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WebSked: Web-Based Scheduling to Improve Resource Utilization and Contingency Planning

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Abstract

This paper presents the results of the initial phase of development done by the Space and Naval Warfare Systems Center San Diego on an automated network-centric solution for employment scheduling and contingency planning in the maritime environment. It includes a description of and results from the deployment of the initial operational capability of the WebSked system, which is a component of the Global Command and Control System – Maritime (GCCS-M). These empirical results are then used to propose one promising instantiation of the scheduling command and control solution. It is shown in this work that the maritime scheduling and contingency planning domain supports tactical command and control. It is also shown that network-centric automated scheduling and planning can be successfully deployed on existing classified military networks both ashore and afloat with a low logistics footprint (e.g., physical, administration) and can achieve a higher degree of information quality and timeliness than previous manual methods.

1 Introduction

The scheduling of military Units for operational employment has traditionally been supported by a variety of information systems, spreadsheets and manual (literally handwritten) tabular displays. In a survey conducted by the authors in 2001-2002, authoritative employment schedules for Navy Units (ships, squadrons, and other embarkable assets) were observed to be present in at least two different schedule management systems (VIPER and EMPSKD)[i], dozens of unique spreadsheet formats, and even in tables laid out in pencil on large format construction paper. Some Unit schedules were coded in HTML and directly displayed on SIPRNET websites.

The schedules represented by these systems, technologies and processes clearly could not be aggregated into an integrated picture of scheduling operations. Just finding the particular schedule information needed was itself sometimes a daunting task.

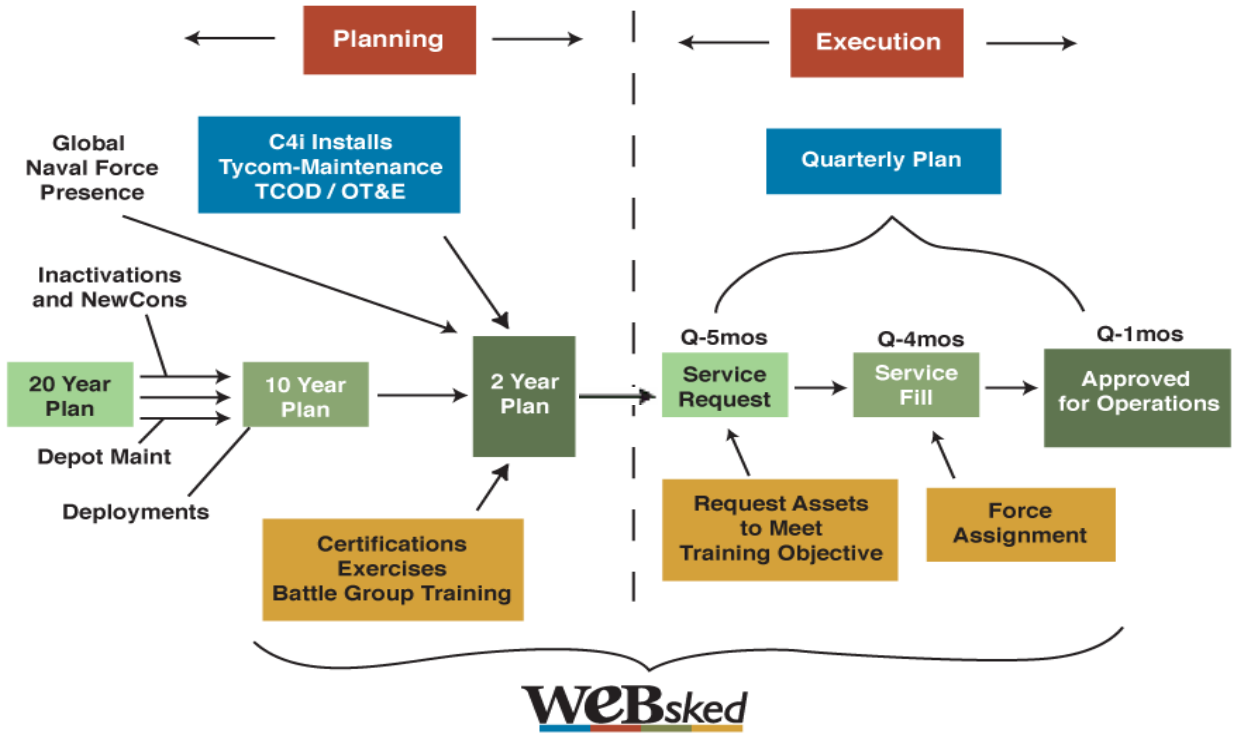

Figure 1 – The Navy Schedule Planning and Execution Process

Due to the lack of system interoperability and data format availability and consistency, personnel and systems outside the Current and Future Operations community often had an incomplete picture of Fleet operations. Schedule information being disseminated was often delayed and no standard means of advising schedule consumers of critical changes was available.

A system has been constructed and deployed[1] by the Space and Naval Warfare Systems Center San Diego (SPAWAR) to solve the problems listed above. Known as WebSked (short for Web-Based Scheduling), this system attempts to satisfy a subset of the schedule information requirements defined for web-based maritime employment and deployment planning operations. It is further described in Section 3. With the deployment of WebSked and its subsequent use for scheduling 99% of all Navy ships, many of the issues inherent in the previous heterogeneous set of schedule maintenance methods have been resolved and major improvements to the timeliness and accuracy of schedule planning and dissemination (as shown in the process in Figure 1) have been realized.

