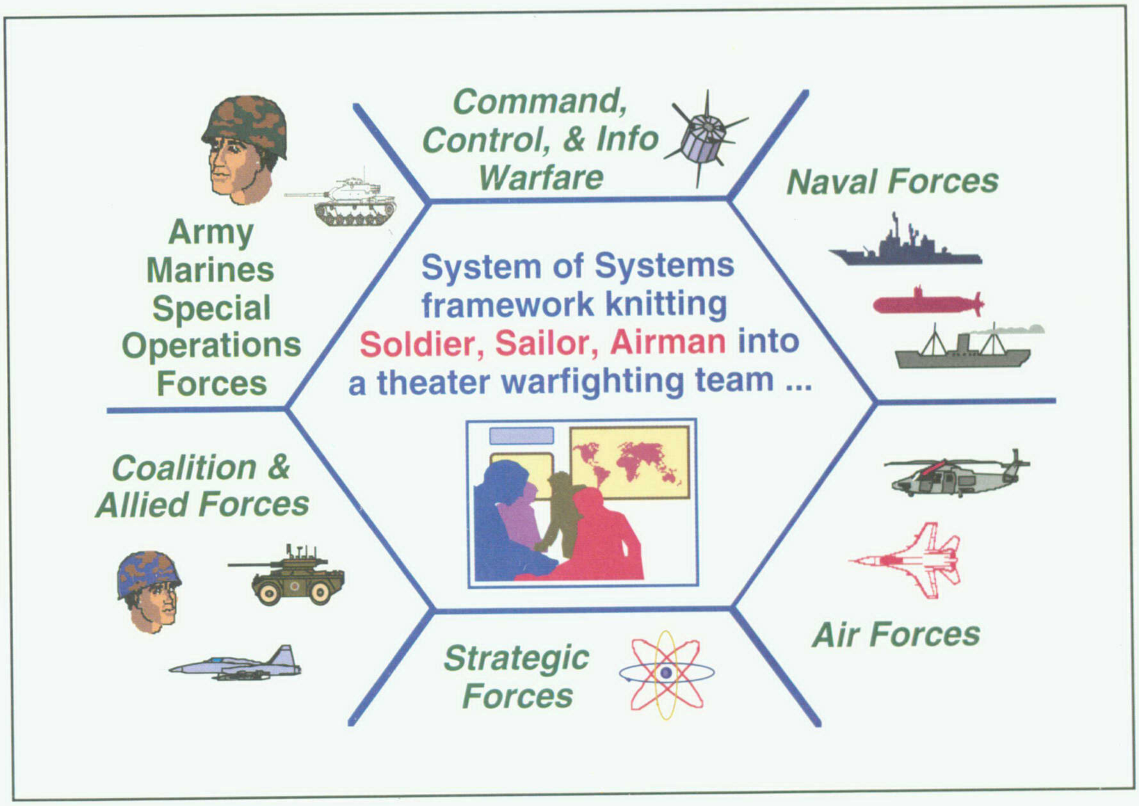
# FOCUS ON MISSION TEAMS

## REPORT ON A

## WARFARE SYSTEM ENGINEERING WORKSHOP



NAVSWC-DD-MP-96-083




May 1996

COMBAT SYSTEMS DEPARTMENT
NAVAL SURFACE WARFARE CENTER DAHLGREN DIVISION
DAHLGREN, VIRGINIA

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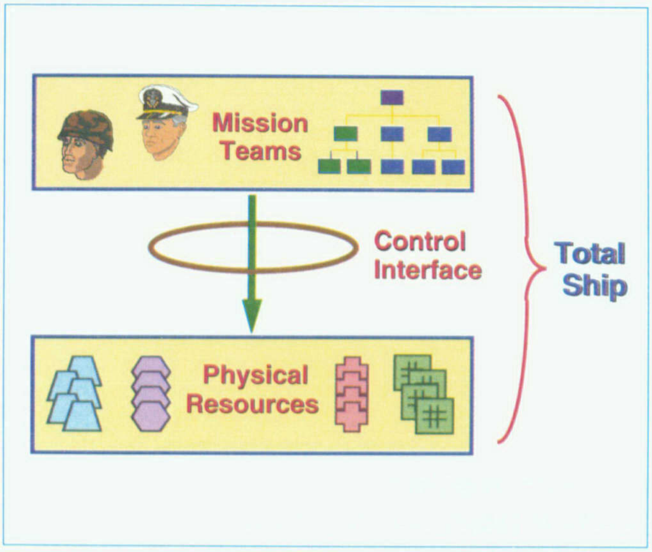
## INTRODUCTION

This report is the product of an effort to reinvent the Navy's process for transforming operational needs into warfare systems and combatants. The objective is to articulate a framework and strategy that fosters teamwork across organizational lines to create a new generation of warships, designed from the keel up to enable onboard mission teams to act as integral parts of a joint operating force and to set a new standard in life cycle effectiveness.

In defining a framework for total ship system engineering, the point of departure is the simple view of warships shown below. This view shows people at the top and mission resources at the bottom, with control interfaces in between. The control interfaces provide a backbone structure enabling mission teams to perform assigned mission tasks and make operations responsive to command direction and control. A ship may have several mission teams, each performing an essential mission task. For combatants, the chief task is to deliver ordnance on target. Other ship types conduct amphibious assault, command support, mine countermeasures, replenishment, and sealift operations.

At one time all shipboard systems were controlled directly by warfighters. Training a gun or changing a fuel flow rate meant moving a lever or valve. Today computers are widely used to implement control functions. While the number of people involved may decline, what warfighters must do remains the focus of attention. Even a fully automated ship would execute plans and orders from a mission team elsewhere.




POINT OF DEPARTURE

NSWCDD TR-95/152 (Reference 1) describes a vision and framework for total ship system engineering. It argues that designers and builders of future naval combatants must escape from stovepipe thinking and work together to maximize value delivered to mission teams on a life cycle basis. As shown below, this can be done only by understanding what mission teams must do, what the associated warfighting processes will be like, and what information will be needed to execute those processes.


