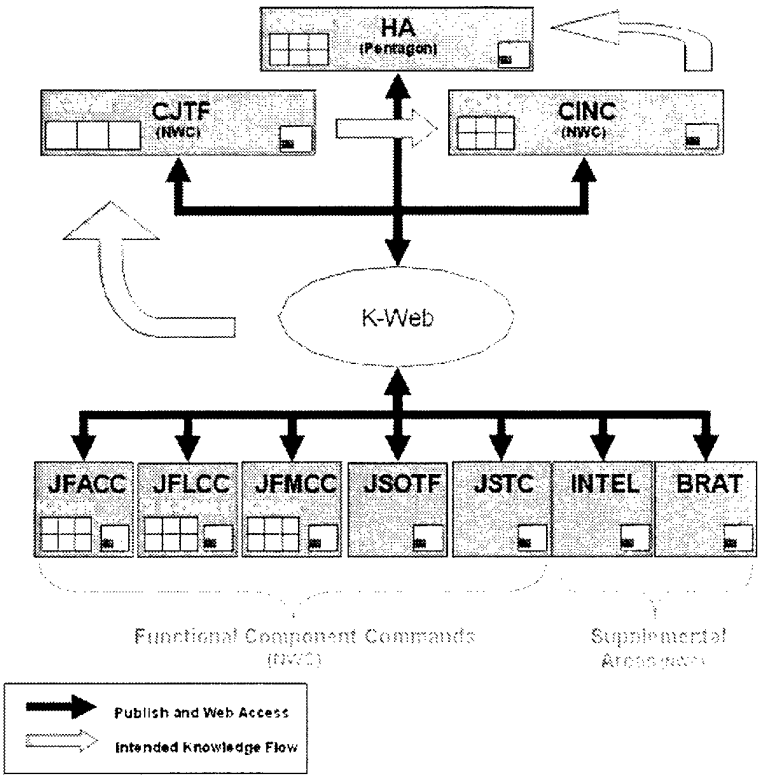


Figure 12. The implementation of the K-Web tools within the Global 2001 command structure.

Green arrows (the wider arrows) in Figure 12 indicate intended K-Web information flow for Global 2001. As shown in Figure 12, Summary Pages created by the operational cells and Supplemental Areas were primarily intended for use by the CJTF and his staff. The CJTF staff created information products for consumption by the CINC staff. The CINC cell produced information for HA. In this information flow model, each echelon primarily "pushes" information up the hierarchy though users at any level of command can, and frequently do, access pages not specifically designed for them.

Training documents (hard copies) were provided to the all of the K-Web tool users. K-Web training documents were also made available on-line to all game participants via the K-Web and *WIGS* systems. All K-Web training documents were made available prior to game start and were available continuously throughout the game. The training documents included:

- *A K-Web business rules brief (Pacific Science and Engineering Group, 2000, 2001),* which described the K-Web concept and tools and provided business rules for K-Web information products including those related to:
    - The intended use of the Summary Pages and the relationship between the Summary Pages and the other K-Web tools (e.g., information on the Summary Pages is reflected on the *KWV* Overview Page).
    - Use of color and shape (change alerting) on the Summary Pages.
    - Appropriate update rates for information products.

- Content and format of linked information, including guidelines related to providing useful information, cross-referencing others information, providing legible information, etc.
- Feedback between information consumers and information producers.
- Saving and accessing information products.

- *A SumMaker training brief and accompanying "quick reference guide" (Pacific Science and Engineering Group, 2000, 2001),* which provided operator instructions for users of the *Sum-Maker* software.
- *A KWV training brief and accompanying "quick reference guide" (Pacific Science and Engineering Group, 2000, 2001),* which provided operator instructions for users of the *KWV* software.
- *A TacGraph training brief and accompanying "quick reference guide" (Pacific Science and Engineering Group, 2000, 2001),* which provided operator instructions for users of the *Tac-Graph* software.

2. DATA COLLECTION

2.1. PURPOSE

The purpose of the data collection for the Global 2001 war game was to evaluate the use, utility, and usability of the K-Web concept and tools. This was accomplished by examining the K-Web information products (Summary Pages), the KWVs (K-Wall and K-Desks) and the K-Web support tools (*SumMaker* and *KWV* software) while they were undergoing extensive operational use during Global 2001. The K-Web Global 2001 data collection plan had five objectives:

1. Verify that K-Web information products, the KWVs and the support tools design solutions supported other previously identified user requirements (see Table 1).
2. Determine whether revised features and functions of the K-Web information products and the K-Web support tools, and the KWVs (K-Wall and K-Desks), met the information integration, cognitive support, and collaboration needs identified by the Global 2000 use evaluation. Table 2 shows the revised and new K-Web features designed to meet those needs.
3. Identify whether additional K-Web user needs exist.
4. Identify ergonomic problems related to the K-Web products and tools that may exist.
5. Assess users' preference for K-Web products and tools, relative to other information technology products they have used.

Table 2. The revised and new K-Web features implemented and evaluated at the Global 2001 war game.

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
SumMaker	Update Rate	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

2.2. DATA COLLECTION TECHNIQUES

Data were collected during periods of game-play at the Global 2001 war game, which took place from 16–27 July 2001. Data collection focused primarily on the JCC KWV used by the CJTF staff and its users. (Most information producers published information primarily for the JCC KWV, indicating that this KWV's user was the "primary watchstander"). However, data were also collected on the use of the Summary Pages by other information consumers, and on the K-Desks and the *Sum-Maker* software, where it was available.

Data collection was planned with flexibility and breadth in mind. The plan was *flexible* to capitalize on opportunities to gather relevant data, such as pertinent verbal communication and additional comments that shed insight into the cognitive processes underlying use of the KWV. In addition, the flexibility of the data collection plan enabled observers to change or redirect data collection efforts as needed. The data collection plan was large in *breadth*, to ensure that as wide a range of data was obtained as possible, from recording expressions of preference to automatically recording keystroke data. The breadth of the plan also ensured that as much pertinent information as possible was collected for use in the evaluation of the K-Web concept and technologies. This approach proved highly successful at Global 2000 and was, therefore, repeated at Global 2001.

To fully understand the nature of the K-Web-related data collection, it is necessary to first understand the nature of the environment in which the data were collected. The war game is conducted in the context of a free flowing, highly realistic—and therefore unpredictable—operational mission featuring a busy and intense decision-making environment that is not conducive to formal experimentation. Further, to limit the impact on game-play, War College officials insisted that the data collection techniques employed be primarily restricted to passive observation and automated data collection. The only exceptions to this restriction were interviews of information producers that were conducted after the conclusion of the exercise (see Section 2.2.3).

2.2.1. Automated Data Collection

Most K-Web data were collected automatically by the *KWV* software. Automated data collection was conducted in order to track URL access and changes in the configuration of KWV displays. Logs of KWV use were created at the beginning of each day and updated each time a change was made. These logs included which Web pages were presented on which KWV display and when the URLs to these pages were accessed. The logs also included other keystroke data, such as when a button associated with one of the operational cells was clicked, or when that Summary Page was moved to another window.

Although the log files are a good source of information about the users' interaction with the system, they do not necessarily give a complete picture of what information was displayed on the KWVs. For example, a user may access a Summary Page that is very useful and, therefore, display it for an extended period of time. The log file will show this as being a minimum amount of activity because the page was only accessed once, yet it would be meaningful to know that a particular page is being heavily used. Further, the KWV users may have run other software (such as *MS PowerPoint*) in a separate window of the KWV; this behavior would not be indicated in the log files. To balance the information collected from the log files, screen captures were taken of the CJTF K-Wall every minute and of the K-Desks every 5 minutes. The screen captures provided supplemental information regarding the content displayed on the KWV windows and how that information was configured. Additionally, the screen captures reflected the use of other applications being displayed that were neither accessed through the *KWV*, nor recorded in the log files.

SumMaker software also provided built-in, automated data collection by saving a copy of each Summary Page published. These files provide information about the content of the Summary Pages, including the color and shape selected for the status indicators, the text of the alerts, impacts, and related links, and the URLs of links on Summary Pages.

2.2.2. Observational Data Collection

Observational data collection focused primarily on the JCC K-Wall used by the CJTF staff. These data were related to system use and utility of the K-Web information products and the KWV, and focused on:

- *The revised features of the Summary Pages and the KWV*, and how well they met users' needs for integration, change alerting, and feedback (between K-Wall users and information producers).
- *Summary Page use patterns*, including the content of the Summary Pages and the context in which Summary Pages were accessed.
- *K-Wall and K-Desk use patterns*, including which tools and URLs KWV users access and how the KWV displays were configured.
- *User preferences*, with respect to Summary Pages and KWVs and compared to other tools used in the past.
- *SumMaker and KWV software usability*, including issues related to the ease and intuitiveness of use.
- *Suggestions and new requirements*, in terms of the content, features, and tools of the Summary Pages and *KWV*.
- *Visibility and other ergonomic issues related to the KWV*, including the legibility of text and graphics on the KWV and issues associated with occlusions, monitor glare, room layout, communication between personnel, etc.

The specific data sources used to collect observational data included:

- *Logging of critical events* that caused a change in Summary Page and KWV use.
- *Time sampling* of the content and configuration of the KWVs, as well as which tools and Summary Pages were being used or viewed (discussed).
- *Manually collected record of verbal comments* made by KWV users as they relate to usability issues, new requirements, preferences, and visibility.
- *Answers to verbal probing* of specific K-Web users about the above issues (new *KWV* and Summary Page features, usability, requirements, preference, and visibility) if observations of behavior have not provided enough information.
- *Measurements and descriptions of variables* related to ergonomic use and visibility of information on the KWV. Measurements were taken of the layout of JCC space. Visibility of the information presented on the K-Wall was also measured.

The observational data collection described above occurred continuously. Similar data were collected across the K-Desk users, whenever possible.

2.2.3. Other Observational Data Sources

Interviews with SumMaker and KWV Software Users. At the conclusion of the exercise, interviews were conducted with the information producers from each operational cell that used the *SumMaker* software to create Summary Pages, and with information consumers that used the *KWV* software using the five K-Desks. Nine users were interviewed in total. The participants' answers were included as part of the observational data. Participants in these interviews were asked the following five questions:

1. What do you think were the best features/functions of the *SumMaker/KWV* software?
2. Generally speaking, did the *SumMaker/KWV* software meet your needs as an information producer?
3. What features/functions should be added or improved to make the *SumMaker/KWV* software better meet your needs?
4. How could/should the information production and dissemination process be improved?
5. Do you have any further comments or suggestions for us?

Knowledge Management Meetings. The observational data include comments made during seminars, discussions with the Knowledge Managers (KMs), and the KM meetings that were held twice a day. The KMs provided invaluable insights into many issues related to the K-Web because of their roles as facilitators for the use of the K-Web and other information technologies. These perceptions were also documented and made available to members of the Command 21 program team during Global 2001.

War Game Information Grid System (WIGS). Many documents and tools used by the information consumers could be accessed via *WIGS*, a Web-based system provided by the NWC. Two of these in particular provided important data regarding the K-Web. The first was the CJTF watch log, maintained by CJTF staff using collaboration software (specifically *CommandNet*[3]). Another source of information was the situation summary (the SitSum) that was updated continuously by exercise participants throughout the exercise. Access to both sources provided information about critical events.

[3] http://www.cmi.arizona.edu/research/dist_collab/CommandNet/index.htm

3. RESULTS

To test and evaluate the effectiveness of K-Web tools and information products, a comprehensive data set was collected from each Global 2001 participant who used the K-Web. These data included both observational data collected by the K-Web research staff and data gathered automatically by each K-Web tool. When considered jointly, these two types of data yielded a thorough description of participant use of the K-Web. Appendix A contains summary tables of the data that were collected automatically; Appendix B contains summary tables of the observational data.

Data collected automatically by the *SumMaker* software containing information related to the content of Summary Pages published during the game were contained in 837 files. Data collected automatically by the *KWV* software and related to the *KWV* use was analyzed for three KWVs: the CJTF K-Wall, the CINC K-Desk, and one of the FCC K-Desks.[4] The *KWV* data included 2145 screen captures taken of the K-Wall used by the CJTF staff, 423 screen captures taken of the CINC K-Desk, and 349 screen captures taken of the FCC K-Desk. These data provided information about the content and configuration of the information on the K-Wall and K-Desks. Data logs from the K-Wall and four of the K-Desks provided information related to the use of the *KWV* software.[5]

The observational data included approximately 200 comments and observed behaviors made by CJTF staff and other users throughout the course of the exercise. The data collected automatically by the *KWV* and *SumMaker* software came from users of the K-Web tools from the CJTF staff, the CINC staff, five FCCs (henceforth referred to as FCC1, FCC2, FCC3, FCC4, and FCC5) and two Supplemental Areas (SuppArea1 and SuppArea2).

Observational data also included data related to critical events. A Subject Matter Expert (SME) identified 16 of the most important developments during the exercise based upon information from CJTF watch logs, the SitSum, and the critical event logs from each day of the exercise. Three other SME raters assigned a "criticality" rating to these events, (4 = critical event, 3 = significant event, 2 = important event, 1 = event of interest). The average critical ratings ranged from 1.7 to 3.7. These critical events were included in several of the analyses discussed below.

Automatically collected and observational data were distributed into six categories, related to:

1. The use, utility, and usability of the K-Web information products (primarily Summary Pages) during Global 2001.

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[4] Only data from a single, representative K-Desk were included in the analyses for a number of reasons. For example, the KWV application was not run on one of the FCC K-Desks so no data log was created for it. Only a limited number of screen captures were taken of this K-Desk. Therefore, data from this KWV were not included in any analyses. Due to technical problems, *no* screen captures were taken of another FCC K-Desk, so no data related to this KWV were included in the analyses. A third FCC K-Desk was operated almost entirely by members of the Command 21 K-Web support team, under the direction of a civilian exercise participant. We were concerned that the usage patterns of these operators would not be representative of the usage by other FCC KWV operators and so excluded the data collected automatically by the *KWV* software from this K-Desk. Note that the observational data regarding these three KWVs *are* included in the Results.

[5] The KWV application was not run on one of the K-Desks (in one of the FCCs), so no data log was created for it. A limited number of screen captures were taken of this K-Desk and, therefore, those data were not included in any of the analyses. Further, due to technical problems, no screen captures were taken of another FCC K-Desk. Due to these circumstances, screen capture data were included for three of the five K-Desks, and log data were included for four of the five K-Desks.

2. The revised Summary Page design features (content, layout, change alerting).
3. The use, utility, and usability of the K-Wall and K-Desks during Global 2001.
4. The revised K-Wall/K-Desk design features (number of monitors, change alerting).
5. Revised *SumMaker* and *KWV* software features and usability.
6. Other emerging themes, especially training and business rules.

The results are organized around these categories and include discussion of the observational data, as well as appropriate analyses conducted on the data collected automatically (i.e., the KWV use logs and screen captures).[6]

3.1. USE, UTILITY, AND USABILITY OF SUMMARY PAGES DURING GLOBAL 2001

3.1.1. Summary Page Use

Summary Pages and the products that they linked to were the predominant products in the K-Web. Information producers used Summary Pages to update senior staff and others about important issues, events, and plans, with respect to operational play. Summary Pages could be accessed easily using the *KWV* software and displayed on the K-Wall and K-Desks.

The number of times that Summary Pages and links were accessed per hour of use on the K-Wall and K-Desks is shown in Figure 13 and Figure 14, respectively. Use is shown as a function of operational phase (see Section 1.3.1). Analysis of the *KWV* data logs indicated that Summary Pages were frequently accessed throughout the exercise. An average of 27.5, 30.0, and 38.8 Summary Pages were accessed per hour in Phases 1, 2, and 3, respectively, across the KWVs. The increase in Summary Page access over the course of the exercise is not surprising because, over time, information consumers should become more familiar with the display technology and the information producers should provide more "developed pages."[7]

In addition, links from these Summary Pages were frequently accessed (an average of 41.5, 25.0, and 27.2 links were accessed per hour in Phases 1, 2, and 3), particularly by the CJTF and CINC KWV users.[8] The display of Summary Pages on the K-Wall and K-Desks is discussed further in Section 3.3.1.

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[6] Note: Comments made are presented in italicized text. Many of them are paraphrased or have been corrected for grammar. Observations are presented in normal font.