Maritime schedule information consumers can be divided into two main types. One is the individual in the chain of command of operational forces whose duty involves the creation, editing, or approval of employment schedules. The other is the individual who has a primary or concurrent duty of supporting operational forces. Examples of this second type would include training groups, C4I installation managers, logistics managers, maintenance managers, and Crisis Action Teams. Both types of user are schedule information consumers. However, the former type is the primary producer of direct employment schedule information, while the latter type is more likely to contribute mission requirements that require

[1] This work was sponsored by SPAWAR Systems Command PMW-157

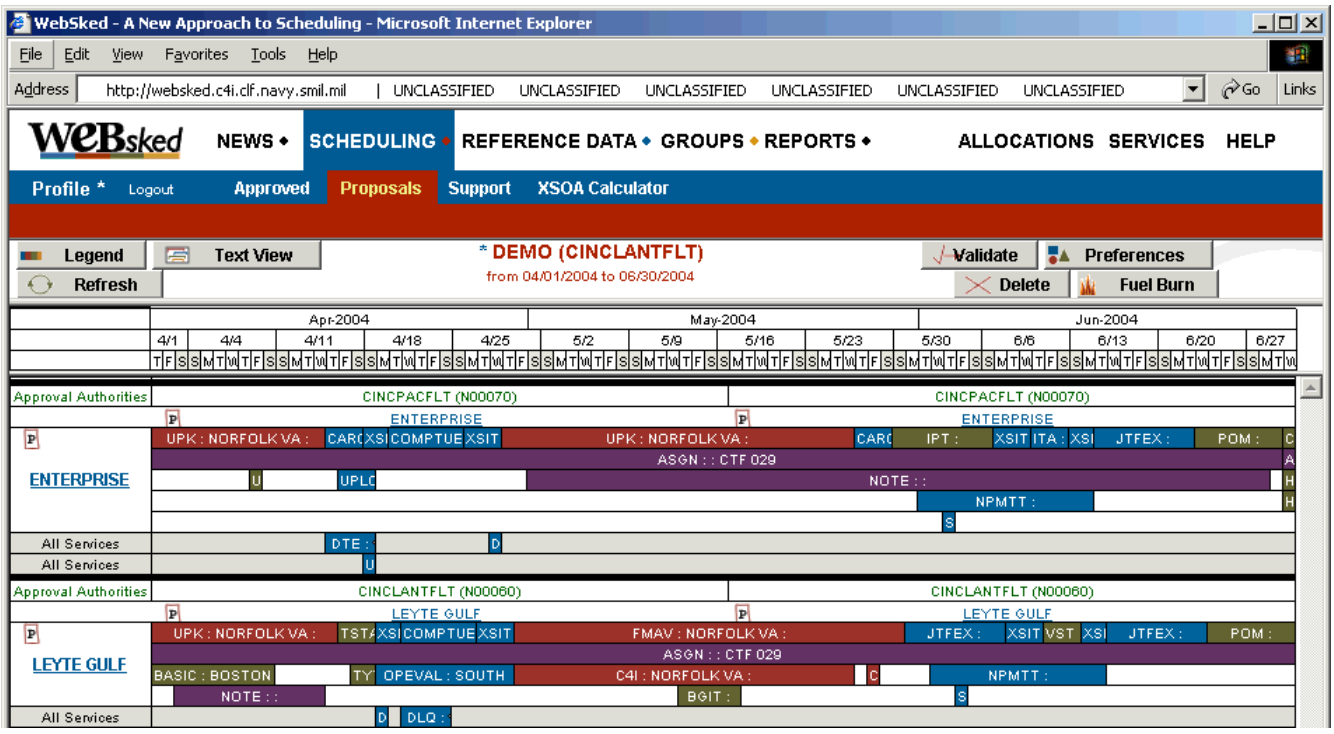

Figure 2 - The WebSked Timeline Editing Display

brokering and allocation to specific resources during scheduling.

Of primary importance to the scheduling mission is the ability for Commanders to be able to plan and communicate a timely and accurate picture of current operations to schedule information consumers. A common grouped picture of Forces of interest is essential to ensure that force projection requirements have been planned correctly and are being carried out. Changes to operations that arise due to reactive planning or other operational necessity need to be quickly transmitted to all information consumers. An example of an integrated employment schedule editing display for two units is shown in Figure 2.

It is shown in this work that the maritime scheduling and contingency planning domain provides a key piece of the command and control solution. It is also shown that network-centric automated scheduling and planning can be successfully deployed on existing classified military networks both ashore and afloat with a low logistics footprint (e.g., physical, administration) and can achieve a higher degree of information quality and timeliness than previous manual methods.

2 Scheduling and Command and Control Functions

The key functions of a command and control System are planning, directing and controlling forces[2]. The directing function includes the allocation of forces to achieve the goal of force projection. In the maritime environment, force projection is realized via force allocation, which is affected by five major factors:

1. Global Naval Force Presence Policy

[2] American National Standards Institute (ANSI) definition of command and control system: "The facilities, equipment, communications, procedures, and personnel essential to a commander for planning, directing, and controlling operations of assigned forces pursuant to the missions assigned."