TOWARD A WARFARE VISION

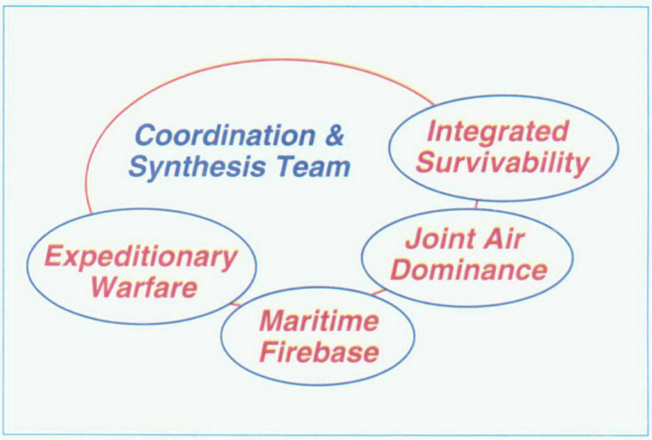
Efforts to engineer a complex process call for two kinds of knowledge. First is knowledge of the existing process; and second, knowledge of potential new ways of doing business. This suggests that a mix of operators, engineers, and technologists be used to address a major warfighting process. Lack of a suitable mix could slow recognition of opportunities for innovation or lead to system concepts that are operationally impractical.

## MISSION TEAMS WORKSHOP

Accordingly, a workshop was set up to involve experienced operators in an effort to reengineer a set of key warfighting processes. The aim was to improve or reinvent process characteristics, based on emerging concepts and technologies, and to identify opportunities for migrating to the target process over time.

### Warfare Process Areas

Since mission teams and tasks are seen as the right starting point for total ship system engineering, process improvement teams were set up to consider four broad mission areas. **Joint Air Dominance**, **Maritime Firebase Operations,** and **Expeditionary Warfare** account for many of the key offensive capabilities necessary to prevail in a littoral campaign. **Integrated Survivability** represents capabilities necessary to sustain dominance to seaward of the littorals. A fifth team was formed to facilitate workshop coordination and synthesize results across mission areas. The figure below shows the resulting team structure.




PROCESS REENGINEERING TEAMS

These mission areas represent a starting point for exploration of a development process that is warfighter driven. However, they do not encompass everything that naval forces will undertake in theater campaigns. Such areas as information warfare and antisubmarine warfare should eventually be considered, as well.

An approach based on mission teams is appropriate for many reasons. Perhaps most important is that it reflects the warfighter-driven character of US military strategy. A revolution in US thinking about military strategy began with a conference held at the Naval War College in 1972. That military officers should take a more active part in devising military strategy was a central theme of the conference. By 1990 each of the uniformed services had articulated a new strategy, based on offensive thinking and the operational level of warfare. These strategies were applied and largely validated in Desert Shield/Desert Storm. The goal now is to move toward a joint doctrinal framework that remains warfighter driven, but is accepted and understood across all services.

### Action Plan

The workshop began with a kickoff session reviewing origin and purpose of the effort. Each team had a mix of 8-12 operators, technologists, and engineers, and followed a four-step plan for addressing the process of interest. The general plan, shown on the opposite page, utilized techniques drawn largely from References 2-6. Between steps, participants shared information on key topics.

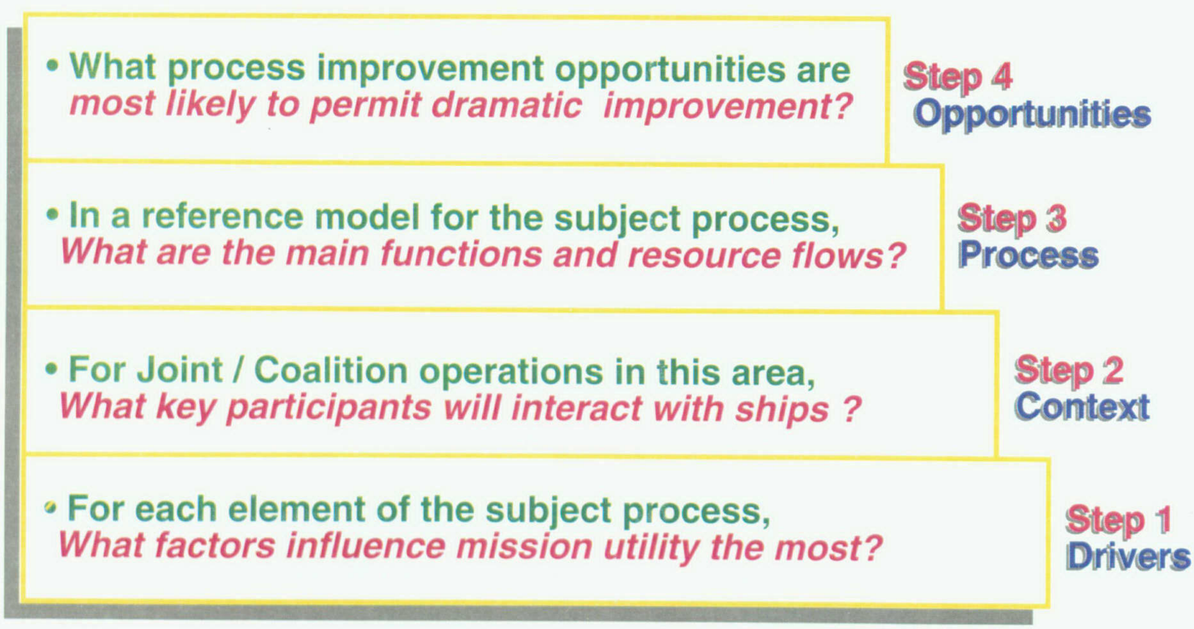
The first step called for discussion to arrive at a shared understanding of the current process (at a high level) and what it is intended to do. In a way, processes are what make effective action possible for large organizations. Almost every thing we do is part of a process. Every process organizes an array of people, materials, energy, equipment, and procedures into work activities, each completing a series of related actions to accomplish a specified task.