[7] The difference in usage patterns (here, and in subsequently reported results) across operational areas and across exercises is also not surprising, given there were many uncontrolled variables that could account for the differences. These variables include, but are not limited to, organizational variables (differences across the commands that participated in the game and across the organizational structures imposed by the game) participants" familiarity with Web technology, exercise scenarios, and information needs of the operational areas. More discussion of these differences is found in Section 3.7.1. of the Results (Training and Business Rules).

[8] Note that these data do not include instances when K-Wall/K-Desk users used the Back button on the KWV application to return to a Summary Page after accessing a link from that Summary Page.

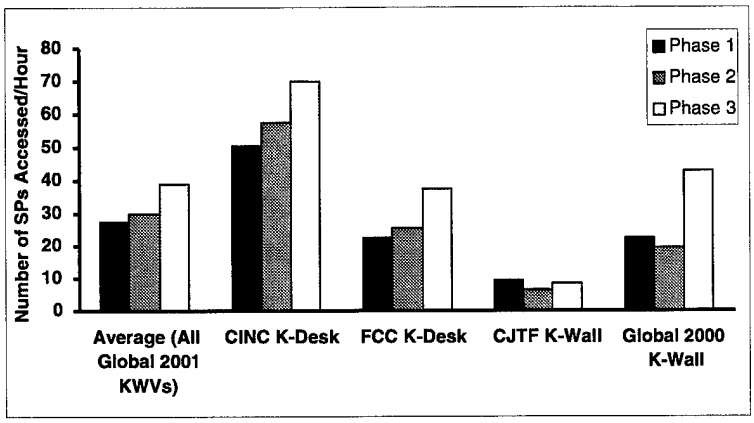

Figure 13. The number of Summary Pages accessed via the *KWV* software on the K-Wall and K-Desks.

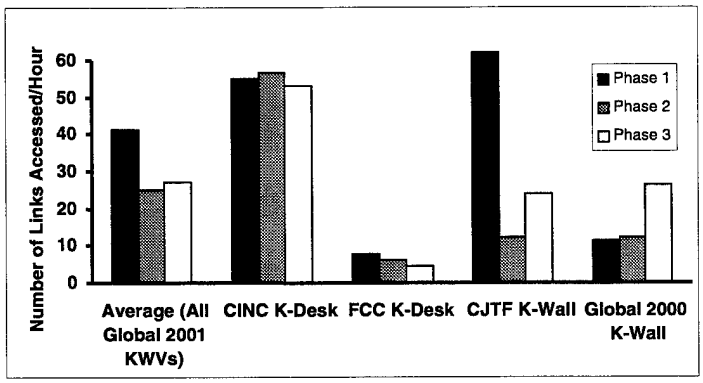

Figure 14. The number of links from the Summary Pages accessed via the *KWV* software on the K-Wall and K-Desks.

In addition to access via the *KWV* software, all information consumers could view Summary Pages via a link to the Commander's Summaries on the War College Web (*WIGS*). Although patterns of access varied, information consumers in all cells, from the FCCs up to HA, used the Summary Pages to become apprised of the operational situation and of other exercise participants' concerns. Observations and comments included:

- *The Commander's Summaries are accessed by the cell players and projected up on the K-Wall.*
- *[FCC2] used the K-Desk to obtain situation awareness (SA) from the other Summary Pages...so the KM could keep track of other pages and to update his own Summary Page and documents.*
- *I'm seeing guys dipping down, grabbing pictures, graphics, text, and providing it to Commanders.*
- *In my cell, 5 to 6 people at a time are looking at the Commanders' Summary Pages.*
- *I'm looking at the pages to make sure no information needs filling in...there's good information that's been converted to knowledge if you know where to get it.*

- *The Commanders' Summary Page—gave [FCC2] a way to give a picture to the JTF staff the way that we wanted/thought they should see it.*

3.1.2. Summary Page Update Rate

If the K-Web is to provide information consumers with current and accurate information, the Summary Pages must be updated by information producers at an adequate rate to reflect events and changes in the operational situation. The rate at which the information producers updated their Summary Pages is shown in Figure 15. Different information producers published at different rates over the course of the exercise. This is not surprising because the amount of information that is *relevant* to the operational situation varies at any point in time across the different operational cells. The design of the *SumMaker* enables users to update "as needed," as opposed to requiring scheduled periodic updates. The *SumMaker* software also allows users to select the rate at which their pages are automatically refreshed on the KWVs (see section 1.2.1, Revised Summary Page Design), thereby providing the most accurate and timely information available while at the same time conserving bandwidth.

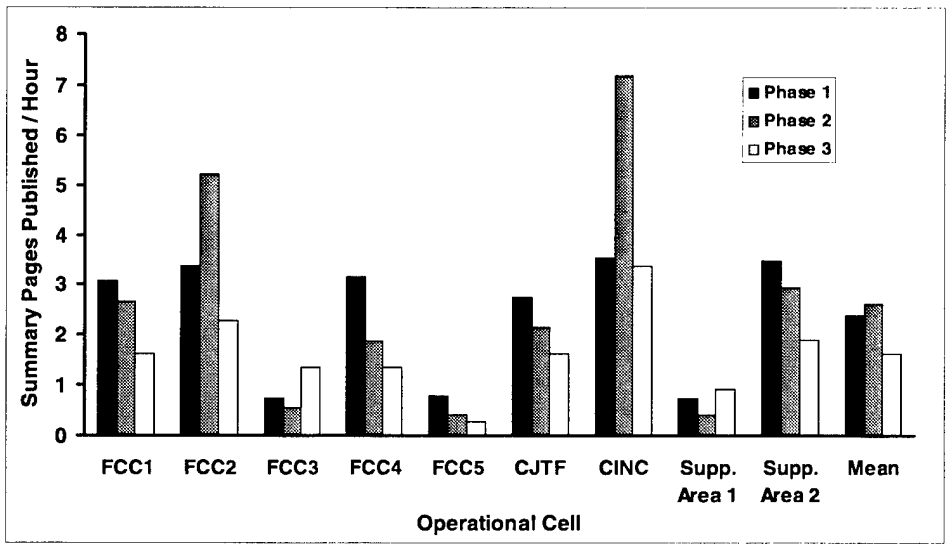

Figure 15. The rate at which Summary Pages were published (number of Summary Pages posted per hour of the exercise).

On average, a Summary Page was published to the K-Web quite frequently—every 3.14 minutes (every 2.78 minutes in Phase 1, every 2.57 minutes in Phase 2, and every 4.07 minutes in Phase 3). Note that this update rate does not take into account the creation and revision of the K-Web information products that were not Summary Pages (i.e., the products that were links from the Summary Pages). As shown, the update rates varied considerably across the various functional areas, confirming the need for user-controlled update rates.

The information consumers' level of satisfaction with update rates varied. Senior staff occasionally instructed the FCCs (via chat and e-mail) to provide more current information on the Summary Pages. Related comments included:

- *[FCC5] has got their stuff populated...that's good.*
- *There still isn't enough content on the Summary Pages.*

- *We've looked on [FCC3] and [FCC2] pages and can't find evidence of [a trigger]...We've already sent them a message to update their Commander's Summary Pages.*
- *The information is coming too fast to update the slide (link re: above) anymore...we were told to use the tools until they break and it looks like they have.*
- *We need all of you to update your Commander's Summary Pages with information about where you are....*
- *We need you to update the Commander's Summaries every morning, afternoon, and as needed for everyone...need to push other information during the day.*

3.1.3. Summary Page Preference

In general, information consumers liked the Summary Pages and some preferred them as a means to communicate status to senior staff and other information consumers, relative to other tools. Many suggestions were made for improvements for new features and tools. These are discussed below (see the discussion of the Revised Summary Page Design, Section 3.2). Representative comments were:

- *The Summary Page gave [FCC2] a way to give a picture to the JTF staff the way that we wanted/thought they should see it.*
- *It standardized everyone's input.*
- *We're trying to figure out templates for our Web Page on the ship...these Summary Pages would work.*
- *The tools found to be very useful included the K-Wall setup, Commander's Summaries....*

3.2. REVISED SUMMARY PAGE DESIGN

3.2.1. Change Alerting

One new feature of the Summary Page design was indicators of new or changed information. *SumMaker* gave information providers the ability to indicate changed and new information by changing the shape (from a square to a diamond) of the color-coded status indicators. Information providers could also include these "change diamonds" in the Alerts and Impacts section to indicate which information was associated with a change in status.

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
SumMaker	Update Rate	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

Figure 16 shows the percentage of Summary Pages that included status change diamonds. Analysis of the KWS files indicated that the information providers included change diamonds very frequently (on average, in 34%, 62%, and 70% of the Summary Pages that were published in Phases 1, 2, and 3, respectively).

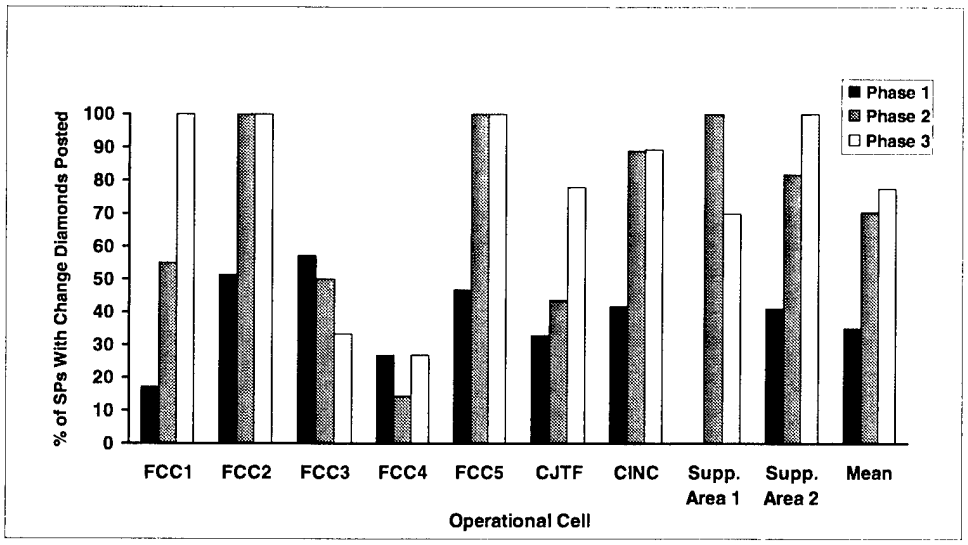

Figure 16. The percentage of Summary Pages that contained one or more change diamonds.

Data from the KWS files were also analyzed to determine whether change diamonds were being used differently after a critical event than during times when there was no critical event. Figure 17 shows the percentage of published Summary Pages that contained change diamonds during the hour following critical events (least critical = an average rating of less than 2, moderately critical = rated between 2 and 3, most critical = rated higher than 3). The figure also shows the average proportion of published Summary Pages that contained change diamonds when there was no critical event. As the criticality of the operational situation increased, information providers included more change diamonds on the Summary Pages. This reflects what would be expected; as criticality level increases, more factors related to operational status would likely be affected.

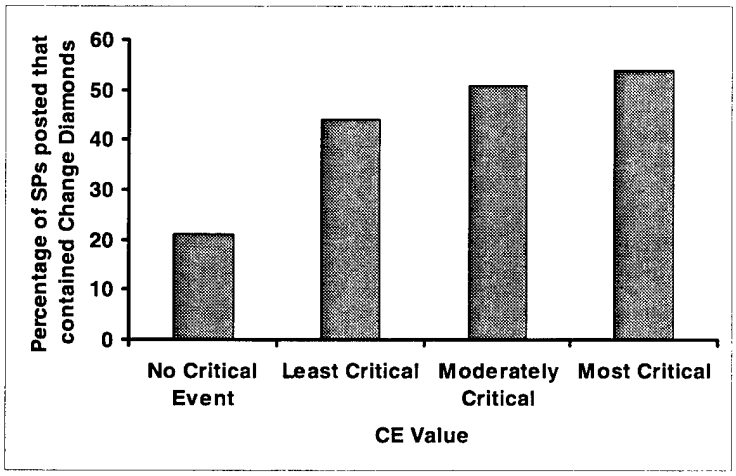

Figure 17. The percentage of published Summary Pages that contained change diamonds, as a function of level of criticality.

The discussion of the revised *KWV* Overview Page (Section 3.6.1) describes in more detail how effective the change diamonds were in alerting users of the K-Wall to new information. Comments related to the summary change diamonds suggested that, although users liked them, further change

alerting issues remain. Representative comments related to the change diamonds on the Summary Pages are:

- *The diamonds were good....*
- *The main feature that is needed is alert functionality.*
- *How do you alert, tailor information for different CCs?*
- *You can post things on the Web all day long but you need to push information...can't assume people will pull off Web.*
- *Need an indication of when alerts were changed or added.*
- *Since it's always on the display...if you know in advance what you want to be alerted to you could be automatically alerted....*

3.2.2. Revised Layout of Summary Pages

Combined Alerts and Impacts. Another change made to the design of the Summary Page was the combination of the Alerts and Impacts areas into a single area. Information providers could include up to seven alerts in this section (along with an associated link and a colored square or diamond for each) and up to four pieces of information in the Related Links section. Each of these 11 fields (alerts and related links) could have a hyperlink associated with it.

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
SumMaker	Update Rate	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

User comments indicate a preference for the standardized Summary Page format. Some information providers, however, thought the Summary Pages were too simple and indicated a need to change the design so that the content and quality of information could be changed. Comments related to the layout and features of the Summary Pages included:

- *I like the idea of everyone having information in the same format.*
- *I need more space to put stuff.*
- *[The Summary Page] is a good looking page with enough white space.*
- *There was only a limited amount of information you could put on it.*
- *The Summary Pages were too simplistic.*
- *It wasn't flexible enough...you couldn't change the information.*
- *You should always put military time on the Summary Pages.*
- *Nice feature to have the time stamp though.*

Information Producer E-mail Address. The revised Summary Page design also included a field in which the information provider could post his or her e-mail address so anyone viewing the Summary Page could send them feedback. Information producers expressed dissatisfaction in the amount of feedback that they received about the content of their information products. This is in spite of the fact that

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
SumMaker	Update Rate	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

the K-Wall users (as well as the CINC and HA) were observed to provide feedback to these users in the form of e-mail or other communications. Related comments included:

- *We need all of you to update your Commanders' Summary pages with information about where you are...[chat message].*
- *I'm looking at the pages to make sure no information needs filling in. If there is, I tell BW1 and he lets the guy know...BW1 is pretty proactive about it too.*
- E-mail from CINC that Today's link is still yesterday's plan.
- *We didn't get enough feedback from upstairs [JCC] about whether there was right information.*
- *We need to know what the CJTF wants to see....*

3.3. USE, UTILITY, AND USABILITY OF KNOWLEDGE WEB VIEWER HARDWARE DURING GLOBAL 2001

3.3.1. Format and Content of Information on the Knowledge Wall/Desks

Analysis of the screen captures indicated that the format of the information displayed on the windows varied across the different K-Walls/K-Desks. The dedicated Overview Page was always displayed on Window 1 of the CJTF K-Wall; therefore, the format of the information there never changed. Figure 18 shows the percentage of time information was displayed on the other windows of the K-Wall as a function of operational phase and format of the information displayed (averaged across Windows 2 and 3). Figure 19 and Figure 20 show the percentage of time information was displayed on the respective K-Desks as a function of operational phase and format of the information displayed (averaged across all six K-Desk screens).

"Auxiliary" K-Web products were any products found in the K-Web that were not Summary Pages, and were usually a link from a Summary Page. As can be seen in Figures 18 through 20, most of information products that were displayed were auxiliary K-Web products, primarily displayed in Window 2 of the K-Wall, and *WIGS* products, primarily displayed in Window 3. Either a Summary Page or an auxiliary K-Web product was displayed on each monitor of the K-Wall 58.5% of the time (Summary Pages were displayed 5% and auxiliary K-Web products were displayed 53.5% of the time averaging across Windows 2 and 3). *MS PowerPoint* products were also frequently displayed, usually during the morning and afternoon CJTF briefings. The information products displayed on the CINC and FCC K-Desks were more varied, but K-Web products still composed the most commonly displayed information. K-Web products were displayed on each monitor of the CINC K-Desks 45.4% of the time (Summary Pages were displayed 24.3%, auxiliary K-Web products 12.1%, and the Overview Page was displayed 9% of the time averaging across all six monitors) and on the FCC K-Desk 23.9% of the time (Summary Pages were displayed 14.2%, auxiliary K-Web products 3.2%, and the Overview Page was displayed 6.5% of the time).