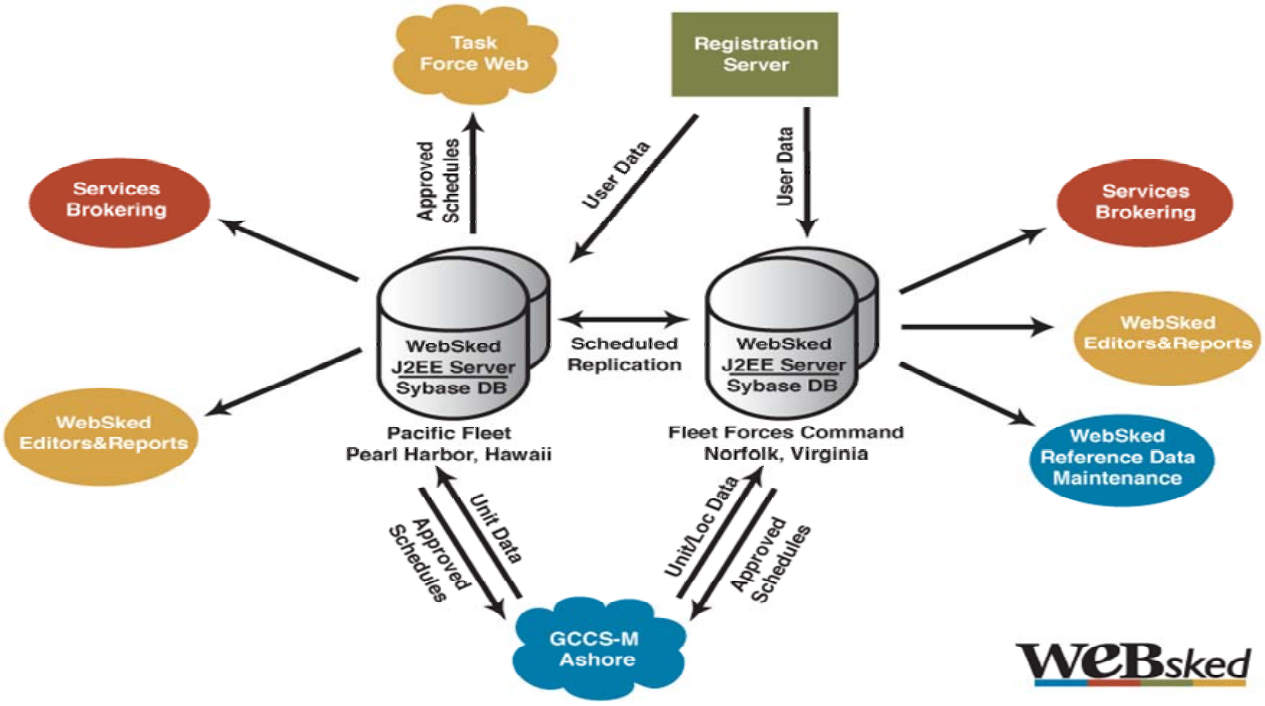

Figure 3 – The WebSked Server Architecture

2. Deployment orders
3. Training and maintenance
4. Contingency planning
5. Reconstitution of forces

It is the requirement to incorporate these factors while directing C2 force projection and the subsequent execution that starts the scheduling process [Stewart, 2003]. The stages of planning and execution to achieve force projection are given in Figure 1.

Scheduling also supports other key mission capabilities required for command and control. It provides awareness of past, present, and planned future operational movements (situational awareness). It is used in the assessment of aggregate force readiness for future operations (the temporal component of force readiness). Finally, it provides an important data source for plan supportability determination in several C2 functional domains, such as operations, logistics, and intelligence (operational decision support).

From the description of four C2 mission capability areas above it can be seen that scheduling supports C2 in several critical ways. The need for more integrated support of C2 (above) through scheduling (as described in Section 1) drove the Navy requirement in fiscal year 2001 for an advanced maritime planning and scheduling tool [Barnes, 2000] that became WebSked.

3 The WebSked System

SPAWAR first deployed WebSked in June of 2002. It is an entirely web browser-based system for scheduling and planning the movement of major maritime assets, such as ships, squadrons, and other embarkable Units. It operates on the Secure Internet Protocol Routing Network (SIPRNET) to manipulate and distribute scheduling data, most of which is classified at the SECRET or CONFIDENTIAL level. It incorporates the schedule editing features best-liked by Navy schedulers from the legacy desktop-based system it replaces.

Its key features are visual scheduling, automated workflow, email notification, a common scheduling picture, ad hoc reporting, and a suite of decision aids to assist the scheduler in optimizing factors such as fuel usage and the time sailors and ships are at sea. Improvements to WebSked currently underway include deployment scheduling through force allocation management (supports global Naval force presence policy with surge support), evaluation support aids, and the capability to maintain of large sets of contingency plans and templates.

The system architecture is shown in Figure 3. It currently consists of four servers with J2EE and Sybase support at two physical Fleet sites and has the capacity to expand to more than 50 servers as needed. It effectively operates as a metacomputer [Freund et al., 98]. The system incrementally replicates data among all servers to maintain a consistent scheduling picture (~3 seconds on-site, 30 minutes between sites) everywhere.

3.1 Requirements for Maritime Scheduling

SPAWAR began work on WebSked in 2001 based on requirements given by the Fleet for Web-based scheduling [Barnes, 2000]. Fleet scheduling was at the time accomplished using a variety of methods as described in Section 1 and reported to CNO via the VIPER stand-alone application, which generated formatted Naval messages to transmit schedule proposals from units to approval authorities. This process required a great deal of manual intervention, which impacted the accuracy and timeliness of scheduling data. Additionally, that system did not support Navy efforts to provide network-centric application services to end-users. As envisioned, Network-centric scheduling would allow a single logical scheduling environment which would better support Navy requirements for all scheduling authorities to have a collaborative, near real time, accurate scheduling database to support the display and analysis of schedule data.