There are complex processes that involve thousands of people and simple ones that take only a part of one person's time. Shipbuilding is an example of a macroprocess; the selection of a shipyard is an example of a major subprocess. Reengineering teams are usually formed to consider a macroprocess. The point of departure for such an effort must be a high-level definition for the process of interest. The aim is to understand what the process does, the underlying concept of operations, and its key inputs and outputs. These are the elements from which a process performance specification is derived. For the workshop, strawman definitions and high-level flow diagrams were provided to serve as a point of departure. However, teams remained free to redefine the model for enhanced results. The session ended with a brainstorming exercise to identify factors driving mission utility.

The second step was to prepare a context diagram for the process of interest. The idea was to identify key interactions with other forces, units, or mission teams in the subject mission area. This helped with identification of process boundaries. While the workshop was based on a concept for engineering ships as systems, the goal was to shape the overall value stream for theater warfighting and not the value added by surface ships alone. Approaching the problem in this light encourages a shift away from stovepipe thinking to global or team thinking. Attention is drawn to the relationships between force elements and the transactions between them that may have the most potential for effectiveness gains.

The third step was to review a strawman reference model for the target process. The strawman identified major participants, events, and activities for the process of interest. The idea was not only to review the existing ways of doing business (conducting operations), but also to reinvent the process in the context of future joint and coalition warfighting operations. Implicitly the results depend on the ability of participants to identify emerging problems and the root causes for them. Emerging strategies and concepts of operation may add new tasks or capabilities to a broad mission area.

The fourth step was to generate ideas about how to make dramatic improvement in the process of interest. The aim was to consider how things should be done, rather than how they are done today. The potential for quick hits to make near-term improvements was also discussed.




PROCESS REENGINEERING TEAMS

**Participation**

The workshop was held in September 1995 at the Naval Postgraduate School (NPS), Monterey, California. Since NPS has a Total Ship Systems Engineering (TSSE) program directed by Professors Charles N. Calvano and Frank Fassnacht, some student participation was expected. In the event, about one third of the participants were NPS students and faculty. Since the school was in the middle of final exams, the enthusiasm and fresh ideas generated by NPS students and faculty reflect favorably on the school and on the Total Ship System Engineering program.

In all, representatives from 15 commands and 5 contractors attended, as shown below.

Joint Air Dominance Team

- LT Ed Burns, NPS
- LT Stan Chien, NPS
- Bill Colson, NPS
- Bob Fuscaldo, Synetics
- LT David Haas, NPS
- Harry Meese, Planning Consultants Inc.
- Robert Stack, Digital Systems Research
- Timothy L. Vance, NSWC Crane
- Ray Walsh, Sonalysts
- Cassandra White, NSWC PHD

Team Leader: Trish Hamburger, NSWC DD
Facilitator: Ralph Smith, NCCOSC (NRaD)

Integrated Survivability Team

- CDR Joe Berner, NSEA 03D1
- Rex Buddenburg, NPS
- John Buziak, NPS
- Chuck Calvano, NPS
- LT Craig F. Merrill, NPS
- LT Phillip K. Pall, NPS
- Paul F. Richardson, Strategic Insight Ltd.
- Sow Thong, NSWC IHD
- Robert Wunderlick, NSWC CD

Team Leader: Ben Raterman, NSWC DD F10
Facilitator: Ron Pollard, NSWC DD N04

Expeditionary Warfare Team

- CDR W. Ernest Bartley, SWDG
- LCDR Fred Beach, NPS
- Major Wayne Breakfield, MCCDC
- Russ Graff, NRaD
- LCDR Daphne Kapolka, NPS
- Leonard F. Picotte, PMS-317
- LT W.M. Rabchenia, EWTGLANT
- LCDR Jay Renken, NPS
- Gary Setti, NSWC DD
- Jon Sweigart, NSWC DD F30
- CAPT Charles P. Vion, Sr., COMPHIBGRU 2
- Dennis M. Warne, NSWC DD F31
- Col. M. Williams, EWTGLANT
- LT Col. W. A. Wright, MCCDC

Team Leader and Facilitator: LT George Snider

Maritime Firebase Operations Team

- CDR Lou Gratski, OPNAV 863F4
- Sue Hyatt, NSWC DD A51
- Thomas E. Jean, NPS
- James Miller, NSWC DD A51
- Michael Stumborg, NSWC CD
- Kai Woehler, NPS

Team Leader: CDR J.D. Stalnaker, NSWC DD
Facilitator: Jerry Gaston, NSWC DD N05

Coordination & Synthesis Team

- Ben Raterman, NSWC DD F10
- CDR J.D. Stalnaker, NSWC DD
- Dennis M. Warne, NSWC DD F31
- Trish Hamburger, NSWC DD
- Ron Pollard, NSWC DD N04
- Bernie Duren, NSWC DD N04

## JOINT AIR DOMINANCE TEAM

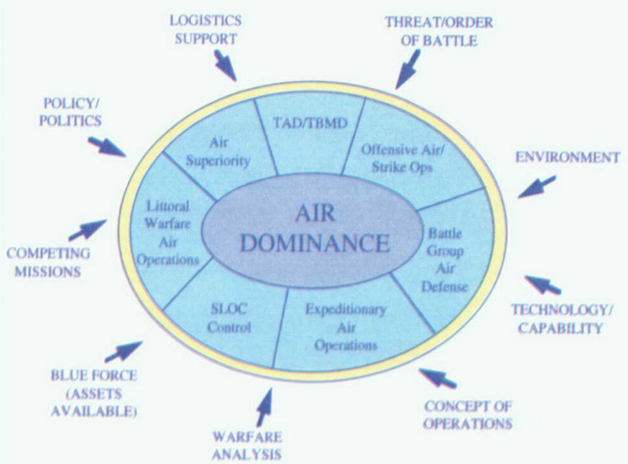
### Objectives

This mission area includes all operations conducted by joint and combined forces to gain command of the air in a theater of war. It involves a series of actions to destroy or neutralize enemy air and anti-air forces and to protect friendly forces from air attack. Navy and Marine Corps elements will participate in such operations by utilizing ready strike, air defense, and fire support capabilities against targets on either side of the shoreline, along the maritime routes of access to the conflict zone, and around strategic seaports, airports, and other essential logistics facilities in a littoral area of operations. As shown below, air dominance covers a number of key activities. Thorough knowledge of the information shown around the outside of the figure is essential in conducting operations. There was extensive discussion of definitions, context, and information flows for the process.