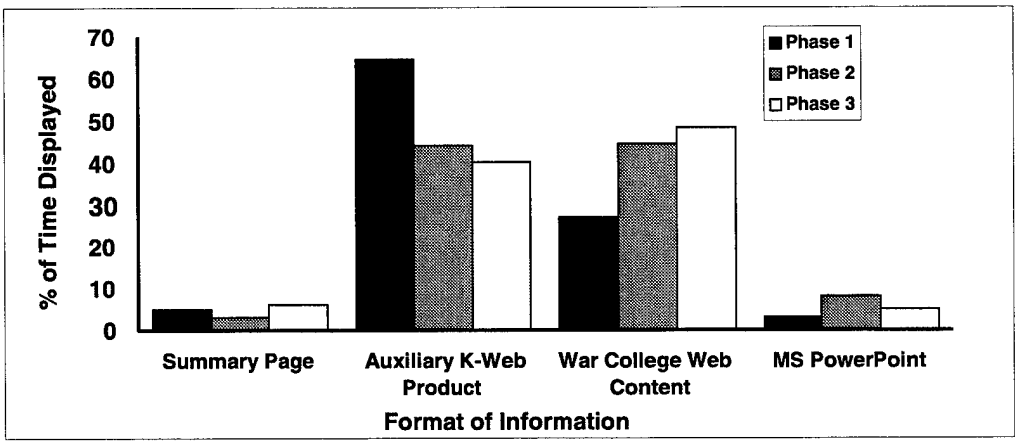

Figure 18. The format of the information displayed on Windows 2 and 3 of the K-Wall.

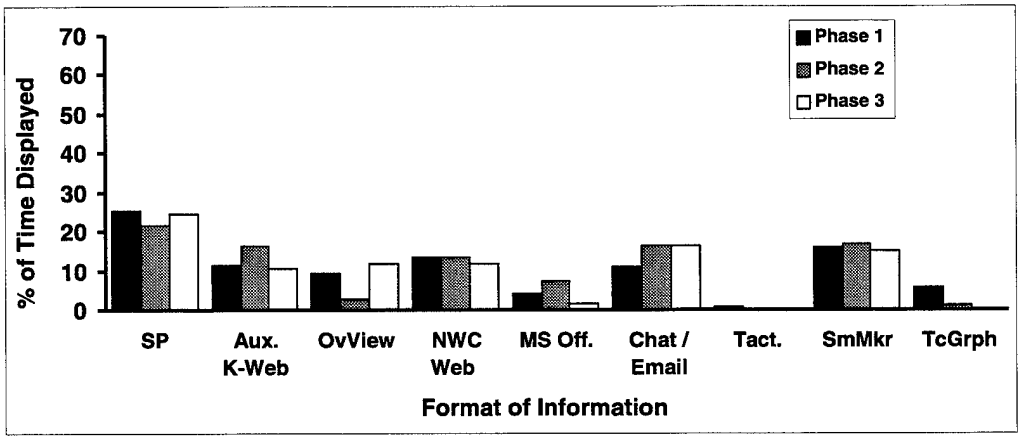

Figure 19. The format of the information displayed on the CINC K-Desk.[9]

[9] SP = Summary Page, Aux. KWeb = auxiliary K-Web (link), OvView = overview page in *WIGS* (link to Commanders Summary Page), NWC Web = *WIGS*, MS Off = *MS Office* products, Tact = tactical information, SmMker = *SumMaker* software, TcGrph = *TacGraph* software.

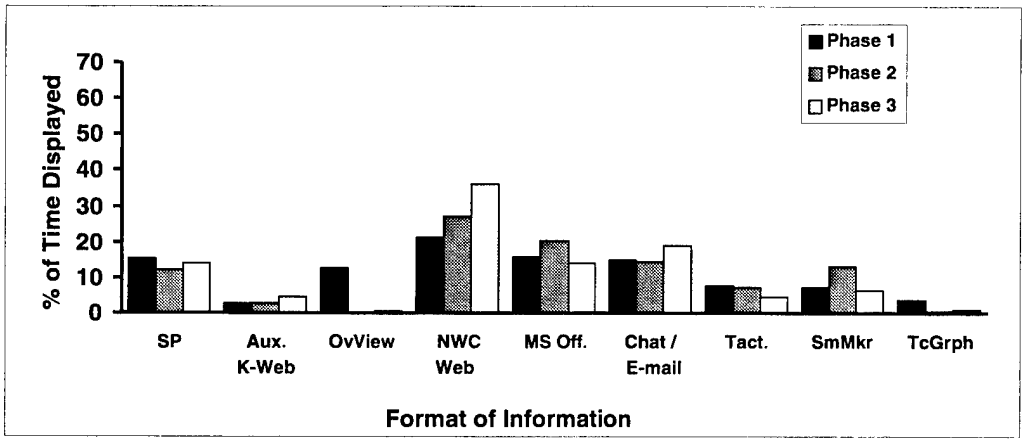

Figure 20. The format of the information displayed on the FCC K-Desk.

Figure 21, Figure 22, and Figure 23 show the content of the information displayed on the K-Wall and K-Desks, as indicated by the screen captures. Most of the K-Web products displayed on the CJTF K-Wall were those created by the Supplemental Areas (displayed 42.1% of the time), whereas the FCC K-Desk was more likely to display Summary Pages and links from the other FCCs (44.6% of the time). Not surprisingly, the CINC K-Desk frequently displayed information from the more senior commanders (the CJTF, the CINC and HA) as well as from the FCCs (39.0% and 33.7% of the time, respectively). The K-Wall and FCC K-Desk frequently displayed the *CommandNet* software (44.6% and 29.5% of the time, respectively), available through the *WIGS* system to maintain watch logs. The CINC K-Desk also frequently displayed the output from *Theater Assessment Profiling System* (*TAPS*), which provided effects-based assessment of the operational system and was available through *WIGS* (16.8% of the time).

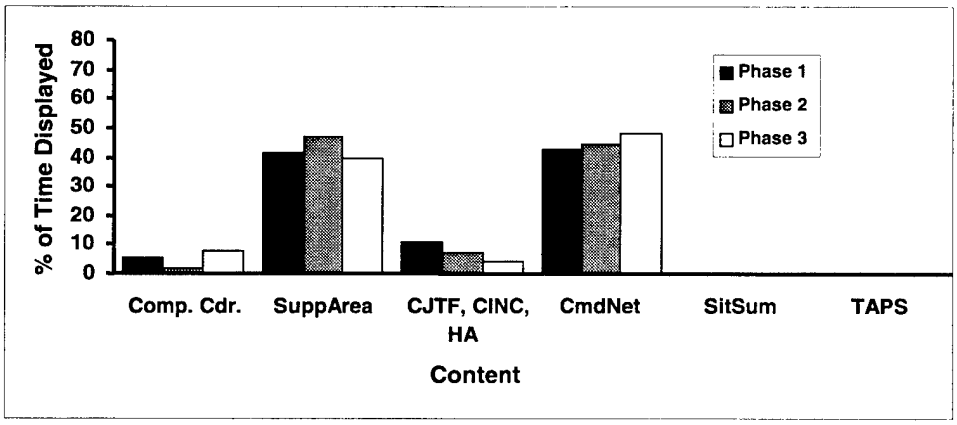

Figure 21. Content of the information displayed on Windows 2 and 3 of the K-Wall.[10]

[10] Comp. Cdr. = FCCs, SuppArea = Supplemental Area, Cdr. Sum = *WIGS* access to the operational cell Summary Pages, CmdNet = *CommandNet* (via *WIGS*), *TAPS* = Theater Assessment Profiling System.

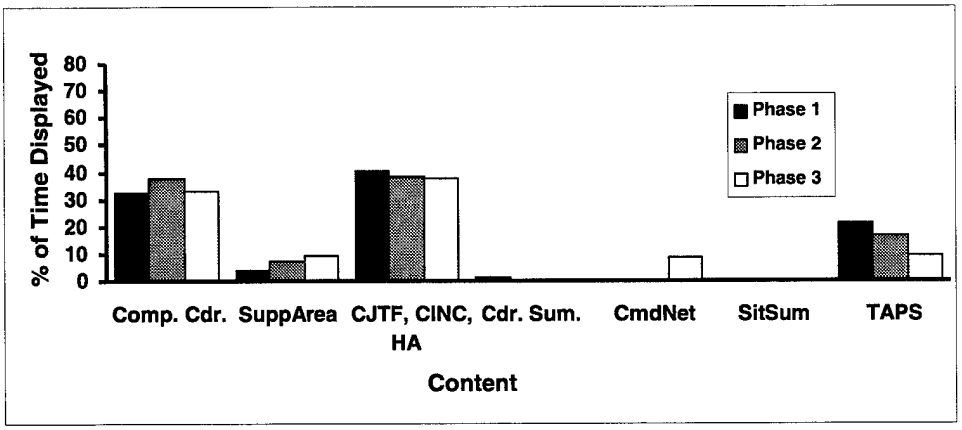

Figure 22. Content of the information displayed on the CINC K-Desk.

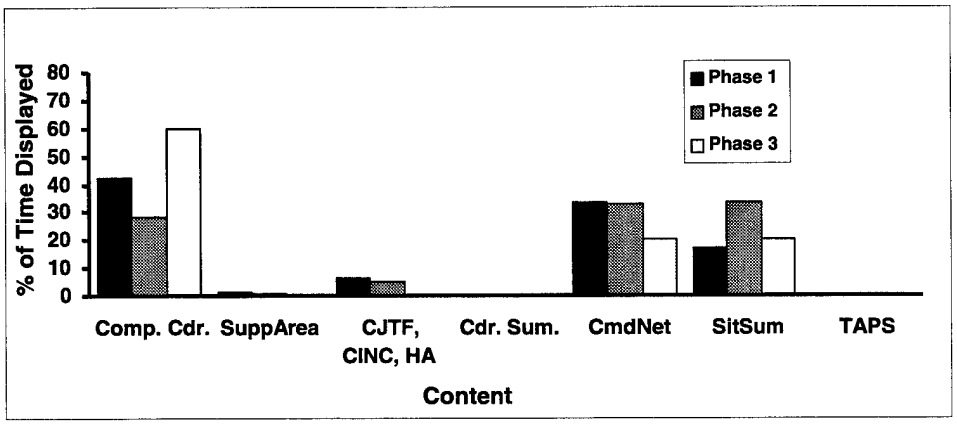

Figure 23. Content of the information displayed on the FCC K-Desk.

3.3.2. Knowledge Wall/Desk Use

Differences in the format and content across the K-Wall and K-Desks provided evidence that different users and organizational cells used the KWVs in diverse ways. Observed behaviors and comments made by users of the JCC K-Wall indicated that the CJTF staff used the information displayed to maintain SA and to stay apprised of the concerns and intentions of the FCCs, the CINC, and HA, and, especially, the Supplemental Areas. The K-Wall was also used to maintain and display the CJTF watch log (in *CommandNet*), as well as for the morning and afternoon CJTF briefings, and for smaller, event-related briefs throughout each day.

In addition to using K-Desks for maintaining SA, the FCCs also used K-Desks to create and edit information products (Summary Pages, *MS Office* documents), to collaborate with others (via e-mail and chat), and to maintain watch logs. The frequency and sophistication of K-Desk use varied across organizational cells, ranging from continuous to occasional, and simple to complex usage patterns. For example, the K-Desk users in one FCC typically displayed an Overview Page and a couple of Summary Pages on Windows 1 through 3 for the majority of the game, but they did not drill down or navigate through the K-Web. Another FCC continuously changed the Summary Pages being viewed and navigated links for further information. In several FCCs, one or more of the K-Desk displays

were projected onto a large-screen display (at the front of the room) so that information on those windows could be shared and viewed by all information consumers in that FCC.

The log files provided some insight as to how the KWVs were being used at different points in the game. These data were analyzed to determine if there was a change in activity level during the 20 minutes prior to, and 30 minutes following each critical event.[11] Activity was defined as any mouse action by the user (e.g. right or left click) from a KWV. Figure 24 represents the activity (across the CINC, CJTF, and FCC KWVs) surrounding critical events, as a function of the level of criticality. The results show that the activity before critical events was varied, depending on the level of criticality, with the least critical events having the most activity and the most critical events having the least activity. This is difficult to interpret, but may be due to differences in the content of the K-Web prior to critical events. User activity after the critical events was virtually the same for all levels of criticality and consistently showed a decrease in activity following a critical event. This decrease may be attributed to users focusing on, and carefully considering, information associated with the critical event that occurred rather than continuing to gather information from sources unrelated to the event.

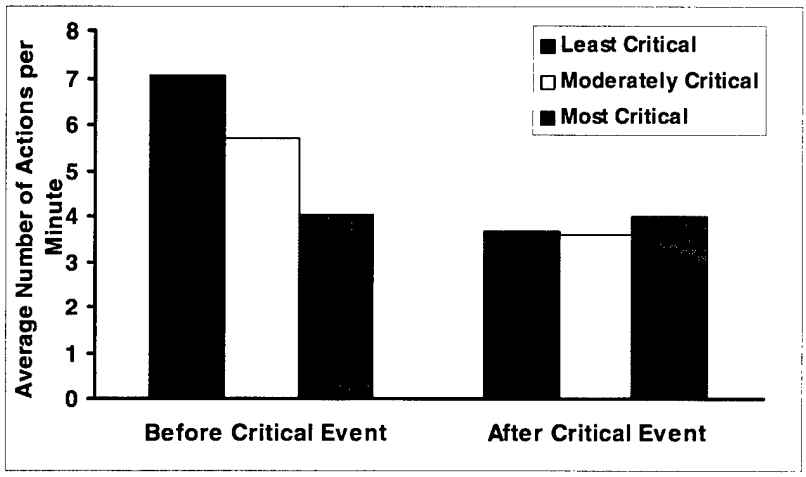

Figure 24. The activity (across the CINC, CJTF and FCC KWVs) surrounding critical events, as a function of the level of criticality.

Comments related to KWV use are as follows:

K-Wall Use

- *People in the JCC completely relied on the K-Wall.*
- *...we can put whatever we want up there...The BWCs are on that part of it...it's good for situation awareness.*
- *In the JCC, other than the Knowledge Wall, there was no management of information.*
- BW1 announces "[SuppArea1] update" or details of change whenever [SuppArea1] has new information ....

[11] Several critical events occurred very early in the day, making it difficult to capture much more than 20 minutes of activity prior to the event. Because information consumers are not all immediately aware of a critical event and because it may take time for information producers to publish new information, it was decided to capture at least 30 minutes of activity after an event to detect differences in activity levels.

- [Three CJTF staff] are discussing information on K-Wall.
- All staff looking at K-Wall...working on the brief.

K-Desk Use

- *The Knowledge Warrior [a participant in the Game] maintained the K-Wall/K-Desk and this was different, inconsistent across different cells.*
- *In [FCC2], we've projected two screens from each K-Desk onto the large-screen display. In [FCC3], two screens from K-Desk are on large-screen display.*
- *[FCC2] uses K-Desk to get SA from other Summary Pages, for the KM to keep track of other pages and to update their own Summary Page and documents.*
- *The commander didn't look at the K-Desk because he was always in chat rooms.*
- *We used the [K-Desk] on watch a lot....*
- *In some cells they had useful info on shared displays...others didn't work so well.*

3.3.3. Knowledge Wall/Desk Preference

Comments made by K-Wall and K-Desk users suggested that they liked the KWVs, particularly with regard to the flexibility the KWVs provided in configuring multiple sources of information. As might be expected, based on the difference in how they used the KWVs, the degree of preference for the K-Wall/K-Desk varied across users and across organizational cells. This is also reflected in the difference in the usage patterns of the K-Desks when comparing across the FCCs, as discussed above. Related comments were:

- *The K-Wall has been really good ....*
- *I like the capability to put any window where you want it.*
- *I like the K-Wall (K-Web?) approach because it uses HTML - shared files.*
- *Excellent tool!*
- *We need this [touch screen capability] on the ship for the admirals brief.*
- *I think the only thing I like about it [the K-Wall] is the touch screens.*
- *The K-Wall and K-Desk were highest ranking tools in the FCC2 survey of tools.*
- *...I liked K-Desk set up, ability to view multiple images.*

3.4. REVISED KNOWLEDGE WALL VIEWER HARDWARE CONFIGURATION

3.4.1. Number of Monitors

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
SumMaker	Update Rate	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

The K-Wall implemented at Global 2000 consisted of 12 display surfaces (ten 21-inch monitors and two 58.25-inch large-screen focus displays), allowing the simultaneous display of information from multiple sources to multiple users. However, both user comments and an assessment of the visibility of the information on the K-Wall suggested users found it very difficult to read the information on the small monitors. The design of the shared K-Wall for Global 2001 was changed so that information was presented on three 58.25-inch displays. The K-Desks that were used in the FCCs were composed of six 15-inch displays.