The challenge in implementing such a system lay in the diverse scheduling capabilities required by the large range of user roles being supported, the challenging network environment afloat and the logistics of supporting and upgrading an application on a regular basis.

3.1.1 Diverse Application Requirements

The Navy performs a mix of top-down and bottom-up scheduling. That is to say deployment requirements move from higher to lower on the chain of command, while the specifics of a deployment implementation are originally formulated at lower command levels and move upward for approval. Support for both centralized planning and dissemination as well as decentralized plan collection and de-confliction may be required depending on the specific capability. The Fleet's main application requirements were to create, de-conflict, display and print the following on the web using those two paradigms:

1. Global Naval Force Presence Schedules
2. Deployment Schedules
3. Contingency Planning
4. Modernization Schedules
5. Exercise Schedules
6. Transit Schedules
7. Services Schedules
8. Mid Range Battle Group Training Cycle Schedules (import)
9. Operational Schedules
10. Fuel Planning and Estimating
11. Historical schedules (last 10yrs of operational schedules)

In addition, a number of specific tools for tempo of operations, best ship fit and reporting were needed.

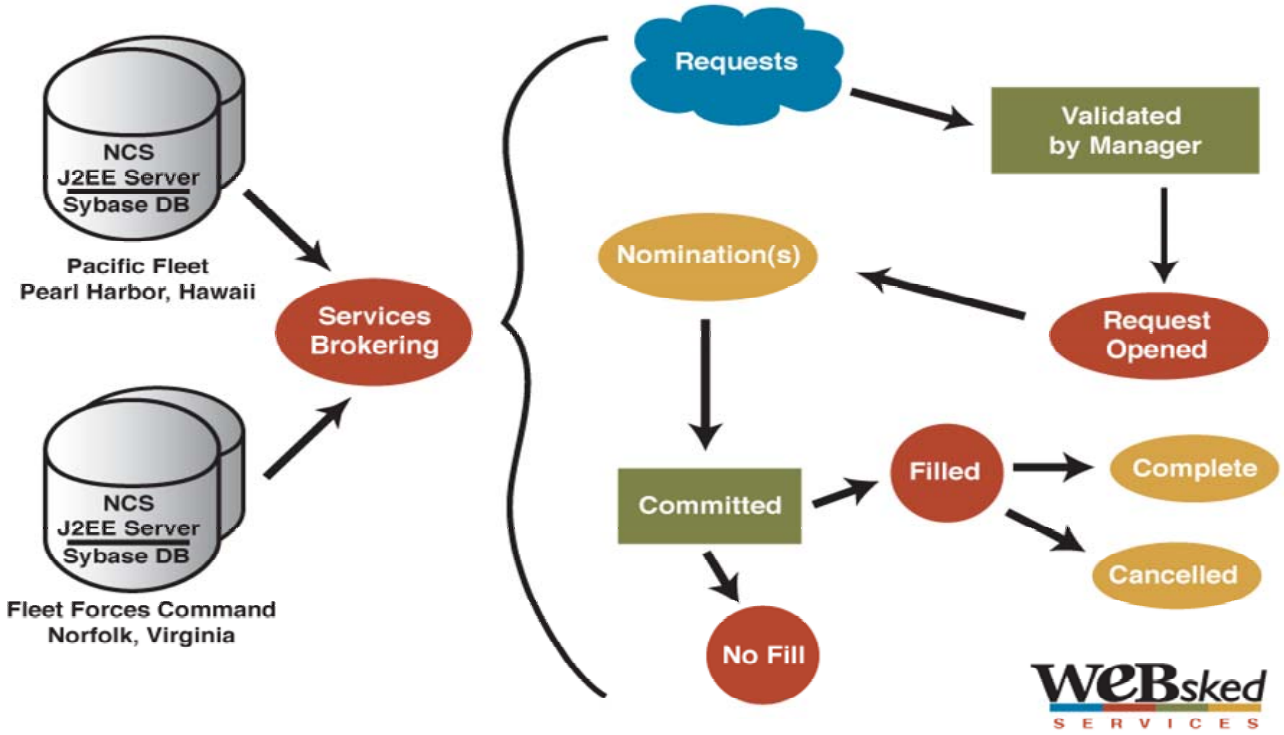

Figure 4 – The Mission Needs Brokering Process (Services)

3.1.2 Challenging Network Environment

The maritime network environment is well-known for its challenges. The Navy requirement to operate 7/24/365 (not just when out of Garrison) across connections that have multiple satellite links to floating platforms makes it unique in the Department of Defense (DoD). Standard reliable transmission protocols, including TCP/IP, FTP, SMTP, PPP, NFS and others are insufficient to bridge the network failures likely to occur on forward-deployed maritime networks. This is because the frequency, duration, and characteristic error signatures of maritime network failures do not match those of the terrestrial networks these protocols were designed for [Stallings, 1997][SPAWAR, 1997]. Efforts such as the DoD Global Information Grid (GIG) seek to relieve this situation, but are a number of years away from realization.

Adding to this problem are the relative autonomy and isolation of maritime WAN nodes. Ships can't easily bring in spares and specialized technical assistance with the same ease that ground facilities can, causing network problems when they occur to be more severe and of a longer duration than elsewhere.

Given the limited amount of network bandwidth available off a ship for scheduling communications during high-tempo operations, it is imperative that the best use is made of that bandwidth [Ambrosius, et al., 1996]. Applications that need to operate reliably on these networks must have pessimistic communications assumptions built into their design.