### Process Improvement

The warfighting process model is shown on the facing page. Major functions are shown along with information flows and resource flows.

Beyond its review of the strawman model, the team generated a second model, breaking the process into mission planning and mission execution subprocesses. The team went on to identify opportunities for process improvement. Highlights are given below.




JOINT AIR DOMINANCE

- Incorporate training functions into the core of each onboard system and make them accessible at watch stations to support off-watch training in port or at sea. The embedded capabilities should include scenario generation or revision on the fly, netting to other ships or joint forces as required, and options for either post-exercise or on-the-fly remediation.

- Develop a common operating environment with a common data warehouse, using a logical database, where data items need to be entered only once and can be retrieved many times from any location. Information that would improve operations is trapped in isolated submodes and could be used for automated trend analysis, reporting, and planning aids.

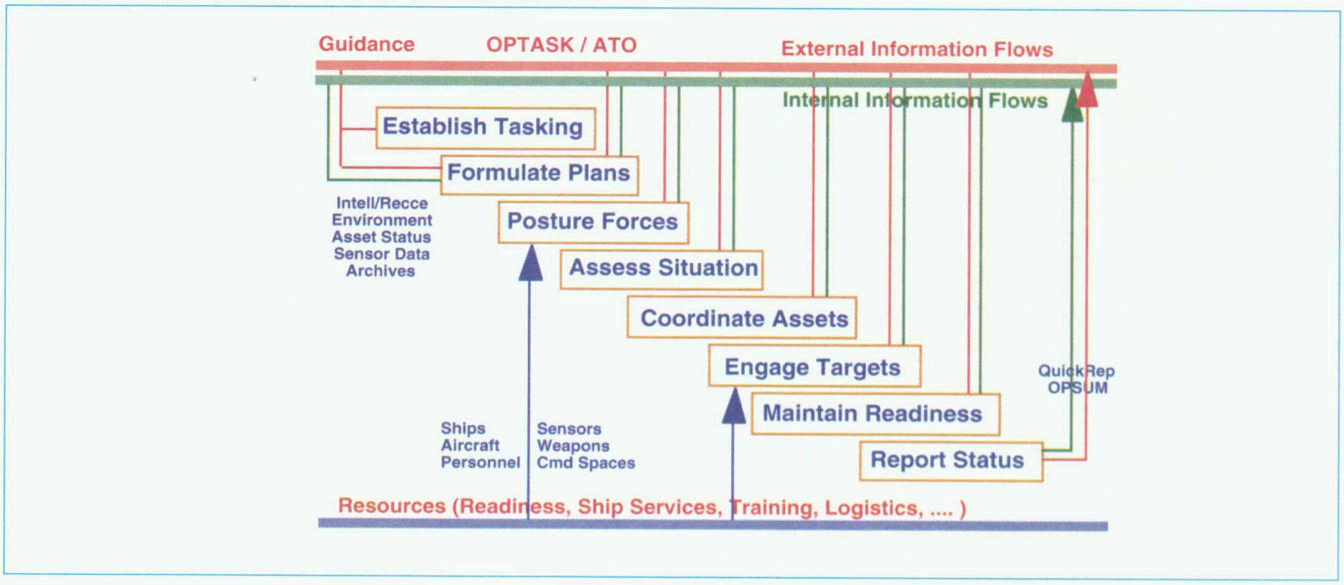
- Provide an integrated decision aiding system that can answer questions and prompt users in situations fitting specified criteria. The system should offer a real-time database and be suitable for tactical and ship service applications shipwide.

- Create an integrated communications system that supports automated communications plan development and configures on-board systems automatically for plan implementation. No more than one operator should be required.

- Develop a command center that brings all warfighting and ship control functions together with easy access to all types of information. Operator interfaces should provide data fusion decision aids, visualization tools, voice recognition to simplify security operations, and automatic, real-time tools for assessment of weapon, sensor, and ship services capabilities. A secondary command center able to perform most warfighting and essential ship control functions should also be provided.

### Associated Issues

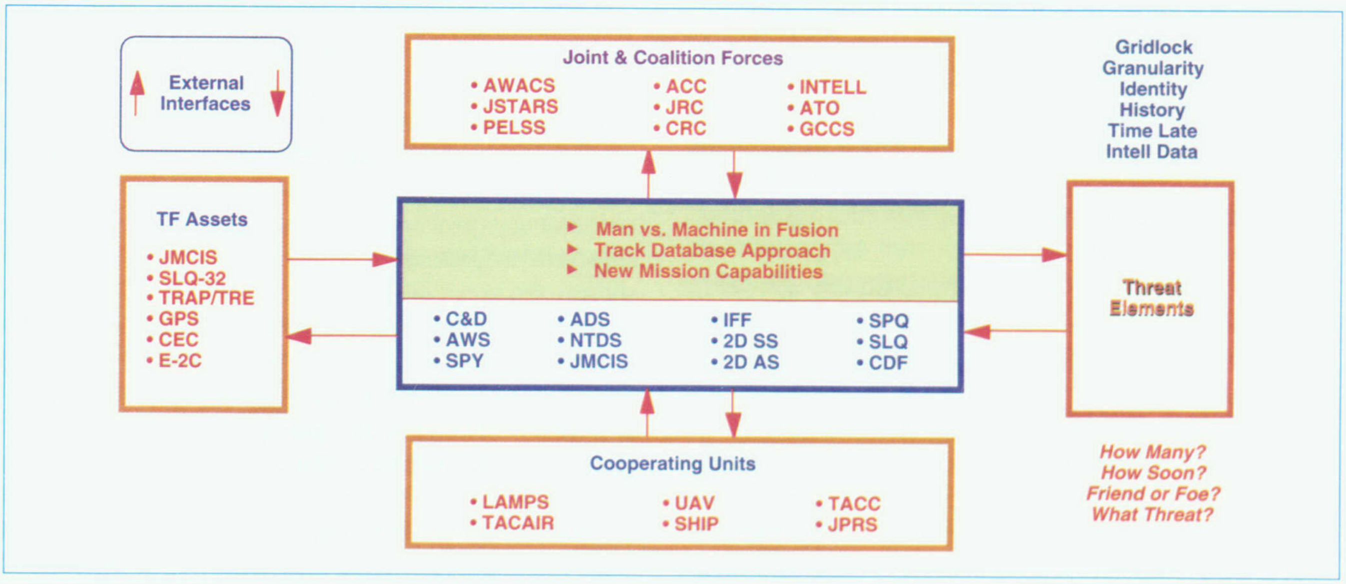
Emerging warfare concepts and technologies may add new tasks or capabilities to this warfighting process. The progress of missile technology is extending the battle space kinematically while making it increasingly difficult to separate