Legibility

K-Wall and K-Desk users made very few comments about difficulty in reading the displayed information. However, information providers did occasionally publish Summary Pages with links to documents that were difficult to read (see the Business Rules/Training section for further discussion of this problem). The most commonly observed comments were about legibility problems related to occlusion of the K-Wall by other game players. The following are examples:

- *Can I move the Select Monitor window to another screen? [because people are standing in front of it].*
- *As soon as we can get a clear view of the screen, we'll pull it up.*
- *The K-Desk needs to be big enough for other people to see it.*
- *It's hard to read that [MS Word document].*
- *It's hard to see that button text (on Viewer) has changed to blue from a distance...maybe change to red or some other color.*
- *Can I send them an e-mail complaining about their [link] ... It's hard to read it.*

To assess the difficulty in viewing information on the Overview Page and on the Summary Pages on K-Wall, a "visibility test" using these formats was conducted. Three observers with normal vision (unaided or corrected to 20/20) were presented an Overview Page (on Window 1 of the K-Wall) and Summary Pages (on Windows 2 and 3 of the K-Wall) that had been populated with random text. Arial font was used for all but one group of text characters (where Times New Roman was used). Both font types were bolded. Several font sizes (18, 20, 24, and 38 point) were used in order to detect any size-dependent variations in visibility. Example stimuli are shown in Figure 25. Viewers were asked to identify all of the text characters displayed, as well as the color and shape of any status indicators. Accuracy was measured when the observers were seated at each of four positions on the JCC command table (positions A–D, see Figure 25).

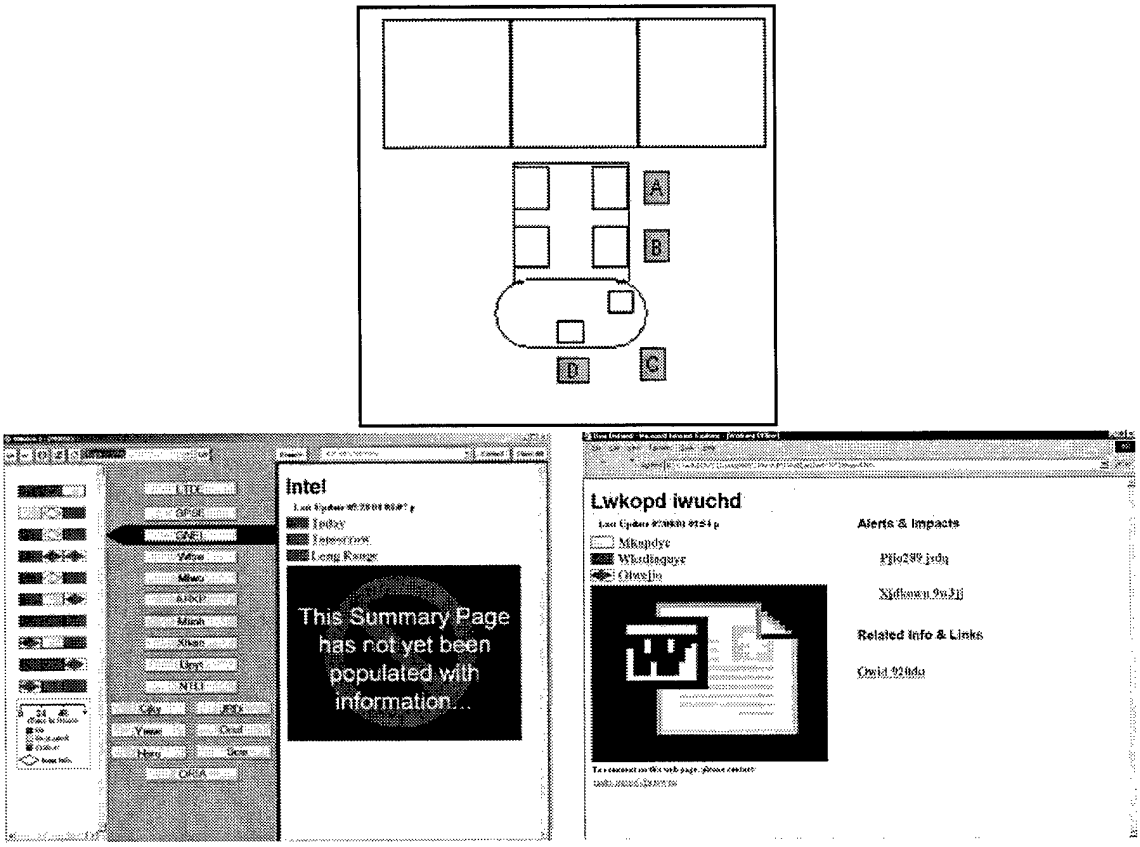

Figure 25. Sample Overview Page (left) and Summary Page (right) stimuli used in the visibility test. The top pane indicates the positions at which participants were seated during the visibility test.

Identification accuracy was very high—in most cases perfect. The lowest average identification accuracy was for the text of the e-mail address on the Summary Pages, where viewers were still 97% accurate on average. The mean percent correct for text and shape identification on the Overview Page and Summary Pages at the four command table positions are shown in Table 3. The mean percent correct for identifying each text and shape displayed on the Overview Page and the Summary Page, across all four command table positions, is shown in Table 4.

Table 3. Mean percent correct for identification of characters on the visibility test stimuli when seated at the four command table positions.

Position	Distance (inches)			Angle (degrees)			Percent Identified		
							Overview Window 1	Summary Page Window 2	Summary Page Window 3
	W1	W2	W3	W1	W2	W3			
A	115	80	67	40	58	95	99.6	100.0	100.0
B	131	105	97	50	68	95	100.0	99.9	100.0
C	179	162	157	60	80	96	98.9	99.8	99.8
D	172	161	165	74	94	105	98.9	99.9	99.7

Table 4. Mean percent correct for identification of characters on visibility test stimuli for the different Overview Page and Summary Page text sizes.

Overview Page		
Text/Object	Font Size	% Identified
Button Text	Bold Arial, 20 pt	98.6
Status Shape		100
Selected Area		100

Summary Page			
Text/Object	Font Size	% Identified	
		Window 2	Window 3
Title	Bold, Arial, 38 pt	100.0	100.0
Last Update	Bold, Arial, 18 pt	100.0	100.0
Status Text	Bold, Arial, 24 pt	100.0	100.0
Status Shape		100.0	100.0
Status Color		100.0	100.0
Alert Text	Bold, Arial, 24 pt	100.0	100.0
Alert Shape		100.0	100.0
Alert Color		100.0	100.0
Rel. Info Text	Bold, Arial, 24 pt	100.0	100.0
E-Mail	Bold, Times NR, 24 pt	97.5	96.3

Tradeoff Between Visibility and Amount of Information Displayed

The tradeoff for increased information visibility is a decrease in the amount of information that can be displayed. Comments related to the number of displays on the K-Wall suggested that the K-Wall users thought that there was not enough screen real estate to display all the information that they wanted to see. This problem was magnified by the fact that an entire window of the K-Wall (Window 1) was dedicated to the Overview Page so that, in effect, K-Wall users only had two windows on which to display additional information. Many K-Wall, and some K-Desk, users expressed dissatisfaction with the fact that the Overview Page always took up an entire monitor. Related comments included:

K-Wall/Desk

- *There aren't enough screens to show everything (looking at PowerPoint brief from [FCC2])*
- *Three screens aren't enough...probably need four or five...three might be enough if you could use the first one. They want Ops up here, Intel on there, they want the logs....*
- *I liked the K-Desk set up, ability to view multiple images.*

Overview Page

- *This stuff [on W1] isn't useful because it takes one-third of the K-Wall.... don't need the key down in the corner. Better to have tabs at top of screen showing status for each area, that you could click to get that area. You could fit up to 14. You wouldn't need to right click to move into another window.*
- *I usually had just one window open...the Overview screen took up too much space.*
- *I like the Overview, but it only lets you see half of a page.*

3.5. REVISED SUMMAKER SOFTWARE

Most of the data related to the usability of the *SumMaker* software and to the new/revised features came from interviews conducted with nine information providers at the end of the game. Comments are divided into (1) those relating to the usability of the software, and (2) opinions and suggestions related to its features.

In general, information providers indicated that they found the *SumMaker* software very easy to use and that using it required little or no training (10 comments). This was in spite of the fact that many of them had no previous experience creating Web pages (two comments). They also noted that the interface of the software was simple and intuitive (two comments).

One usability problem was associated with transitioning between the Summary Page interface and the Miscellaneous Link interface (two comments). Switching between the two interfaces requires the click of a single button; however, this button is located in a different position on each interface. Users also noted difficulties associated with moving linked information (i.e., source documents) to the appropriate folder on the K-Web server. Users suggested streamlining the steps involved in publishing and saving the Summary Pages (three comments). A final problem, that was in part an artifact of the game, was the need to manually include "game time" on the Summary Page every time it is published (three comments). Typically, the *SumMaker* software automatically includes the time from the information producer's computer clock. However, since the system time on the computers used at Global 2001 did not correspond to game time, users had to add game time manually. *SumMaker* users expressed frustration in needing to do this.

The information providers indicated that they believed *SumMaker* to be a good and useful program that met their needs (five comments). They liked the template approach, which standardized their input (three comments), although one user indicated that he was dissatisfied with the lack of flexibility in changing the layout of the Summary Page. They also liked the ability to use *MS Office* products and to link to products already created for other purposes (four comments). Information providers also expressed a preference for the ability to drag and drop information into the fields of the interface (two comments).

Several features were suggested by the information providers that may reflect new user requirements. Many of them indicated a need to archive old information (Summary Pages, linked documents) (five comments). One user suggested that a phone book be provided with the software and another suggested that *SumMaker* be linked to collaboration systems. (See also discussion of Feedback to Information Providers, next section). Comments about the usability and features of the *SumMaker* software included:

SumMaker Usability

- *It made it easy to produce Web pages with minimal training.*
- *I wish [other tools] were as obvious...wish it were all this easy.*
- *...I never published a Web page before I got here.*
- *It had a clean Interface...simple and intuitive.*
- *The transition between SumMaker and Miscellaneous Links interface was not obvious.*
- *It was confusing that you had to copy files into a separate directory—this step should be taken away from the user.*

- *It would have been nice if the computer clock had been set to game time. It wasn't that easy to add the time....Nice feature to have the time stamp though.*

SumMaker Features and New Requirements

- *It was a useful way to present information from [SuppArea2].*
- *Nice to have a template, to be able to keep updating....*
- *It supported MS Office products and file formats.*
- *There was a loss of flexibility (because of the same reasons that make it sailor-proof).*
- *I liked the fact that you could drag-and-drop information into SumMaker.*
- *Users need the ability to archive old information.*
- *A phone book feature on Summary Pages would be nice (mouse over for details about person, hyperlinks to each).*
- *You might want a link to another collaboration system (e.g., whiteboard).*

3.5.1. Increased Link capacity

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
SumMaker	Update Date	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

The *SumMaker* software allowed information producers to easily link products to the Summary Pages they created. The revised *SumMaker* software allowed for up 15 links (i.e., one in each of the three status areas, a graphic, seven Alerts and Impacts, and four Related Information links). Information producers were encouraged to link to "existing" information (e.g., products found in *WIGS* and products that had been created for other purposes by the information producer) and to cross-reference information from other organizational cells in the K-Web. Figure 26 shows the average number of links that were included on Summary Pages. On average, information producers included 8.9 links (5.8, 10.9, and 10.0 links per page for Phases 1, 2, and 3, respectively).

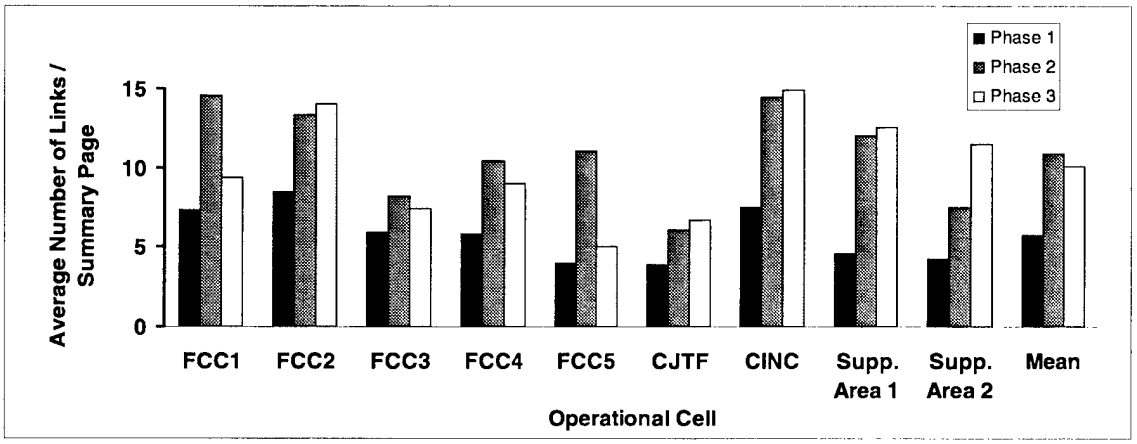

Figure 26. The number of links included on the Summary Pages.

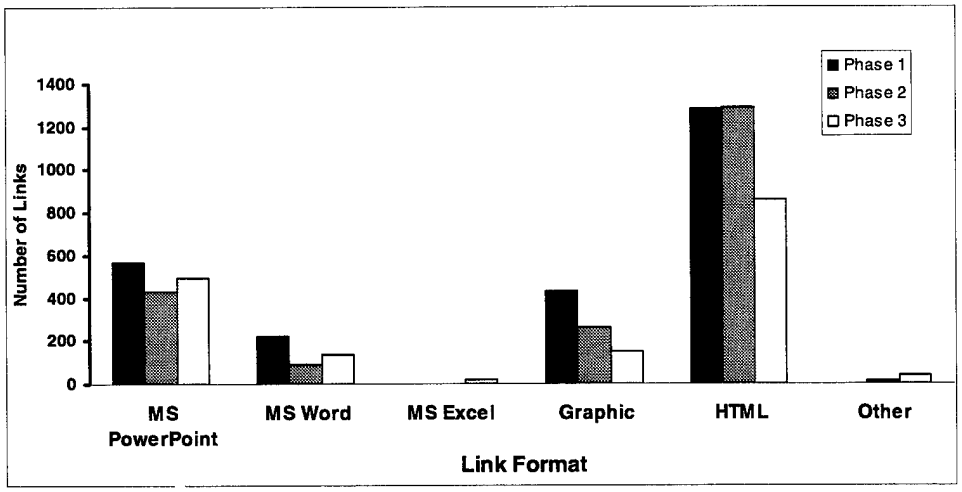

Figure 27. The format of information linked to the Summary Pages.

Figure 27 shows the format of the information linked to the Summary Page. Links were most commonly in HTML format, although information producers frequently included *MS PowerPoint* documents and graphics as links.

Recorded comments also suggest that many information producers took advantage of the information posted by other information providers to the K-Web, to update their own Summary Pages and other products. These comments included:

- The BWC is telling others how their information will be a link from the CJTF Summary Page.
- [FCC1] indicates that their information for evening brief is in a link from their Summary Page.
- *[FCC2] uses K-Desk to get SA from other Summary Pages, for the KM to keep track of other pages and to update their own Summary Page and documents.*
- *The CINC [Summary Page] has a link to ROEs, can you put it on our Summary Page?*
- The CINC page has a link to [SuppArea1] links.