3.1.3 Support/Upgrade Logistics

Scheduling in the Navy occurs at an extremely diverse collection of afloat and ashore sites all over the world. The difficulty of distributing and installing updates worldwide is compounded by the fact that the afloat units are at sea for long portions of each year.

It was clear that to meet the requirement for rapid upgrade of system capabilities the new scheduling system must be a SIPRNET web-based, interactive, asynchronous application running on multiple ashore servers (with backup) each containing a copy of the master scheduling database. It certainly had to eliminate the burdensome process of message generation and message parsing that kept its predecessor system from achieving its desired data entry goals. Key to the network environment was that users could access the application via a Web-browser, and yet have the capability to work offline locally (on desktop systems) to create/edit, post to, and download from the web. Upgrades to the WebSked application should not require modifications to the user's desktop computer.

Because of these constraints, a thin-client web-based architecture was chosen for WebSked. Since all Navy-Marine Corps Intranet ashore and Information Technology 21 afloat desktop computers contain Microsoft Excel, that COTS application was selected to field the additional offline functionality required. In this way no client desktop software upgrades are ever required, saving many thousands of dollars in upgrade costs over the product lifecycle.

3.2 WebSked Operation

The system is constructed with the application, network, and support logistics requirements in Section 3.1 in mind. WebSked is a multi-user, single entry (input data once, use it everywhere) application that supports cooperative development and management of schedules by users all over the world. This is in keeping with the overall DoD strategies of Only Handle Information Once (OHIO) and data-centric systems[3].It does not use Record Messages, relying instead on a stateless editing interface (no user work is lost if the network goes down) and optional offline facilities via Microsoft Excel for easy distribution from the Web to the desktop. The system provides alerts by email when schedules are changed or proposals have been submitted. It provides discretionary access control so authorization to submit changes and authorization to approve changes is strictly controlled. The system uses user groups, roles, and permissions to control software review, approval, and data library modifications.

WebSked is specifically designed to improve the contingency planning problem, which is illustrated in Figure 5. Contingency Plans A, B, C, D may be laid out and scheduled during the long-term planning process to address possible changes in force requirements through the mid-term (2-5 years). As time progresses, one of these contingency plans may be selected and executed. Let's say it is Plan B. At that point contingencies to Plan B would again need to be envisioned and set up, such as Plans B1, B2, B3, B3. At some point another contingency is selected from that timeline for execution (B1), and the process begins again with alternatives B1a, B1b, B1c and so on.

The number of contingency plans the scheduling community is being asked to support is large and growing as more flexibility is being required of the forces involved. WebSked supports faster contingency planning and larger sets of contingency schedules through automated employment scheduling, mission needs brokering, and fuels and tempo assessment.

3.2.1 Employment Scheduling

Employment schedules are normally prepared and promulgated on a quarterly basis. They provide detailed information on the utilization and status of naval forces for planning and control purposes. Approved

[3] Department of Defense Directive 8001.1, re-certified in 21-Nov-2003, section 4.4.2