JOINT AIR DOMINANCE PROCESS MODEL

threats from clutter. There are opportunities for naval forces to develop new roles in coordinating joint assets to achieve air dominance, and in coordinating air dominance assets to support the land battle. In particular, naval forces may be well fitted to carry out such a role in the opening stages of a theater campaign. There may be a need for associated capabilities: e.g., transfer of an air dominance commander from ship to shore as theater operations progress. In addition, naval forces may develop new capabilities in such areas as cruise missile defense over land. The figure below highlights the importance of rationalizing information flows in this mission area (as in others).

Another issue has to do with assumptions about the nature of mission teams. Normally they involve onboard personnel and resources, but there is potential for outsourcing some teams and tasks. Relevant concepts include use of embarked teams and resources, fly-away teams, cooperative engagement, and telepresence.




RATIONALIZING JAD INFORMATION FLOWS

## MARITIME FIREBASE TEAM

### Objectives

Ships may be considered to act as maritime firebases in delivering ordnance against land targets of all types, including coastal installations. As suggested in the illustration at right, a ship conducting maritime firebase operations must destroy or neutralize enemy targets ashore using a variety of missile and gun systems as well as armed helicopters. The list of combat resources can be extended to include launch and support of air and ground units if desired.

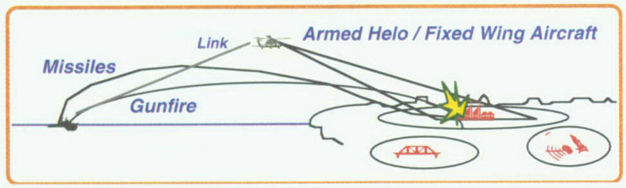
In future, maritime firebase operations are likely include a wide range of mission tasks, from invasion stopping, strike, and fire support to littoral battlespace dominance. This extends the target set to include not only enemy tactical missile forces but also to missiles and aircraft in flight over land. Surface ships performing these tasks must be able to deliver ordnance quickly against fixed and mobile targets, at ranges up to 1000 nmi, with great accuracy and firepower. Ships will work together with air and ground elements, along with national reconnaissance assets, to provide combined arms firepower for theater warfighting. Key supporting tasks may include control of air and surface assault operations, surveillance, control of air marshaling areas, and control of unmanned air vehicles.

### Process Improvement

The basic warfighting process is shown by the diagram model. Major functions are shown along with information flows, resource flows, and drivers. References 7 and 8 provide further information.

After reviewing the reference model, the team was asked to identify opportunities for improvement in maritime firebase operating processes. Highlights are given below.

- Automate naval surface fire support to reduce manpower and training requirements while adding new capabilities for sensor-to-shooter integration. In particular, ammunition handling and navigation functions should be automated, with new capabilities provided for combat identification and decision aiding.




CONCEPT OF OPERATIONS

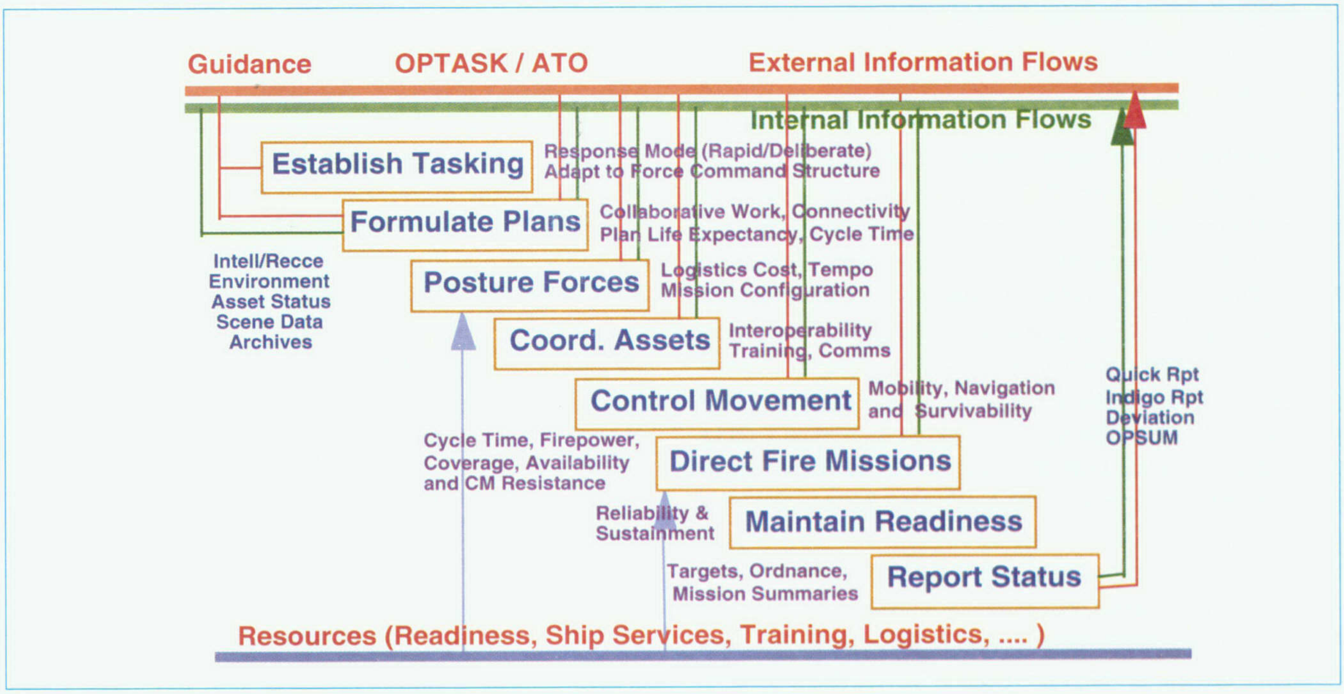
- The communications requirements for fire support operations should be addressed across all services, and efforts should be made to develop a standard data structure for mission data flows.