3.5.2. Feedback to Information Providers

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
SumMaker	Update Rate	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

Comments made by information providers using the previous version of the *SumMaker* software (during Global 2000) indicated that they wanted feedback about the access and use of their information products by others. In an attempt to meet this need, the revised *SumMaker* software allows users to designate one KWV as their primary watchstander, from whom they could receive feedback. When *SumMaker* users published a new Summary Page, the time that it was posted to the K-Web was indicated on the *SumMaker* interface. When the designated primary watchstander accessed the Summary Page (using the *KWV*), the time that the page was viewed was automatically reflected on the interface. Information providers were thus given information about when the K-Wall users had looked at their page and could compare that to the time at which they published it. (Note that this type of

feedback supports the change alerting functionality provided by the Summary Pages, allowing the *SumMaker* users to post change diamonds based on knowledge of whether and when K-Wall users had viewed their Summary Page.)

Comments made by information providers (and other game players) indicated that many of them did not believe they were receiving adequate feedback about the use of their Summary Pages. Some of these comments suggest that *SumMaker* users were not aware of the automatic feedback provided by the software. *SumMaker* and Summary Page user comments were:

Feedback related to Summary Page access

- *You need to have feedback that people are using your information.*
- *I don't know what the CINC is getting from us [the CJTF staff]—I know it's on our page but I don't know that the CINC is looking at it.*
- *You need information about who's viewed your information (specifically who) so you can talk to the person about it—even if in the form of e-mail.*

3.6. REVISED KNOWLEDGE WEB VIEWER SOFTWARE DESIGN

3.6.1. Revised Overview Page

The revised *KWV* software implemented at Global 2001 featured a dedicated Overview Page on Window 1, which facilitated attention management and information integration. The revised Overview Page design is described in Section 1.2.4 above. Specific features of this page include:

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
SumMaker	Update Rate	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

- Easy access to Summary Pages.
- Overall status of all areas over time.
- Indications of new or changed status information.

Data related to each of these features are discussed separately.

Easy access to Summary Pages. Each button on the Overview Page allowed users to quickly and easily display information about an operational cell. When users selected a button with their mouse, a portion of the selected Summary Page was displayed on the right side of the Overview Page. If users wanted to drill down for further information, they could display the entire Summary Page on one of the other *KWV* windows by right-clicking on the button. This brought up a "select Window" control, which allowed them to move an entire Summary Page to the window of their choice within the *KWV* software.

K-Wall and K-Desk users frequently right-clicked on buttons to move Summary Pages from the Overview Page window to other windows of the K-Wall or K-Desk. Figure 28 indicates that the CJTF K-Wall users, especially, used the left and right mouse buttons to take advantage of this capability. (Other means of moving/manipulating information using the *KWV* software will be discussed in Section 3.6.2 Revised *KWV* Software: Usability.)

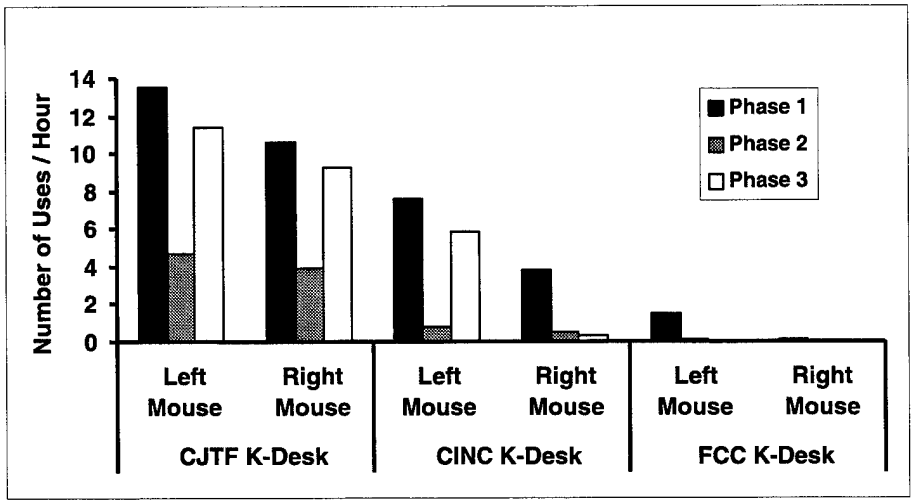

Figure 28. KWV operations on the Overview Page to display Summary Pages (left mouse click) and move them to windows on the K-Wall and K-Desks (right mouse click).

Overall Status of all Areas Over Time and New or Changed Information

K-Web Tool	Tool Feature	New or Revised	User Requirement
Summary Pages	Change Diamonds	N	Cognitive Support
	Combined Alerts & Impacts	R	Cognitive Support
	Producer E-mail Address	N	Collaboration
KWV Hardware	K-Wall Reconfiguration	R	Shared SA/Visibility
	K-Desk Configuration	N	Integrated Info
SumMaker	Update Rate	N	Info Age/Reliability
	Additional Links	R	Integrated Info
	Viewer Timestamp	N	Collaboration
KWV Software	Overview Status Bar	R	Integrated Info
	Overview Change Diamonds	N	Cognitive Support

Using colored rectangles (for existing/known information) and diamonds (for new or changed information), the status bar on the Overview Page shows the predicted status of each functional area over three time periods: Today (the next 24 hours), Tomorrow (24 to 48 hours), Long-Range (beyond 48 hours. This design allows KWV users to easily integrate information from these areas "at a glance," allowing rapid appraisal of (1) the predicted status over time for all of the operational cells and, (2) whether the reported status information represents new or changed information. Further, the color of text on the buttons of the Overview Page changed from black to blue whenever the Summary Page corresponding to that button had been updated. (This change only occurred on a given KWV for those operational areas that had selected that KWV as their "primary watchstander." During Global 2001, all of the FCCs and the supplemental areas connected to the CJTF K-Wall as their primary watchstander. The CJTF information provider connected to the CINC K-Desk.)

Surprisingly, no comments were made related to the status indicators. However, some CJTF K-Wall users did periodically discuss the status of operational cells in terms of, for example, "things turning yellow" (i.e., from green, indicating a deterioration in status). This suggests that these users were gaining status information from the Overview Page.

One indication that KWV users took advantage of integrated status information would be whether they were more likely to access Summary Pages from operational cells that indicated that their predicted status was degraded (i.e., a change from green to yellow, green to red, or yellow to red). Analysis of the CJTF *KWV* log (which indicates access times) and the automatically captured *SumMaker* data files (which indicate update times) indicated that this was the case, at least for the CJTF K-Wall. As can be seen in Figure 29, Summary Pages that indicated deterioration in status were reflected on the Overview Page and were accessed more quickly overall (17 minutes after they were

published) than those that indicated improved or unchanged status (36 and 35 minutes after being published, respectively).

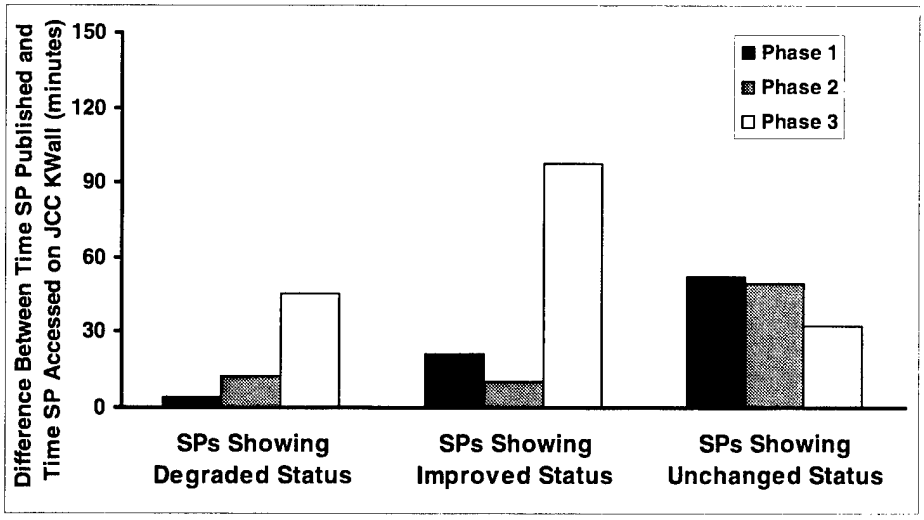

Figure 29. Access time (by the CJTF *KWV*) for Summary Pages as a function of type of change in status over time.

It should be noted that, because *very* few yellow and red status indicators were posted, these results are based on a very small amount of data and should be interpreted with caution. (A total of only seven Summary Pages indicated degraded status and five Summary Pages indicated improved status across all operational cells.)

Figure 30 shows the average number of minutes that it took CJTF K-Wall users to access a Summary Page after it had been published. These data only include the access times for published Summary Pages that produced visual change in the Overview Page when they were posted. Pages that caused no change in the status bar when published were excluded from the analysis.[12] On average, Summary Pages were accessed 30 minutes after they were published, though access times generally decreased during the course of the game, suggesting that users became more familiar with the use and intent of change diamonds as the game progressed.

[12] For example, an information provider may have published a Summary Page before the CJTF K-Wall users had accessed the last page that they posted. If this new page did not include any new information about status, there would be no indication of it on the K-Wall (the button would already be blue and the status representation would remain the same).

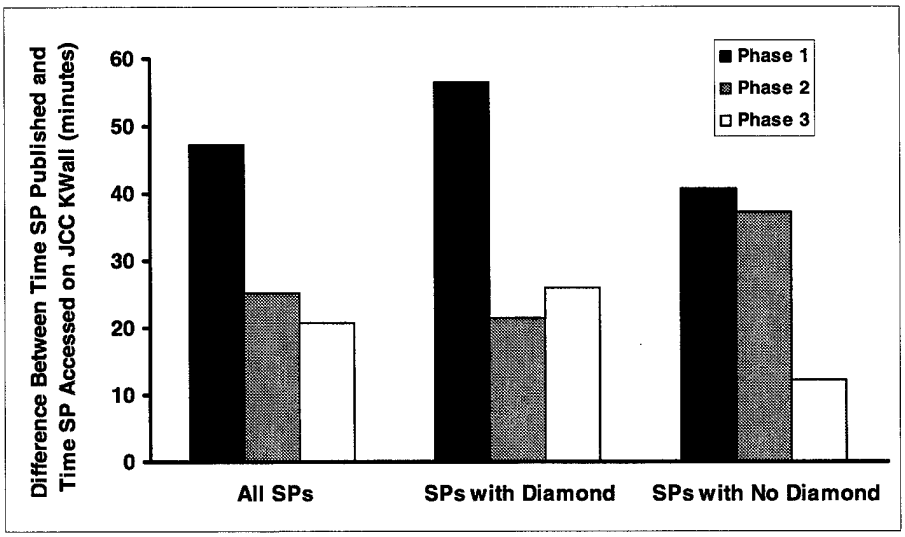

Figure 30. Access time (by the CJTF *KWV*) for Summary Pages as a function of the presence of change diamond.

Figure 30 also shows the difference in access time, relative to when information providers published a Summary Page, as a function of whether or not the Summary Page contained a change diamond. Interestingly, Summary Pages *with* change diamonds were accessed *less* quickly (47 minutes after being published) than those without change diamonds (31 minutes after being published). This surprising fact is difficult to interpret; however, it has been suggested that perhaps users felt more comfortable with areas that they knew were being well managed (as evidenced by change indicators) and therefore did not feel the need to access these areas as quickly or as often as those that showed no activity.

Information providers also made several suggestions related to the current *KWV* and K-Web change alerting functionality, indicating a need for more effective change alerting. Many of these comments reflect the fact that K-Wall users did not find the change in button text from black to blue to be a salient indicator of recently published information. They also expressed dissatisfaction with the inconsistent use of change diamonds by information providers on the Summary Pages. In particular, they indicated that more information about changes should be indicated on the K-Wall (such as when change diamonds were included in the Alerts and Impacts section of a Summary Page) or on the Summary Pages themselves (such as when new information is available on a link from that page). Sample comments were:

- *Things are turning blue, telling me that there are changes so I'm going to check them.*
- *[SuppArea1] IP verbally notifies BW1 and shows him his page It's faster than blue text on viewer.*
- *They have blue stuff (new hyper links on the Summary Page) but no change diamonds.*
- *You need something that pulses for ~20 seconds when something changes to a diamond ...need to know that information has changed. Blue text is not an "alert"—need something more salient.*
- *I wish they had status for Alerts & Impacts on K-Wall...we changed Today, Tomorrow, LR status once a day but changed Alerts more often.*

- *It should indicate on Summary Page when you've updated a linked document, e.g., change the Today link to a diamond.*
- *It was easy to just make changes to files...without having to republish everything.*
- *You can post things on the Web all day long but you need to push information...can't assume people will pull off Web.*

General comments related to the Summary Page included:

- *...it's easy to use.*
- *The Overview Page/K-Web could almost do away with voice communications.*
- *The WIGS Web page* (an overview page on WIGS) *was not intuitive because it didn't match the Overview Page on the KWV.*

3.6.2. Revised Knowledge Web Viewer Software: Usability

The revised *KWV* software provided several functions that allowed users to configure KWV content, update information, and run other software tools. The Overview Page allowed users to easily bring up Summary Pages and move them to other windows (see section 3.6.1 Revised Overview Page). The menu bar on each window included controls common to Web browsers (see Figure 31). A control menu (see Figure 32), accessible from each window, allowed users to hide or show underlying applications (e.g., *MS PowerPoint*, tactical displays, *SumMaker*,) and gave users access to two preset configurations (Preset 1, in which only Windows 1 through 3 were shown, and a default setting, in which all six windows were shown).

Figure 31. The *KWV* software menu bar.

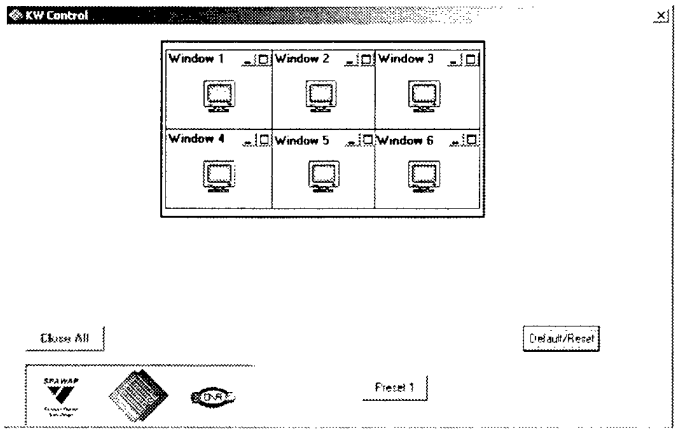

Figure 32. *KWV* control menu.

Analysis of the *KWV* data logs indicated that users took advantage of these capabilities differently in each of the operational cells. Figure 33, Figure 34, and Figure 35 show how often operators of the CJTF K-Wall, the CINC K-Desk and FCC K-Desks, respectively, used the various *KWV* functions. CJTF K-Wall users frequently reconfigured the display using the left and right mouse click operations on the Overview Page. Users of the CINC K-Desk were more likely to move information into *KWV* windows via the Channels menu (a pull-down list that provided access to the operational cell

Summary Pages, as well as to *WIGS*), and they regularly used the Refresh command. The FCC K-Desk operators were equally likely to access information using these two methods. They also frequently used the Hide command (via the Control Menu), probably in order to display tactical information and/or the *SumMaker* software on the K-Desks (see Figure 35). Overall, though, the FCC K-Desk operators used the various KWV operations much less often than either the CJTF K-Wall users or the CINC K-Desk users.

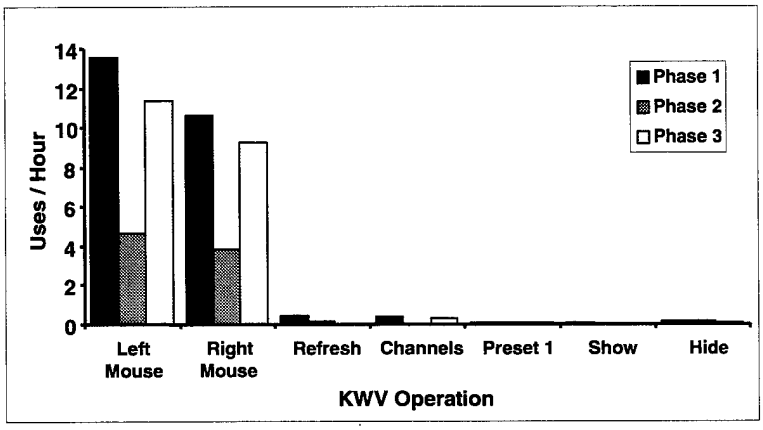

Figure 33. *KWV* software use on the CJTF K-Wall.