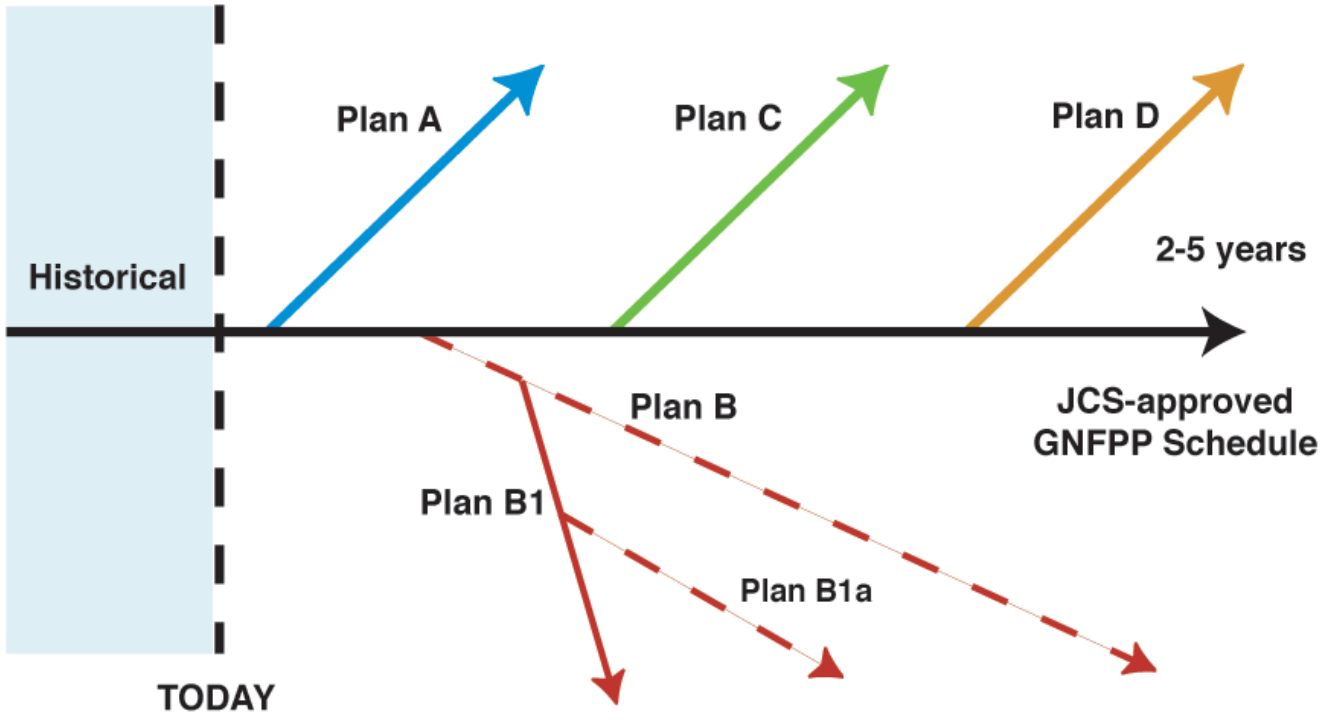

Figure 5 - The Contingency Planning Problem

employment schedules have the directive authority of an operations order[4] and constitute authority for movement. WebSked provides the capability to create, modify, and approve day-to-day unit level employment schedules. A screen shot from the WebSked timeline editor display is shown in Figure 2. Following a unit to ISIC (Immediate Superior in Command) to higher ISIC to Approval Authority workflow, WebSked has automated a process that took days into one that now can take only hours. Thus Combatant Commanders can gather and organize scheduling data in a format that allows them to make decisions in a timely manner. In addition, such information identifies not only current activities in the Area of Responsibility (AOR) but also helps to identify future trends.

3.2.2 Mission Needs Brokering (Services)

The fundamental business process underlying maritime scheduling involves taking the mission required to be performed and negotiating the required resources to be applied to that mission. The Navy calls these mission requirements to be filled "Services". Through its Services module, WebSked provides the capability for users to request and command authority to assign forces to meet validated operational, training, and testing requirements. This is done following the high-level process given in Figure 4. Filled (assigned) requirements are incorporated into the employment schedules as shown in Figure 2. WebSked implements operational, training, and testing requirements in response to daily operations, crises or unseen conditions. These include the following: forces abroad permanently, deployed forces either rotating or temporarily assigned for exercises, conducting combined training or participating in programs such as International Military Education and Training (IMET). A Combatant Commander is not the only one to identify training/testing objectives for his AOR. Many other government agencies do so as well. All these agencies

[4] Per Naval Warfare Publication 1-03.1 and COMFLTFORCOM Operations Order 2000-03.

[6] Derived from interviews with personnel in the scheduling community. No numeric speed to approval metrics exist across these older methods.

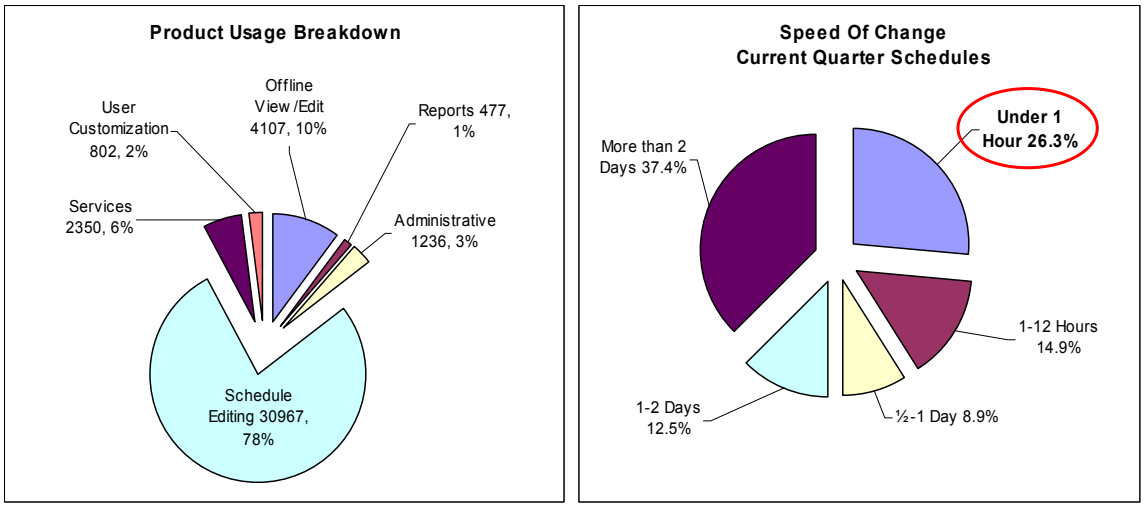

Figure 6 – WebSked Usage and Approval Speed

pursue various cooperation activities; some conflict and some coincide. The challenge for decision makers using employment schedules is to orchestrate scheduling to make the best use of limited resources. WebSked provides unit schedule guidance to Combatant Commanders to accomplish tasks and missions based on current unit availability and capabilities.

3.2.3 Fuels Assessment

The Navy uses many millions of gallons of diesel fuel each year to mobilize its Fleet world-wide, so fuel costs are an important component of employment planning. WebSked provides the capability to calculate the amount of fuel required to execute an approved employment schedule. It automatically determines the vessels state (At Sea, In Port, In port Steaming, and Cold Iron) and multiplies by the units current allotted fuel burn rate. Additionally, comparison between the current approved schedule and a proposed change is provided to assist the command authority in determining the impact of the schedule change on fuel allocations.

3.2.4 Tempo Assessment

To ensure a better quality of life for sailors, CNO has imposed constraints on the amount of time a unit may be away from homeport in peacetime. Current thresholds are: 28 days out of homeport per quarter while not deployed and two days non-deployed for every day deployed. WebSked provides the capability to calculate both Nights Out of Homeport and Operational Days. Comparing the unit's location with a location data lookup, it resolves for In Homeport Area, In Port - Not Homeport Area, and At Sea. Additionally, counting the number of days In Port - Not Homeport Area and At Sea it identifies deployments and provides the next available date that the unit will be a candidate to re-deploy. Comparison between the current approved schedule and proposed changes is provided to assist command authority in determining the impact of the schedule change on current TEMPO constraints.