- Work toward development of a joint doctrine and an integrated concept of operations for all-arms fire coordination in support of the land battle.

- Assign 8-10 cruisers and destroyers to provide dedicated support for Amphibious Ready Group (ARG) operations. These ships should be configured with improved gun systems for use in the maritime firebase role. Air defense capabilities should be retained to add firepower to the ARG. Modified electronic warfare, intelligence, and communications suites will be needed to support full integration with the ground forces. It is envisioned that these ships would be assigned to the amphibious group commands to ensure they are fully integrated into the planning, training, and deployment cycles of the ARGs. Arsenal ships will make a welcome addition to this nucleus, once deployed.

### Associated Issues

US Soldiers, Sailors, and Airmen are set to enter the 21st century armed with new warfighting doctrines that emphasize the mobility of modern forces. Where the Sailor and the Airman are almost forced, by the nature of their operational domains, to think in terms of projecting power beyond the medium in which they operate, the Soldier's objective is to destroy the enemy's armed forces and will to fight. The challenge for naval forces is to contribute




MARITIME FIREBASE PROCESS MODEL

heavy firepower to such operations, whether in support of US battle forces or regional allies. Use of a maritime firebase to stop an attacking ground force (acting to assist an ally) is an example. There may be an opportunity for naval forces to develop new operational roles and capabilities in coordinating combined arms fire support for the land battle. Associated command and control structures may change as new doctrines and capabilities for theater warfighting emerge.

Some form of combined arms fire coordination capability, providing for integration of strike and battle space dominance with existing fire support capabilities (including air, surface, and artillery elements) is probably necessary for successful execution of the new doctrines. As long as massive amounts of ammunition are necessary in the land battle, ships are likely to remain the most affordable way of delivering weapons to the battlefield. Surface ships have the mix of endurance and flexibility necessary to accommodate maneuver warfare operations while sustaining US presence in forward operating areas. Thus maritime firebase operations are likely to become an even more important element of US theater warfare capabilities.

Associated warfighting processes must be greatly improved to provide envisioned capabilities. This calls for a faster reactive strike capability, seamless connectivity between sensors and shooters, quick response targeting capabilities, and weapons that can be effective against a broad array of targets.

Today each weapon system maintains its own target database, and the tactical picture ashore is clearly of interest. Since target sets overlap, it is not clear if there should be several different (single purpose) tactical picture systems or one multipurpose system. Dealing with target identification requirements involves a similar set of questions. Other key concerns will include mission planning cycle time and reducing the incidence of collateral damage.

A ship conducting maritime firebase operations will also have to deal with a variety of cooperating commands and units, each providing a piece of the ship's overall tactical picture. As in joint air dominance, it appears the process can be improved by rationalizing information flows.

# EXPEDITIONARY WARFARE TEAM

## Objectives

Maritime forces with embarked Marine elements will be a key part of tailored force packages used in peacetime stability and crisis response operations. The force packages of interest include Amphibious Ready Groups (ARGs) and Naval Expeditionary Task Forces (NETFs). Both are able to carry ground forces to a distant operating area and to establish them ashore despite the possibility of enemy attack. The aim for this team was to address what future ARGs must do. This part of the workshop was an early step toward "Design for Ownership" in the LPD-17 program.

An ARG consists of a MEU(SOC) - Special Operations Capable Marine Expeditionary Unit - plus a detachment of Navy SEALs, embarked in 3-5 amphibious ships. The MEU(SOC) is built around a reinforced infantry battalion landing team, a composite helicopter squadron, a SOC platoon, and a service support group. Each MEU undergoes a very demanding process to certify its readiness for conducting special operations before deployment. Cruisers and destroyers may be assigned to provide added firepower; mine countermeasures assets, to clear enemy minefields from shipping lanes; and auxiliaries, to supply ammunition, fuel, and stores. Each contributes to ARG warfighting capability. At times a carrier battle group may undergo fleet certification with an ARG/MEU, and the two groups then operate together at sea. If necessary, several ARGs and carrier battle groups can operate together as a Naval Expeditionary Task Force. Reference 9 provides further information on amphibious warfare doctrine.

## Process Improvement

After reviewing the process reference model, the team considered opportunities for improvement in processes for expeditionary warfare. Many of the ideas raised have to do with improving the flow of tactical information between naval and ground forces. Littoral warfare involves a different kind of battle space, one in which events ashore have a great deal to do with mission goals and tasks. Naval forces add depth to the battle space and create new opportunities for maneuver. But this isn't a Navy battle space alone; the naval forces and tactical forces ashore must develop a shared understanding of the military situation. While connectivity was achieved for many years by passing information through a flagship, such as an aircraft carrier, future combatants may act as integration nodes in theaterwide command and control networks that tie sea-based and land-based forces together. Getting surface ships "in the loop" is thus a key problem in expeditionary warfare. Highlights are summarized below.

- Work toward a joint doctrinal framework that will allow sea, air, and land forces to fight as one in future expeditionary warfare operations. Adoption of common doctrine will enable development of integrated approaches to communications, decision aids, data structures, training and logistics support.

- Work toward an integrated approach to mission planning. Commonality in mission planning will begin with a shared concept of operations and command structure, and in many regional conflicts the decision criteria for key phases of the campaign will have a joint flavor. Problems can arise in planning because ships do not participate in the rapid-reaction planning process used by the Marine Corps. Overall, planning must bring together three different views of a mission: a blue view, a green view, and a combined view.

- Provide for sharing of amphibious warfare data across the ARG. Major warfighting systems are increasingly becoming networks with nodes in the air, afloat, and ashore. While mission teams and warfighting capabilities generally reach the combat zone in ships, they must be able to operate as part of a distributed warfare system.