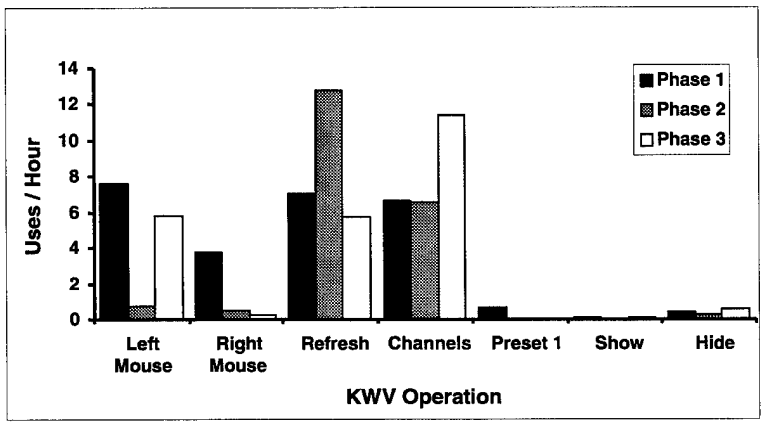

Figure 34. *KWV* software use on the CINC K-Desk.

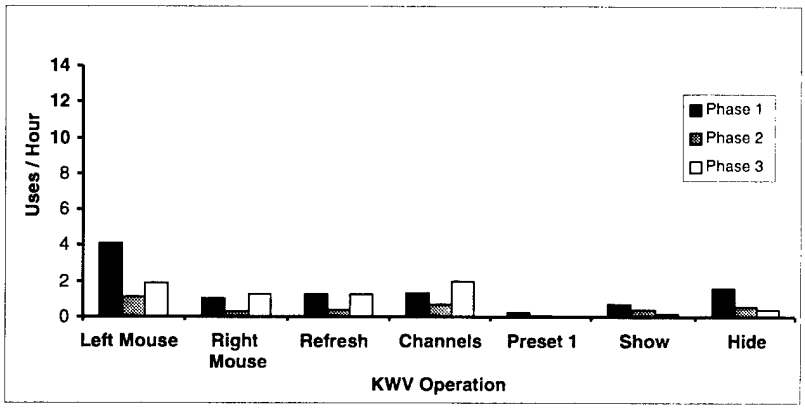

Figure 35. *KWV* software use on the FCC K-Desk.

Most *KWV* operator comments suggested they liked the software, especially the ease with which it allowed them to move information around. One user of the K-Wall expressed dissatisfaction with the method of moving information into another window via right-clicking a button on the Overview Page. One problem expressed by many users was the inability to predict in which window of the *KWV* dialogue boxes would appear (i.e., not necessarily the "expected" window, or the one in which the user was working). This problem was not caused by the *KWV* software *per se*, but was due to the way that *MS Windows* handles multiple monitors. The comments related to *KWV* usability issues were:

- *It was easy to display information on the K-Wall.*
- *The K-Wall helped us...BWC was comfortable using it....*
- *I wish there was an easier way to put stuff on windows other than right-clicking.*
- *Problem that you didn't know where a window would pop up.*
- Some confusion arose on the K-Wall when more than one person attempted to operate the KWV simultaneously (K-Wall KWV control could be implemented via two sets of mouse and keyboard controls or the touch screens).
- *Problems when we wanted to run a PowerPoint slide show...when we clicked on another window, slides advanced (because it's a single desktop)...you should be able to keep functions running in the background.*

3.7. OTHER EMERGING THEMES

3.7.1. Training and Business Rules

The training documents provided to K-Web tool users were described in the Training and Business Process section of the Introduction (Section 1.3.3). Information providers and users of the KWVs were given individual training on the K-Web tools they would be using during the game. Training was conducted by K-Web designers prior to, or during, the game as the schedule and events allowed. Training typically involved reviewing the K-Web business rules brief and appropriate operator instructions. These presentations were immediately followed by one-on-one tutoring in the use of K-Web tools. Unfortunately, training was sometimes not given until the second or third day of the game because some users' roles were not identified until then. Further, K-Web training was not given

to all game players, even though they would potentially use the K-Web products (i.e., Summary Pages and their links). Rather, K-Web training was only given to identified information providers and KWV operators.

Users who *did* have contact with K-Web training materials believed them to be very useful. However, much of the data in the results section points to a lack of understanding of (or lack of adherence to) the K-Web business rules. Specifically, this includes, but is not limited to:

- insufficient knowledge about the availability of feedback between information providers and consumers;
- inconsistent use/overuse/under use of content features (e.g., the status indicator shapes and colors) on the Summary Pages;
- indiscriminate access of information products by consumers; and
- variability in use of the K-Web tools across the operational cells.

Many other observations and recorded comments further suggest a lack of understanding, by many players, of the K-Web concept and business rules. The following are examples:

Training

- *The training documents were fairly intuitive...didn't have problems figuring things out.*
- *It would have been nice if the WIGS training had let people know the Summary Pages were there.*

K-Web Concept

- *How do we know that the Component Commanders know what's going on?*
- *Does the CINC have access to the same information as we do?*
- *We need help/advice about how to take advantage of the wall.*
- *The system assumed people knew where to go for information.*
- *There should have been business rules about how to share information....*
- *Fusing, focusing, displaying information is different at different levels.*

Specific K-Web Business Rules

- *We've fought the war today exactly the way we weren't supposed to....with PowerPoint.*
- *They used diamonds in Alerts and Impacts but not in the Today, Tomorrow, Long-Range area.*
- *There has been a lot of debate regarding content: Where [on information products] should information be red—[i.e,. if not in status over time].*
- *I didn't feel like ROE for use of the system was established, e.g., when to use a green diamond vs. a square, how long a diamond should be up....*
- *The Admiral did not know what the colors meant.... You need some sort of key to the symbology....*

4. GENERAL DISCUSSION

Based on the K-Web use evaluation from Global 2000, several K-Web tool design changes were implemented at Global 2001. The primary focus of this discussion is the evaluation of the revised K-Web design features in relation to the user needs identified during the Global 2000 games. Specifically, data analyses of observational and automatically collected data lent to the assessment of whether:

- The K-Web information products, and the KWVs and the support tools, supported other previously identified user requirements.
- The revised features of the K-Web information products, and the KWVs and K-Web support tools, met the information integration, cognitive support, and collaboration needs identified by the previous Global 2000 use evaluation.
- There were user needs not being met by the current K-Web products and tools.
- There were ergonomic problems related to the K-Web products and tools.
- Users preferred the K-Web products and tools to other information tools.

The following discussion summarizes the results described above and when possible, within the context of a comparison to the Global 2000 findings.

4.1. SUMMARY PAGES

Summary Pages were continuously updated and accessed throughout each phase of the Global 2001 war game. As a result, Summary Pages and their links composed K-Desks and K-Wall content the majority of time during Global 2001. Data were not collected by the *SumMaker* software during the Global 2000 game; therefore, the content of the Summary Pages and their links cannot be compared across Global 2000 and 2001. Observational data, however, do allow some comparison of the use of and preference for Summary Pages. Comments and observations made during both war games suggest that the players found the Summary Pages to be very useful for tracking the operational situation and staying apprised of other players'/cells' activities and concerns. Overall, the revised standardized Summary Page format was considered easy to use and successful in terms of meeting the needs of both information providers and consumers.

During Global 2000, information providers and consumers stated a need for a means of alerting other users to important changes in Summary Pages and their links. The revised Summary Page design developed for the Global 2001 game addressed this need with the change alerting functionality (change diamonds) on the Summary Pages and the *KWV* Overview Page. Information providers took advantage of this functionality during Global 2001 by including change diamonds in a high proportion of Summary Pages. The excessive use of change alerts, however, could be problematic; when change alerts are always present, users tend to ignore them (Mayhew, 1992). The use of change diamonds only when there has been an actual change in status should yield even stronger support for this tool.

Improved training regarding business rules should lead to more appropriate use of change diamonds in Summary Pages. Attention research literature points to the fact that it is very difficult for people to keep track of changes, especially when they are interrupted or switching between tasks (e.g., Rensink, O'Regan, & Clark, 2000). Changes in a busy, multi-task environment, such as a

military command center, must be *salient and meaningful* enough to be detected. Adequate training is necessary to provide users with a relevant "attentional set" for the indicators of important change (Folk, Remington, & Johnston, 1992). Other attention management and change detection issues that need to be examined in the context of K-Web information products include:

- How to represent *when* the change indicator was added to the Summary Page (in real time and/or relative to other posted changes).
- How to determine which Summary Page users will find changes/alerts regarding changes most relevant (to allow tailoring of change alerting to users).
- How to automate change alerting.

The Global 2001 Summary Page design included the information producer's e-mail address so that users viewing the Summary Page could send feedback regarding page content. Many information consumers were observed providing feedback to the producers in the form of e-mail or other communications. However, information producers expressed dissatisfaction in the amount of feedback that they received about the content of their information products, suggesting that a better mechanism or tool for providing content-related feedback should be included in future Summary Page designs.

4.2. KNOWLEDGE WALL/DESKS

4.2.1. Knowledge Wall/Desks Use

Observations made during the Global 2001 and 2000 games (see Appendix B) pointed to differences in K-Wall use by the different CJTF staffs. One of the most significant differences was the increased role that the K-Wall played as a briefing tool at Global 2001.

A noteworthy finding from the Global 2000 evaluation was the impact that the K-Wall had on eliminating the need for a traditional 8-hour briefing cycle. That K-Wall was used as a means of visualizing mission-status in a *continuous* fashion, through the display of K-Web Summary Pages and other information products. Its users required only occasional, impromptu briefs, which occurred as the operational situation demanded; these briefs were typically conducted via the display of existing K-Web products. Users emphasized how the radical change in briefing process and purpose effectively changed and improved their overall Concept of Operations.

The Global 2001 K-Wall, in contrast, was used less as an SA tool than the previous year, and more as a briefing tool. The K-Wall was used to brief the CJTF staff daily and to prepare the CJTF's daily brief to the CINC. Most content for the briefs consisted of *PowerPoint* slides created expressly for this purpose.

K-Wall data collected at each game also facilitates a comparison of K-Wall use across the two war games. Figure 13, which shows the number of Summary Pages accessed on the KWVs, indicates that users of the Global 2000 K-Wall accessed almost 3.5 times as many Summary Pages using the KWV software. This result is to be expected since there were 12 displays on the Global 2000 K-Wall on which to display information (vice three on the 2001 K-Wall). Conversely, the number of links accessed via the KWV software in 2001 was almost double that of 2000. This too is probably attributable to the number of display surfaces available.

Screen captures of the two K-Walls (the 2000 vs. the 2001 K-Walls) also indicate a difference in the type/format of information displayed on them. Figure 36 shows the percentage of time that

K-Web products and other information products were displayed on the Focus Monitors (two large central monitors) of the 2000 K-Wall, all 12 monitors of the 2000 K-Wall, and Windows 2 and 3 on the 2001 K-Wall. In addition to the differences in the usage patterns of K-Web products, there were also differences in the amount of time that tactical displays and other software were displayed. Users during Global 2001 never displayed tactical information on the K-Wall, whereas tactical information was a common focus during the previous year. The reason for this is most likely the fact that the tactical software used during Global 2001[13] was run on other shared displays. The screen captures also indicate that the Global 2001 users were more likely to run the *PowerPoint* software on the K-Wall, supporting the observational finding that it was used frequently to prepare and display briefs. Finally, the Global 2001 K-Wall users were more likely to display *WIGS* products on the K-Wall. In particular, the CJTF watch log was frequently displayed and updated on Window 3 of the K-Wall.

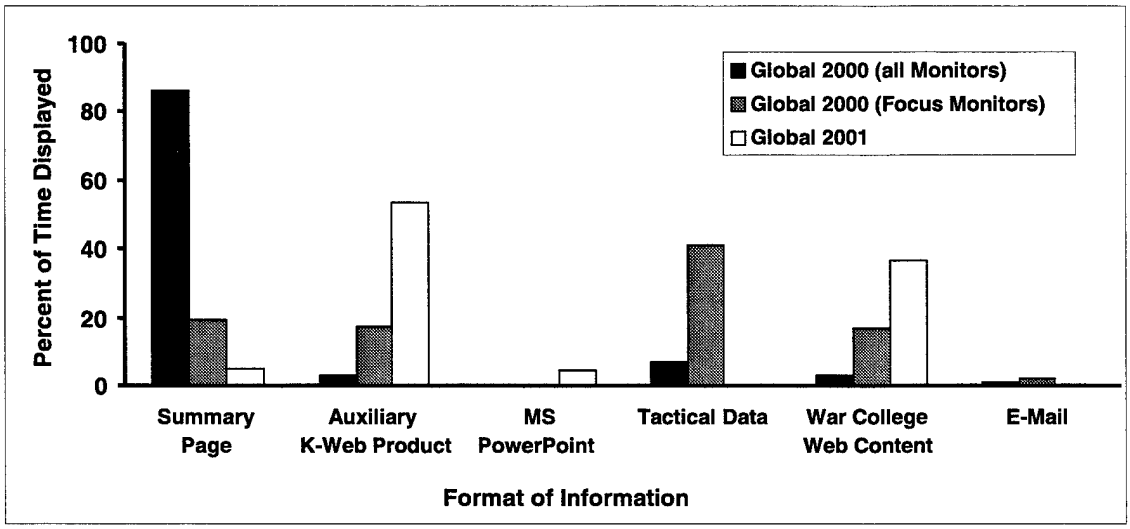

Figure 36. Format of information displayed on the Global 2000 and 2001 K-Walls.

As would be expected, the K-Desks were used differently than the K-Walls, and use of the K-Desks varied across operational cells. One of the intents of K-Desk design was to support both information production and information consumption. The K-Desks were used in both ways during Global 2001; they were used for the maintenance of SA, as well as for the creation and revision of information products and for collaboration with others.

4.2.2. Knowledge Wall/Desks Legibility

The Global 2000 K-Wall evaluation found that users had difficulty reading the information on small peripheral monitors of the K-Wall implemented for that game. In response to this problem, the design of the shared K-Wall at Global 2001 was changed so that it consisted of three large monitors. Visibility assessments taken during both games indicated that identification accuracy of information on the K-Wall improved from an average of ~91% in 2000 to near 100% in 2001. However, this

[13] BattleScape NT (http://www.autometric.com/NEW/Products/Visualization/bs.html) and EDGE Viewer (http://www.autometric.com/NEW/Products/Visualization/viewer.html)

came at the cost of a reduction in the amount of information being displayed—a trade-off that many users found unsatisfactory.

4.2.3. Information Age and Source

Global 2000 users also expressed a need for information about the age and source of information products in the K-Web. This was not addressed in the 2001 Summary Page or *SumMaker* designs. Future K-Web design efforts will attempt to meet these needs.

4.3. THE SUMMAKER SOFTWARE

The *SumMaker* tool proved to be successful at meeting the needs of information providers during both Global 2000 and 2001 war games. Users who had no experience publishing Web pages were able to do so with little or no training. Of course, suggestions for improvements to the *SumMaker* software tool were made during both games. In addition to populating the basic information fields of the Summary Page format, *SumMaker* users exercised their option to link additional information sources to their pages; Summary Page viewers accessed these frequently. In fact, user comments indicated the need to add more links to Summary Pages. With so much information being linked to Summary Pages, the need has developed for better link organization and navigation. User comments also indicated that the standardized format available through *SumMaker* made it easier for information providers to create and update their pages.

Information providers at Global 2000 expressed a need for feedback from information consumers about use of their products. Although, the revised *SumMaker* software provided two methods of feedback (in the forms of an e-mail link, and a visual indication regarding whether the watchstander had viewed the Summary Page), comments made by Global 2001 information providers indicated a desire for additional feedback regarding the use of their products. Some of these comments suggest that *SumMaker* users were not aware of the automatic feedback provided by the software that indicated whether the watchstander had viewed the Summary Page. Even for those who did view such feedback, it was judged to be insufficient in communicating information the consumer needs. This was evidenced by comments from consumers, such as senior staff, indicating that they were not getting the information they needed when they needed it, and from information producers who could not determine whether the information they were providing was useful to the information consumers. These results are due, in part, to the insufficient training of both the information providers and information consumers regarding appropriate Summary Page content and the available feedback tools. However, it also suggests a need for a different mechanism for providing feedback. Timely and relevant feedback can be an important motivating factor in ensuring successful task performance (Pinder, 1998). In the case of K-Web tool use, successful task performance means providing K-Web users an up-to-date and accurate view of the operational situation.