4 WebSked Usage Today

Since the release of WebSked version 1.0 in June, 2002 and version 2.0 in September, 2003 WebSked use has risen steadily. Schedulers have migrated off of other scheduling methods and Fleet directives have been issued to move to WebSked. Figure 6 and Table 1 give usage statistics for WebSked for a three month (one quarter) period beginning in December, 2003.

Table 1 – WebSked Quarterly Statistics

Registered User Logins	10,853
Total Registered Users	1,045
Total Active Users	517
Total Units in System	449
Active Units	325
Modified Events	40,896
Total Updates	67,364
Max Transactions/Day	2,837
Avg Transactions/Wkday	1,228
# of Schedules Approved	2,910
Avg Reviews/Schedule	3
Avg Unit Schedule Chgs	9
1-Unit Proposals	91%

Table 1 shows the overall use of the system by registered users, who are mostly schedulers. The system holds schedules on 449 military units over a five year period. 72% of these units are scheduled during a quarter. The number of Units managed by WebSked is expected to triple as air assets are included over the next year. There are over a thousand registered users, about half of which login at least once a quarter. On average, 155 users are logged onto WebSked each work day. Users request an average of 1,228 major application functions (called transactions) each work day. The data in WebSked is very dynamic, with schedules being changed over 40,000 times during the quarter, and more than 17,000 other changes to the database (Services, Groups, Reports, etc).

WebSked has allowed easier and more granular updates to the schedules of the units it manages, with the average actively scheduled unit's schedule being updated nine time each quarter, after the changes are reviewed by an average three other Commands. 91% of proposed schedule changes that were approved during the quarter involved only one unit. This shows that schedules are processed by the schedulers on an incremental basis rather than being grouped in quarter planning proposals and sent up only periodically as in the past. The result is that WebSked is updated with changes more frequently and thus schedules there are more timely and accurate than before.

Schedule changes also move through the system faster. Previously schedule changes took an average of two weeks to be approved[6] with VIPER and other manual methods. The right-hand chart in Figure 6 shows that 26% of schedules for the current quarter in WebSked were approved in less than one hour, and 41% in less than 12 hours. This means that schedules obtained through WebSked are far fresher than previous methods and allows schedule information to be used to support tighter decision cycles.

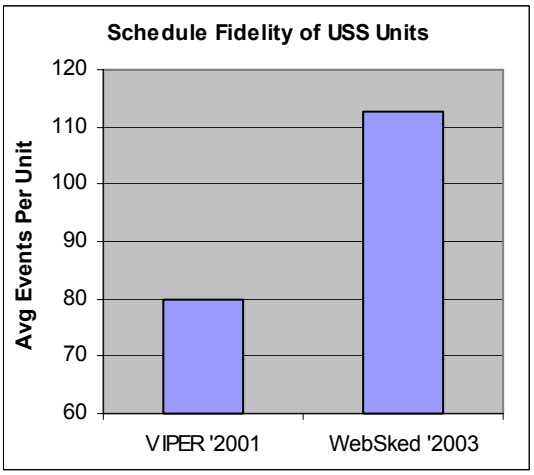

Figure 7 – Improvement in Fidelity

Another way WebSked has improved information being provided to the schedule consumer is in the increased fidelity of the schedules it provides. When compared with data on "USS"-designated ships from the previous system, VIPER, that were reported officially to the Chief of Naval Operations (CNO), WebSked schedules provided to CNO had 40% more detail in them. This is shown in the graph in Figure 7. This means better schedules are now available to consumers and to CNO to answer questions about how Navy forces are being employed over time.