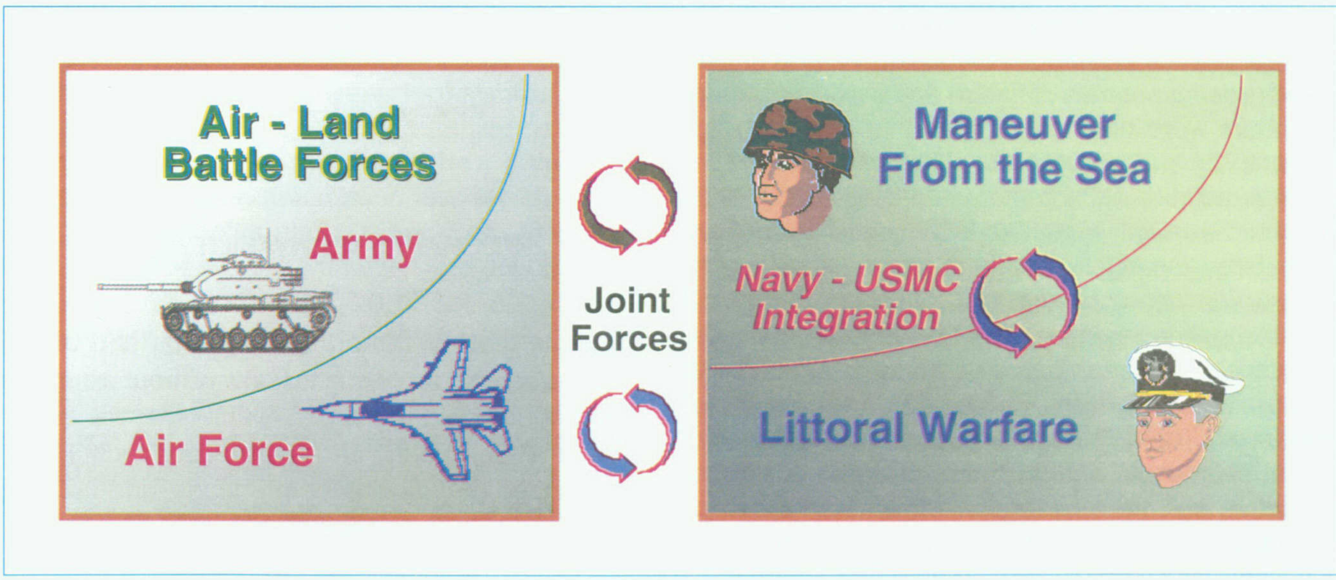
- Given the importance of a shared understanding of the battle space, the Navy and Marine Corps can't risk not having a common situation plot. This involves more than a common command and control console. It means getting appropriate information to users at all locations and levels of command, regardless of the actual equipment used. The information must be timely and can't be just an interpretation of events; it must have the ring of validity.

## Associated Issues

The term "expeditionary" implies a mind set, a culture, and a commitment to forces designed to operate forward and to respond swiftly against a distant adversary. As the figure below suggests, the concept calls for closer integration of the Navy and Marine Corps and new capabilities for joint operation with air-land battle forces.

There are significant opportunities in this area for creating a joint "system of systems" to achieve dominance ashore. While the ground forces available in the first three weeks of a crisis may be primarily allied forces, Navy and Marine Corps support to allied defenses could be substantial. Identifying how to incorporate arsenal ship capabilities in such crisis response operations would be worthwhile. After three weeks, however, delivery of sizeable Navy and Marine forces to a theater is possible. This involves capabilities we don't have today in such areas as prepositioning, forward presence of mine countermeasure assets, and fire support. Key concerns include protection of shipping, assault lift, awareness of the tactical situation ashore, in-stride mine countermeasure operations, control of air marshaling areas, and support for embarked mission teams. The importance of joint operations means warfare processes of the naval services must be based on joint operating concepts and operational maneuver from the sea doctrine, outlined by Reference 10. This has major implications for command, control, and communications capabilities needed in surface combatants assigned to ARG or NETF operations.

There are other opportunities as well. Naval expeditionary warfare begins with operations to gain command of the sea, then exploits the same to project power against the land. Interdiction of maritime air and surface traffic, amphibious operations, and strategic nuclear warfare are established methods for power projection in a global war context. There are opportunities for the naval forces to develop new roles and capabilities for regional warfighting and for operations other than war. Capabilities for interdicting maritime air and sea traffic using nonlethal force, and application of information warfare techniques to influence decision making by a potential adversary are examples.




THEATER WARFARE ROLES AND MISSIONS

## INTEGRATED SURVIVABILITY TEAM

### Objectives

The term *survivability* is defined by Reference 11 as ... "capacity of the ship to absorb damage and maintain mission integrity." In effect, this team considers a concept of survivability that allows for avoiding threats as well. From this point of view, survivability involves the integrated use of all shipboard systems to anticipate and thwart or recover from failure modes and effects due to hostile action or the environment. The aim is to consider how a total ship approach to survivability should be defined and implemented. Key concepts include automation and integration of signature management, hard kill, soft kill, and passive defenses against threat weapon systems. This area calls for a new level of integration across traditional boundaries between combat and ship systems categories. A balanced view of both own ship and threat status must be provided to maintain command situational awareness. This involves new problems in resource allocation, deconfliction, and target information sorting. An illustration is shown to the right.