4.4. KNOWLEDGE WALL VIEWER SOFTWARE

The *KWV* operators at both Global 2000 and Global 2001 indicated that they liked the software, especially with regard to the ease with which it allowed them to move information around on the displays. However, problems occurred on both the Global 2000 and 2001 K-Walls when multiple users attempted to control the *KWV* simultaneously using multiple concurrent inputs (multiple mice and keyboards and touch screen input) available on the K-Walls.

The Overview Page provided on the *KWV* included functionality allowing users to easily access the Summary Pages and move them to other windows. Users frequently took advantage of this functionality. The color-coded status bar on the Overview Page was designed to give consumers an integrated view of the operational status (by showing overall status over time for all the operational cells) and whether this status information was new or changed (indicated by change diamonds). The data indicated that users *did* access pages with degraded status more quickly than pages with unchanged or improved status, suggesting that they took advantage of the status information being conveyed on the status bar. However, users did not access Summary Pages indicating a *change* related to status more quickly than those with no change diamonds. This latter result suggests that better change alerting functionality is necessary.

4.5. TACGRAPH

One other notable difference between the Global 2000 and 2001 war games was in the use of *TacGraph*. The *TacGraph* software that emerged as a very popular and useful tool at Global 2000 was used minimally during the 2001 game. Based on observations during the 2001 game, one likely reason for this shift is the use of the tactical software, *Battlescape NT*, which was very strongly encouraged by the NWC staff, to the exclusion of other map-based applications. Poor *TacGraph* utilization may also be attributable to the limited training provided on this tool. Most players were not aware of *TacGraph*'s capabilities or even that it existed for use in the game. Comments made by the few players that used *TacGraph* can be found in Appendix B.

4.6. TRAINING

Many of the differences described above are to be expected given the many factors that varied across the two games. These include organizational variables (differences across the commands that participated in the game and across the organizational structures imposed by the game), differences in the scenarios, and differences in the available information tools. However, the most notable cause of many of the observed differences in K-Web use between the two games was the difference in the amount of training players received on the K-Web tools before and during the game.

For the Global 2000 war game, users of the K-Web tools and products (i.e., senior decision-makers and software tool users) were identified far in advance by CJTF staff and War College personnel. Identified personnel were thoroughly familiarized with the intended Concept of Operations and were given adequate training and extensive practice with the provided K-Web tools. Specifically, most users received approximately 1 to 2 hours of training and hands-on practice before game-play began, after which they received additional one-on-one assistance, as needed during the first few hours of use. Due to a number of factors, the training conducted at Global 2001 was limited and sporadic, at best.

The importance of implementing K-Web training sessions and training tools cannot be emphasized enough. K-Web products and tools are designed to be as user-friendly and intuitive as possible. Nevertheless, both information producers and consumers require training in order to use the K-Web to their greatest advantage. In order to do so, K-Web users need to know what the system capabilities are and how to use them. They also need to be familiar with, and practice/adhere to the business rules. The key to understanding both the technology and the business rules is training. Training can play a critical role in users' motivation to utilize the system. Needs assessment should occur before the training, in order to identify the skill/knowledge levels of the participants, as well as their understanding of the purpose and value of Global war games and related technologies. The more that

K-Web users can make a connection between the capabilities of the system and the requirements of their jobs, the more likely they are to benefit from training and use the system as it was designed to be used (Goldstein, 1993).

5. CONCLUSIONS AND RECOMMENDATIONS

Several design changes were made to the K-Web products and tools based on the Global 2000 use, utility, and usability evaluations. A re-evaluation of the K-Web at the Global 2001 war game provided invaluable insights regarding the effectiveness of these design changes. Overall, the K-Web proved to be quite successful as a knowledge management and SA tool. The redesigned Summary Pages provided users with an easy-to-use, standardized view of information contained in and disseminated via the K-Web. The change alerting functionality provided by the Summary Pages and Overview Page was a good first step in supporting users' attention to management needs. The K-Web display tools (KWVs) and other support tools, such as the *SumMaker* and *KWV* software applications, were also considered highly successful.

In addition to enabling an assessment of newly developed K-Web technologies, the data and observations collected during the Global 2001 war game point to specific areas that can be improved by future K-Web research, development, test, and evaluation efforts:

- Develop mechanisms for improved dissemination of K-Web business rules to support optimal use of the K-Web by information providers and consumers.
- Continue development of cognitive tools to support attention management and change detection, including those that tailor change alerting to meet the needs of different users.
- Research means of providing feedback between information consumers and providers related to both the use and needed content of K-Web information products.
- Develop integrated training to promote a better understanding of K-Web tool capabilities by information producers and consumers.

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APPENDIX A:
DATA COLLECTED AUTOMATICALLY DURING GLOBAL 2001

Table 1. The number of Summary Pages accessed via the *KWV* software on the K-Wall and K-Desks (Figure 10).

Number of Summary Pages Accessed/Hour			
	PHASE1	PHASE2	PHASE3
Average (All Global 2001 KWVs)	27.5	30.0	38.8
CINC K-Desk	50.49	57.47	70.18
FCC K-Desk	22.38	25.73	37.73
CJTF K-Wall	9.51	6.67	8.55
Global 2000 K-Wall	22.3	19.4	43.0

Table 2. The number of links from the Summary Pages accessed via the *KWV* software on the K-Wall and K-Desks (Figure 11).

Number of Summary Pages Accessed/Hour			
	PHASE1	PHASE2	PHASE3
Average (All Global 2001 KWVs)	41.46	25.02	27.18
CINC K-Desk	55.03	56.80	53.00
FCC K-Desk	7.51	6.13	4.45
CJTF K-Wall	61.84	12.13	24.09
Global 2000 K-Wall	11.4	12.3	26.3

Table 3. The number of links included on the Summary Pages (Figure 12).

Average Number of Links/Summary Page			
	PHASE1	PHASE2	PHASE3
FCC1	7.34	14.55	9.39
FCC2	8.48	13.36	14.00
FCC3	5.93	8.25	7.40
FCC4	5.85	10.43	9.00
FCC5	3.93	11.00	5.00
CJTF	3.87	6.13	6.67
CINC	7.49	14.46	14.89
Supp. Area 1	4.57	12.00	12.50
Supp. Area 2	4.24	7.50	11.43
Mean	5.75	10.85	10.03

Table 4. The format of links included on the Summary Pages (Figure 13).

Number of Links			
	PHASE1	PHASE2	PHASE3
MS PowerPoint	568	429	497
MS Word	219	89	136
MS Excel	0	0	19
Graphic	159	119	28
HTML	1283	1287	859
Other	0	15	37

Table 5. The rate at which Summary Pages were published (number of Summary Pages posted per hour of game play) (Figure 14).

Summary Pages Published/Hour			
	PHASE1	PHASE2	PHASE3
FCC1	3.05	2.67	1.64
FCC2	3.37	5.20	2.27
FCC3	0.74	0.53	1.36
FCC4	3.16	1.87	1.36
FCC5	0.79	0.40	0.27
CJTF	2.74	2.13	1.64
CINC	3.53	7.20	3.36
Supp. Area 1	0.74	0.40	0.91
Supp. Area 2	3.47	2.93	1.91
Mean	2.40	2.59	1.64

Table 6. The percentage of Summary Pages that contained one or more change diamonds (Figure 15).

% of Summary Pages With Changes Diamonds Posted			
	PHASE1	PHASE2	PHASE3
FCC1	17.24	55.00	100.00
FCC2	51.56	100.00	100.00
FCC3	57.14	50.00	33.33
FCC4	26.67	14.29	26.67
FCC5	46.67	100.00	100.00
CJTF	32.69	43.75	77.78
CINC	41.79	88.89	89.19
Supp. Area 1	0.00	100.00	70.00
Supp. Area 2	40.91	81.82	100.00
Mean	34.96	70.42	77.44

Table 7. Activity before and after critical events, as a function of level of criticality (Figure 16).

Actions/Minute			
	Least Critical	Moderately Critical	Most Critical
Before	7.05	5.7	4.03
After	3.67	3.6	3.99

Table 8. The format of the information displayed on Windows 2 and 3 of the K-Wall (Figure 18).

% of Time displayed			
	PHASE1	PHASE2	PHASE3
Summary Page	5.04	3.05	6.28
Auxiliary K-Web Product	64.74	44.15	40.39
War College Web Content	26.92	44.40	48.34
MS PowerPoint	3.21	8.27	4.84

Table 9. The format of the information displayed on the CINC K-Desk (Figure 19).

% of Time displayed			
	PHASE1	PHASE2	PHASE3
SP	25.27	21.84	24.37
Aux. KWeb	11.37	16.28	10.50
OvView	9.60	2.87	12.04
NWC Web	13.36	13.60	11.76
MS Off.	4.22	7.28	1.68
Chat/Email	11.06	16.48	16.25
Tact.	0.77	0.00	0.14
SmMkr	15.92	16.67	15.27
TcGrph	5.53	1.31	0.14

Table 10. The format of the information displayed on the FCC K-Desk (Figure 20).

% of Time displayed			
	PHASE1	PHASE2	PHASE3
SP	15.18	12.29	13.99
Aux. KWeb	2.66	2.50	4.46
OvView	12.68	0.00	0.30
NWC Web	21.36	26.88	36.01
MS Off.	15.92	20.54	13.99
Chat/Email	15.02	14.47	18.75
Tact.	7.82	7.08	4.46
SmMkr	7.43	13.13	6.55
TcGrph	3.70	0.63	0.89

Table 11. Content of the information displayed on Windows 2 and 3 the K-Wall (Figure 21).

% of Time displayed			
	PHASE1	PHASE2	PHASE3
Comp. Cdr	5.22	1.76	7.64
SuppArea	41.24	46.88	39.68
CJTF, CINC, HA	10.89	6.98	4.34
CmdNet	42.50	44.39	48.34
SitSum	0.00	0.00	0.00
TAPS	0.15	0.00	0.00

Table 12. Content of the information displayed on the CINC K-Desk (Figure 22).

% of Time displayed			
	PHASE1	PHASE2	PHASE3
Comp. Cdr	32.44	37.62	33.13
SuppArea	3.97	7.47	9.38
CJTF, CINC, HA	40.31	38.25	37.44
Cdr. Sum.	1.11	0.00	0.00
CmdNet	0.00	0.00	8.72
SitSum	0.00	0.00	0.00
TAPS	21.06	16.67	9.37

Table 13. Content of the information displayed on the FCC K-Desk (Figure 23).

% of Time displayed			
	PHASE1	PHASE2	PHASE3
Comp. Cdr	42.05	28.25	60.00
SuppArea	1.24	0.64	0.00
CJTF, CINC, HA	6.02	5.08	0.00
Cdr. Sum.	0.25	0.00	0.00
CmdNet	33.64	32.69	20.00
SitSum	16.80	33.33	20.00
TAPS	0.00	0.00	0.00

Table 14. The percentage of published Summary Pages that contained change diamonds, as a function of level of criticality (Figure 24).

Percent of Published Containing Diamonds	
No Critical Event	21.15
Least Critical	44.00
Moderately Critical	50.94
Most Critical	53.85

Table 15. The use of the KWV operations (left and right mouse clicks) on the Overview Page to display Summary Pages and move them to windows on the K-Wall and K-Desks (Figure 25).

Number of Uses/Hour			
	PHASE1	PHASE2	PHASE3
CJTF K-Desk (left mouse)	13.51	4.69	11.36
CJTK K-Desk (right mouse)	10.59	3.85	9.27
CINC K-Desk (left mouse)	7.62	0.77	5.82
CINC K-Desk (right mouse)	3.78	0.46	0.27
FCC K-Desk (left mouse)	1.46	0.08	0.00
FCC K-Desk (right mouse)	0.05	0.00	0.00

Table 16. Access time (by the CJTF KWV) for Summary Pages as a function of type of change in status over time (Figure 26).

Difference Between Time Summary Page is Published and Time Summary Page is Accessed on JCC K-Wall (minutes)			
	PHASE1	PHASE2	PHASE3
SPs Showing Degraded Status	4.25	12.70	45.43
SPs Showing Improved Status	21.35	10.15	97.48
SPs Showing Unchanged Status	52.47	49.58	32.68

Table 17. Access time (by the CJTF KWV) for Summary Pages as a function of the presence/absence of change diamond (Figure 27).

Difference Between Time Summary Page is Published and Time Summary Page is Accessed on JCC K-Wall (minutes)			
	PHASE1	PHASE2	PHASE3
All SPs	47.32	25.15	20.75
SPs with Diamond	56.47	21.43	26.07
SPs with No Diamond	40.85	37.28	12.32

Table 18: Use of the *KWV* software operations on the CJTF K-Wall (Figure 31).

Uses/Hour			
	PHASE1	PHASE2	PHASE3
Left Mouse	13.51	4.69	11.36
Right Mouse	10.59	3.85	9.27
Refresh	0.43	0.15	0.00
Channels	0.38	0.00	0.27
Preset 1	0.11	0.08	0.09
Show	0.05	0.00	0.00
Hide	0.16	0.15	0.09

Table 19: Use of the *KWV* software operations on the CINC K-Desk (Figure 32).

Uses/Hour			
	PHASE1	PHASE2	PHASE3
Left Mouse	7.62	0.77	5.82
Right Mouse	3.78	0.46	0.27
Refresh	7.08	12.77	5.73
Channels	6.59	6.54	11.36
Preset 1	0.65	0.00	0.00
Show	0.05	0.00	0.09
Hide	0.43	0.23	0.55

Table 20: Use of the *KWV* software operations on the FCC K-Desk (Figure 33).

Uses/Hour			
	PHASE1	PHASE2	PHASE3
Left Mouse	4.09	1.08	1.88
Right Mouse	1.03	0.33	1.24
Refresh	1.30	0.38	1.30
Channels	1.35	0.72	2.00
Preset 1	0.22	0.05	0.03
Show	0.72	0.41	0.12
Hide	1.59	0.59	0.42

Table 21: Format of information displayed on the Global 2000 and Global 2001 K-Walls (Figure 34).

Uses/Hour			
	Global 2000 (All Monitors)	Global 2000 (Focus Monitors)	Global 2001
Summary Page	85.92	19.10	5.00
Auxiliary K-Web Product	3.07	17.32	53.48
MS PowerPoint	0.00	0.00	4.70
Tactical Data	6.85	41.10	0.00
War College Web Content	2.81	16.85	36.70
E-Mail	0.75	2.06	0.00

APPENDIX B:
OBSERVATIONAL DATA COLLECTED DURING GLOBAL 2001

Use, Utility, and Usability of K-Web Products During Global 2001

Summary Page Use

- *The Commanders' Summaries are being accessed by the cell players and projected up on the K-Wall.*
- *[FCC2] uses the K-Desk to get SA from the other Summary Pages...so the KM can keep track of other pages and to update his own Summary Page and documents.*
- *[FCC1] used the K-Desk to pull up Commanders' Summaries and see what others were doing...*
- *I'm seeing guys dipping down, grabbing pictures, graphics, text and providing it to Commanders.*
- *In my cell, 5-6 people at a time are looking at the Commanders' Summary Pages.*
- *I'm looking at the pages to make sure no information needs filling in...there's good information that's been converted to knowledge if you know where to get it.*
- *The Commanders' Summary Page – gave [FCC2] a way to give picture to the JTF staff the way that we wanted/thought they should see it.*
- *When I wasn't posting, I was trolling other's Web pages...to be apprised of others.*

Number and Format of Summary Page Links

- BWC is telling others how their information will be a link from the CJTF Summary Page.
- [...looking at a link on the K-Wall] *Can we use this in our brief?*
- [FCC1] indicates that their information for evening brief is in link from Summary Page.
- *[FCC2] uses K-Desk to get SA from other Summary Pages, for KM to keep track of other pages and to update their own Summary Page and documents.*
- *Ask [FCC1] what all these circles are? Put it on your slide.*
- *The CINC [Summary Page] has a link to ROEs, can you put it on our Summary Page?*
- The CINC page has a link to [SuppArea1] links (same that's always displayed on W2)

Summary Page Update Rate

- *[FCC5] has got their stuff populated...that's good.*
- *I'm seeing guys dipping down, grabbing pictures, graphics, text and providing it to Commanders.*
- *There still isn't enough content on the Summary Pages.*
- *We've looked on [FCC3] and [FCC2] pages and can't find evidence of [trigger]...We've already sent them a message to update their Commanders' Summary Pages.*
- *The information is coming too fast to update the slide (link re: above) anymore...we were told to use the tools until they break and it looks like they have.*

- [CJTF staff to component commands]: *We need all of you to update your Commanders' Sum pages with information about where you are...*
- E-mail from HA to [information provider] to update their page...HA is not getting the picture they need.
- *We need you to update the Commanders' Summaries every morning, afternoon and as needed for everyone...need to push other information during the day.*
- *We used the Summary Page to post ... data [that] wasn't used much in the game so we didn't update much (daily).*

Summary Page Preference

- *The Summary Page gave [FCC2] a way to give picture to the JTF staff the way that we wanted/thought they should see it.*
- *It standardized everyone's input.*
- *We're trying to figure out templates for our Web Page on the ship...these Summary Pages would work.*
- *The tools found to be very useful included the K-Wall setup, Commanders' Summaries...*

New Summary Page Design

Change Alerting

- *The diamonds were good...*
- *The main feature that is needed is alert functionality.*
- *How do you alert, tailor information for different CCs?*
- *You can post things on the Web all day long but you need to push information...can't assume people will pull off Web.*
- *Need an indication of when alerts were changed or added.*
- *Since it's always on the display...if you know in advance what you want to be alerted to you could be automatically alerted...it took too long to find these things out.*
- *Is there any way we can make a history of these pages?*
- There are still problems that purple links aren't accessed because they are thought to go to old information.