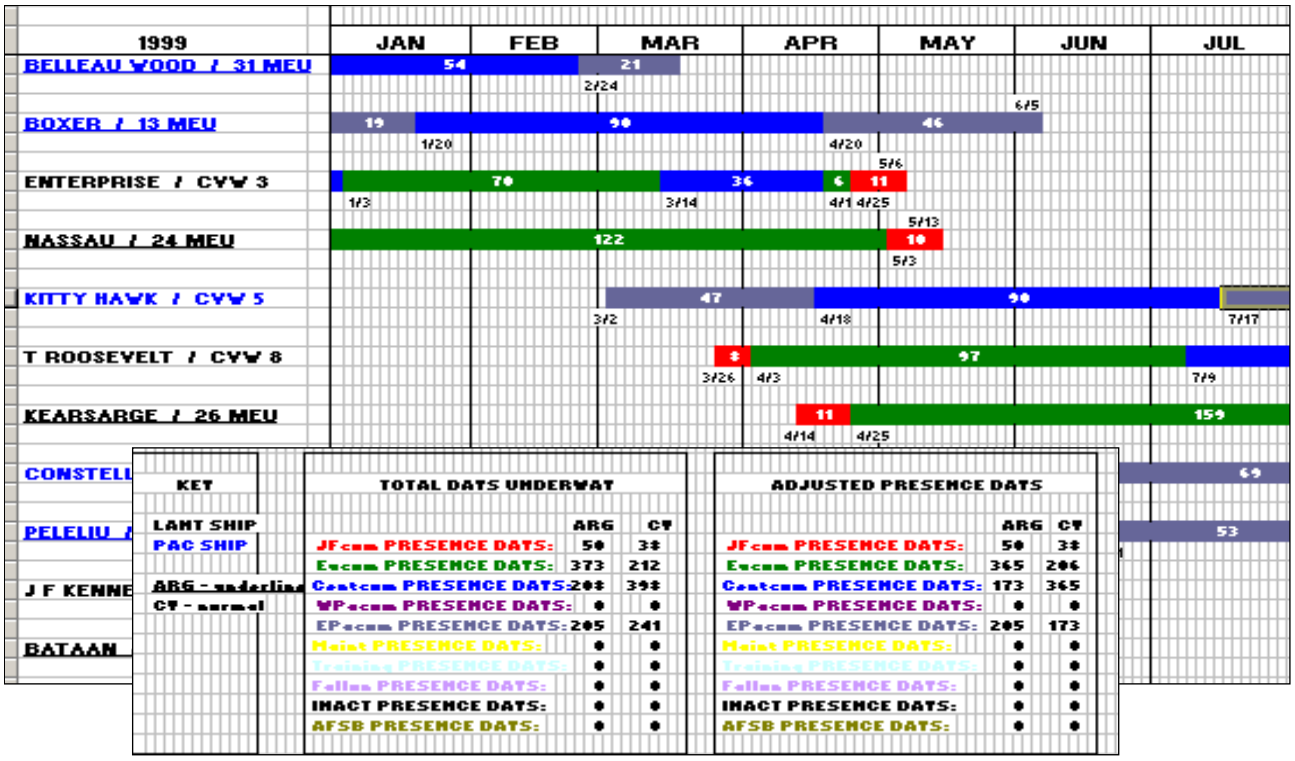

Figure 8 – Deployment Planning Concept

The left-hand chart in Figure 6 shows the breakdown of transactions in the system by functional area. It is important to note that these figures to not include information requests made by anonymous users on the SIPRNET, to which approved schedule data is available. This type of activity is estimated to be a significant additional portion of the total activity each quarter, over and above registered user activity on the system.

5 Current Work

WebSked is currently at version 2.1. Significant maintenance upgrades of the product are currently underway during the year 2004. Enhancements to Navy deployment scheduling and interoperability of the system in the Network-centric warfare environment are being implemented.

5.1 Interoperability

WebSked has become a central authoritative Navy data source for most major unit schedules. With this change the need for other maritime and Joint systems to pull schedule data from and submit proposed changes directly to WebSked has emerged. WebSked currently features an XML-based service for approved schedule retrieval, and an enhanced web data service is currently being developed to allow authenticated system access for bi-directional data transfer using industry-standard interface protocols. Some systems that have current or planned interfaces with WebSked include:

- Task Force Web (TFW)
- TYCOM Readiness Management System (TRMS)
- Naval Training Information Management System (NTIMS)
- IC3 (for Military Sealift Command)
- Joint Forces Scheduling Tool (JFST)
- Joint Execution Scheduling System (JESS)

- Theater Security Cooperation Management Information System

The generalized nature of the enhanced web services (no point-to-point interfaces) being produced are expected to meet the requirements of a growing number of Navy and Joint systems sharing the common goal of information sharing in the new network-centric data environment.

5.2 Deployment Scheduling

It has been a Fleet requirement since the inception of WebSked that the two parts of scheduling, employment and deployment, be integrated into the system. This is to consolidate the scheduling process from its beginning (Global Naval Force Presence planning), through to its end (the individual Unit schedule). With the process consolidated into WebSked, the integrity of scheduling can be ensured and the traceability of original force requirements to end-point implementation of them may be verified.

A deployment scheduling module is currently being constructed in WebSked to implement this functional capability. It will contain the following features:

1. Deployment schedule creation, editing, and approval with GNFPP constraints and requirements support as envisioned in Figure 8.
2. Force allocation management system allowing the integration of GNFP and other force directives into a single, authoritative source of force groups over time and available as a web service.
3. Integration of force allocation into the mission needs brokering module to support bottom-up allocation through the nomination process (Figure 4).
4. Verification of force plan execution to validate that individual employment schedules continue to meet their unit's obligations as part of their membership in a force group.

With this module in place, the Navy planning process as shown in Figure 1 will truly be automated from end-to-end.

6 Summary and Conclusions

In this paper, the main concepts and goals of maritime scheduling have been introduced (Section 1) and their role in supporting command and control has been explained (Section 2). A description of the WebSked system which implements the scheduling solution for maritime C2 was given (Section 3) and some of the metrics collected from actual deployed system operation were presented to show usage and benefits derived (Section 4). Finally, on-going enhancements to the system and their expected improvements to maritime scheduling were listed (Section 5).

WebSked was shown to have been fielded successfully on Military classified internetworks with a low physical (web browser only) and logistics (server upgradeable) "footprint" (Sections 3.1.3/3.2/4). The metrics and results from WebSked suggest that the current business process for Navy scheduling has indeed been improved through this automated information system. Evidence of reduced schedule change latency time (Section 4 and Figure 6), and increased reporting fidelity (Section 4 and Figure 7) was shown. WebSked features that support optimization of resource usage and reducing the decision cycle time were shown (Section 3.2). These features include automated employment scheduling, mission needs brokering, and fuels and tempo assessment. The improved performance and features shown in WebSked have given the Warfighter an enhanced capability to utilize the right resources for the right mission, and to carry out timely and accurate contingency planning

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[i] Visually Integrated Planning and Employment Resource (VIPER) and Employment Scheduling (EMPSKD)