Other Features and New Layout of Summary Pages

Summary Pages

- *I like the idea of everyone having information in the same format.*
- *I need more space to put stuff.*
- *[The Summary Page] is a good looking page with enough white space.*
- *Need ability to scroll or add space.*
- *There was only a limited amount of information you could put on it.*
- *The Summary Pages were too simplistic.*

- *It wasn't flexible enough...you couldn't change the information.*
- *You should always put military time on the Summary Pages.*
- *Nice feature to have the time stamp though.*

Miscellaneous Links Page

- *The font size for Miscellaneous Links is too large.*
- *Change the template for Miscellaneous Links so you can include graphics there...easier to look at than text. Make it closer to the [Summary Page]...*
- *Users need to be able to add diamonds and squares to Miscellaneous Links.*

Use, Utility, and Usability of the K-Wall/K-Desks During Global 2001

Format and Content of Information on the K-Wall/K-Desks

- *It would be better have CNN up there...and information about Intel and Effects.*
- The CJTF staff has requested a Summary Page from FCC5 as well as access to it via a button on the Overview Page.
- The CJTF staff has requested a Summary Page from SuppArea1 as well as access to it via a button on the Overview Page.
- The CJTF staff has requested a Summary Page from SuppArea2 as well as access to it via a button on the Overview Page.
- The morning CJTF brief is presented on the K-Wall.
- *Having the [K-Desk] screen and the COP on the shared display really helps.*

K-Wall and K-Desk Use

K-Wall Use

- *People in the JCC completely relied on the K-Wall.*
- *The K-Wall has been really good ...we can put whatever we want up there...The BWCs are on that part of it...it's good for situation awareness.*
- *I'm just using it as my own personal computer since I don't have one.*
- *In the JCC, besides the Knowledge Wall, there was no management of information.*
- Most activity the last hour revolves around prepping for afternoon brief.
- BW1 announces "[SuppArea1] update" or details of change whenever [SuppArea1] has new information....
- [Three CJTF staff] are discussing information on K-Wall.
- All staff looking at K-Wall...working on the brief.

K-Desk Use

- *The Knowledge Warrior maintained the K-Wall/K-Desk and this was different, inconsistent across different cells.*

- *The difference in how the K-Wall was used shows how it's driven by the human element...whatever we put out there has to be flexible enough to deal with human element (configuration differences, preference for text or graphics etc...)*
- *In [FCC2], we've projected two screens from each K-Desk onto the large screen display. In [FCC3], 2 screens from K-Desk are on large screen display.*
- *[FCC2] uses K-Desk to get SA from other Summary Pages, for the KM to keep track of other pages and to update their own Summary Page and documents.*
- *The Commander didn't look at the K-Desk because he was always in chat rooms*
- *We used the [K-Desk] on watch a lot...*
- *In some cells they had useful info on shared displays...others didn't work so well.*

K-Wall/K-Desk Preference

- *The K-Wall has been really good ...we can put whatever we want up there...*
- *I like the capability to put any window where you want it.*
- *I like the K-Wall (K-Web?) approach because it uses HTML - shared files.*
- *Excellent tool!*
- *It's a great tool!*
- *We need this* [=touch screen capability] *on the ship for the admiral's brief.*
- *I think the only thing I like about it [the K-Wall] is the touch screens.*
- *The K-Wall and K-Desk were highest ranking tools in the FCC2 survey of tools*
- *I liked K-Desk set up, ability to view multiple images*
- *The K-Wall helped us...the BWC was comfortable using it...*
- *Any tool like this should communicate information to the boss, to peers, to subordinates...the K-Wall had flexibility to do that.*

New KWV Design

New Overview Page

- *Things are turning blue, telling me that there are changes so I'm going to check them.*
- [SuppArea1] IP shows BW1 his page – alerting by him (via coming up to command table to let him know that he's updated) *It's faster than blue text on viewer.*
- *It's hard to see that button text (on Viewer) has changed to blue from a distance...maybe change to red or some other color.*
- *They have blue stuff but no change diamonds.*
- *I recommend that when changes are made to Commander Summaries that "diamond" flash/pulse for 15-20 secs in order to alert people immediately of new changes.*
- *Need something that pulses for ~20 seconds when something changes to a diamond...need to know that information has changed. Blue text is not an "alert" - need something more salient (like on WIGS but not flashing all the time).*

- *I wish they had status for Alerts & Impacts on K-Wall...we changed Today, Tomorrow, LR status once a day but changed Alerts more often.*
- *It should indicate on Summary Page when you've updated a linked document, e.g., change the Today link to a diamond.*
- *It was easy to just make changes to files...without having to republish everything.*
- *You can post things on the Web all day long but you need to push information...can't assume people will pull off Web.*

Overview Page General

- *It's easy to use.*
- *The Overview Page/K-Web could almost do away with voice communications.*
- *The Web page (Overview Page on WIGS) was not intuitive because it didn't match the Overview Page on the KWV.*

Number of Monitors

Visibility

- *It's hard to see that button text (on Viewer) has changed to blue from a distance...maybe change to red or some other color.*
- *Problem with people standing in front of K-Wall – the KW-operator (J-KW1) can't see K-Wall (trying).*
- *Can I move the Select Monitor window to another screen? [because people are standing in front of it].*
- *As soon as we can get a clear view of the screen, we'll pull it up.*
- *There should be no walkway in front of it...that's been a problem a couple times today.*
- *The K-Desk needs to be big enough for other people to see it.*
- *It's hard to read that [MS Word document].*
- *Can I send them and e-mail complaining about their [link] ... It's hard to read it.*

K-Wall

- *There aren't enough screens to show everything (looking at PowerPoint brief from [FCC2])*
- *3 screens aren't enough...probably need 4 or 5...3 might be enough if you could use the 1st one. They want Ops up here, Intel on there, they want the logs...*

Overview Page

- *This stuff [on W1] isn't useful because it takes 1/3 of the K-Wall...don't need the key down in the corner. Better to have tabs at top of screen showing status for each area, that you could click to get that area. You could fit up to 14. You wouldn't need to right click to move into another window.*
- *I usually had just one window open...the Overview screen took up too much space.*
- *I like the Overview, but it only let's you see half of a page.*

K-Desks

- *I liked the K-Desk set up, ability to view multiple images.*

K-Web Support Tools

SumMaker Software Usability and Features

SumMaker Usability

- *It made it easy to produce Web pages with minimal training.*
- *I wish [other tools] were as obvious...wish it were all this easy.*
- *I had no trouble learning to use it.*
- *It was easy to use once somebody showed you how to use it.*
- *It's easy to get information in there.*
- *It looks very sailor proof. I could take a junior person and they would be very comfortable in 10-15 minutes.*
- *Simplicity... really easy to use. Easy to link files.*
- *I only needed 15 minutes to do training.*
- *It's easy to get information in there.*
- *I only got 4-5 minutes of training...within a half hour most computer literate people could use it too.*
- *I never published a Web page before I got here.*
- *I've never done any Web publishing before.*
- *It's very intuitive, user-friendly...it required minimal training.*
- *It had a clean Interface...simple and intuitive.*
- *Miscellaneous Links took a lot of steps (problem with finding Miscellaneous Links saved file).*
- *The Miscellaneous Links page was cumbersome...too restrictive because it was a list ...you couldn't group, organize [need formatting tools].*
- *The transition between SumMaker and Miscellaneous Links interface was not obvious.*
- *I couldn't go back to SM when in Miscellaneous Links.*
- *It was confusing that you had to copy files into directory - step takes it away from the user.*
- *It was hard for people to remember to put stuff in the [right] folder.*
- *Moving information from on place to another is what slows things down...why it's not working in some cells.*
- *There was a problem when people wanted to use information that they saw on a Summary Page link in slides but it had been changed since they saw it last...*
- *Users need one button to publish and save, keep SM open...*
- *Too many mouse clicks to publish it.*
- *It's a problem that you have to click so many buttons when ...not a big problem but you want to instantly publish things once.*

- *It would have been nice if the computer clock had been set to game time. It wasn't that easy to add the time...nice feature to have the time stamp though.*
- *One problem was having to put in game time...but this wouldn't be a problem in the real world.*
- *You had to remember to change the time/date stamp...you need the flexibility so that you have the choice to get system time from simulation or real time.*

SumMaker Features and New Requirements

- *It was a useful way to present information from [SuppArea2].*
- *It was a good program...All in all I don't have any complaints.*
- *The capability was good.*
- *I didn't get near to taking advantage of its capability/discovering its limitations. For what it was designed to do, it was fine.*
- *[SumMaker] pretty much fulfilled the requirements...*
- *Nice to have a template, to be able to keep updating...*
- *It standardized everyone's input.*
- *I like the idea of everyone have information in the same format.*
- *The flexibility in linking was good.*
- *There was a loss of flexibility (because of the same reasons that make it sailor-proof).*
- *It supported MS Office products and file formats.*
- *The flexibility in linking was good.*
- *We don't stop to prepare briefs...information in briefs is information we're already using for own operations.*
- *We used PowerPoint to make sub pages.*
- *There was a loss of flexibility (because of the same reasons that make it sailor-proof).*
- *I liked the fact that you could drop information.*
- *Users need the ability to archive old information.*
- *It was hard to archive...*
- *It would be nice to be able to archive old information.*
- *There was a problem when people wanted to use information that they saw on a Summary Page link in slides but it had been changed since they saw it last...*
- *We wanted to link to archived the SuppArea1 stuff...there weren't enough links to do that.*
- *A phone book feature on Summary Pages would be nice (mouse over for details about person, hyperlinks to each).*
- *You might want a link to another collaboration system (e.g., whiteboard).*

Feedback to Information Providers

Feedback related to Summary Page access

- *I didn't know how my Summary Page was used...didn't even know who was looking at it.*
- *You need to have feedback that people are using your information.*
- *Better feedback is necessary.*
- *I don't know what the CINC is getting from us [the CJTF staff] – I know it's on our page but I don't know that the CINC's looking at it.*
- *You need information about who's viewed your information (specifically who) so you can talk to the person about it - even if in form of e-mail.*

Feedback about Summary Page content

- *We've already sent them a message to update their command Summary Pages.*
- *We need all of you to update your Commanders' Sum pages with information about where you are...[chat message].*
- *I'm looking at the pages to make sure no information needs filling in. if there is, I tell BW1 and he lets the guy know...BW1 is pretty proactive about it too.*
- E-mail from CINC that Today's link is still yesterday's plan.
- *There's not enough time in the game for the CJTF to figure out what he wants, at what point do things go from yellow to red. It needs to be put in place before game.*
- *We didn't get enough feedback from upstairs [JCC] about whether there was right information.*
- *I didn't feel like anyone was using it. If they were, we would have gotten more feedback from other people about what they needed to see.*
- *We need to know what the CJTF wants to see...*
- *I didn't get any comments about what the Component Commanders wanted to see.*

New KWV Software: Usability

- *It was easy to display information on the K-Wall.*
- *The K-Wall helped us...BWC was comfortable using it...*
- *Can I move the Select Monitor window to another screen?*
- *I wish there was an easier way to put stuff on windows other than right clicking.*
- *Problem that you didn't know where a window would pop up.*
- Problem caused when one user is trying to use the touch screen at the same time as another is using the mouse to control the K-Wall.
- *Problems when we wanted to run a PowerPoint slide show...when we clicked on another window, slides advanced (because it's a single desktop) ...you should be able to keep functions running in the background.*

Other Emerging Themes

Training and Business Rules

Training

- *The training was good.*
- *The training documents were fairly intuitive...didn't have problems figuring things out.*
- *It would have been nice if the WIGS training had let people know the Summary Pages were there.*

K-Web Concept

- *How do we know that the Component Commanders know what's going on?*
- *Does the CINC have access to the same information as we do?*
- *We need help/advice about how to take advantage of the wall.*
- *At the beginning of the game you don't know what you need to know.*
- *The system assumed people knew where to go for information.*
- *We didn't use it the way it was intended to be used...The learning curve started slow, we didn't know how were going to use it.*
- *There should have been business rules about how to share information...some guys used Commanders Summaries, some used shared drives...*
- *Fusing, focusing, displaying information is different at different levels.*
- *There's not enough time in the game for the CJTF to figure out what he wants, at what point do things go from yellow to red needs to be put in place before game.*
- *We need to be careful about standardization because we also used it as our means of updating ourselves.*
- *The KWarrior maintained the KW/K-Desk and this was different, inconsistent across different cells.*
- *We didn't have an information management or organizational plan in place...*

Specific K-Web Business Rules

- *We've fought the war today exactly the way we weren't supposed to...with PowerPoint.*
- E-mail suggests that the [information providers] move some Alerts into related Information and Links.
- *They used diamonds in Alerts and Impacts but not in the Today, Tomorrow, Long Range area.*
- *There has been a lot debate regarding content: Where [on information products] should information be red – [i.e. if not in status over time].*
- *I didn't fell like ROE for use of system was established, e.g., when to use a green diamond vs. a square, how long a diamond should be up...there was nothing in place that indicated what should be pushed or pulled...how the systems, including the collaboration tools, should be used.*

- *The Admiral did not know what the colors meant...- you need some sort of key to the symbology...*

Comparison to last year's K-Web

- *An example showing how this game has taken a step backward from last year's Global is the morning briefings.*
- *Last year, the K-Wall was updated so that brief didn't need to be ready by 1600 and stop game play. It was a different way of doing business.*
- *Last year the BWC/CJTF indicated what he wanted from the 1st day of the game...what was red, what was important*
- *Last year, we thought the K-Wall was great... but it was a collection of information that was current 0 time late...it needed projected information, EBO etc.*
- *CCG3's JTFEX this year was incredible...because they had experience with tools...and the tools were tailored for their needs.*
- *The K-Wall started out as unwieldy...not very workable product but [last year's players] said "let me play with it a while" and it turned into something useful.*

TacGraph

- *A problem with TacGraph is that text size does not change when you zoom in or out.*
- *When you click on the Unit tool to add a unit but change your mind, can't unselect it...have to add a unit and then delete it.*
- *Put an undo feature in TacGraph.*
- *TacGraph wasn't very useful...would have been if you could import pics from other tool.*
- *Tabbing between the lat and long didn't work. You need a distance tool...couldn't specify dimensions of objects.*

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The Command 21 project is directed at supporting the needs of senior decision-makers and support staff in military command centers. One goal of the Command 21 project is the development and operational evaluation of the Knowledge Web concept and technologies to support shared situation awareness, to facilitate group interaction, and to augment the decision-making capabilities of senior staff. This report describes a major operational evaluation in the continuing efforts directed toward this goal.

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