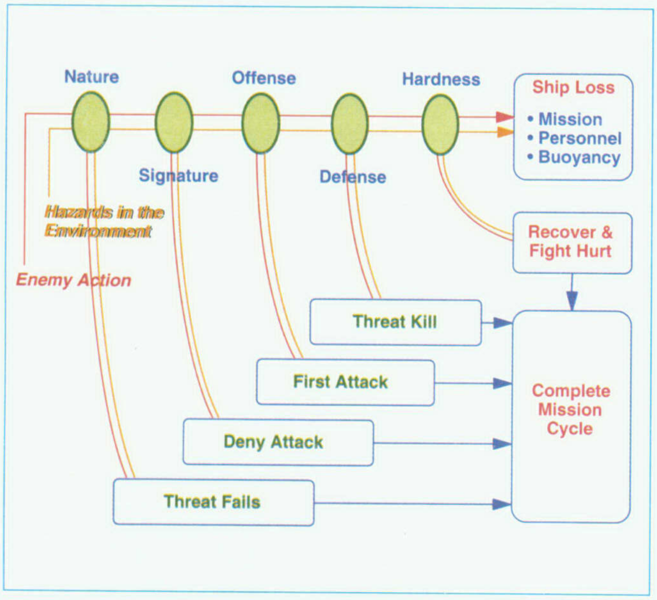
### Process Improvement

There was extensive discussion of alternative viewpoints for process definition and modeling. Team members were generally agreed that susceptibility, vulnerability, and recoverability characteristics must be considered in design for integrated survivability. This approach is readily quantified in terms of ship survival probability. One element that might be added to the diagram is development of survivability doctrine. Another approach involves a matrix of objectives versus functions. This approach assumes that doctrine is established, resources are allocated, and threats have appeared. The objectives are situational awareness, threat avoidance, and limitation of damage. Each objective can then be broken down into a set of functions (sense-control-act). The potential for cross-functional integration makes this approach interesting. An object-oriented approach was also discussed.

The process diagram shown on the next page represents an attempt to capture major elements of the discussion. Major functions are shown along with information flows, resource flows, and drivers.

After reviewing the reference model, the team proceeded to identify process improvement opportunities. Highlights are given below.

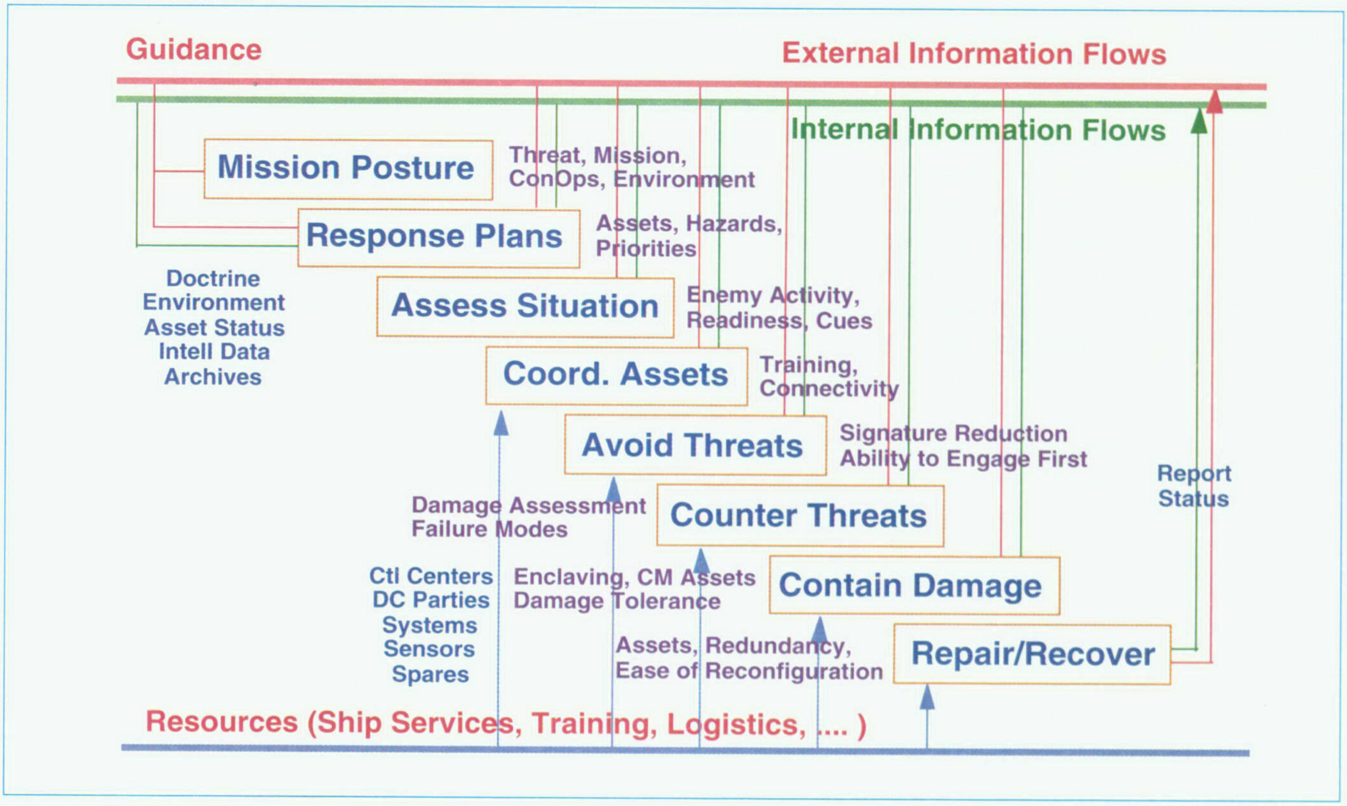
- Provide automated capabilities for cueing ship systems as to the potential for loss or damage, along with a mix of decision aids and automated response capabilities. A series of experiments, models, and analysis efforts to determine how to reconfigure given a hit prediction are necessary as a prerequisite. A total ship approach to data transfer media and more extensive automation (e.g., remotely operated watertight doors) are also involved.




INTEGRATED SURVIVABILITY CONCEPT

- Pursue state-of-the-art displays that can tell an operator what he needs to know without extensive and specialized training. This involves the use of information layering and visualization techniques, advanced graphical user interfaces, and tailoring of displays to the needs of individual operators.

- Pursue development of more survivable ship designs. This includes a focus on designs that remove weak links (e.g., chilled water), reduce manning, improve fire suppression systems, and enhance ship structural integrity (box girder, double-double hull, enclaving).




INTEGRATED SURVIVABILITY REFERENCE MODEL

### Associated Issues

The interactions between manning practices and design for survivability were highlighted. For example, automation to reduce manning can also mean casualties are reduced when ships are damaged. However, automation also leaves fewer people to plug holes and put out fires. A set of ground rules for dealing with such interactions may be useful as a starting point for a process improvement effort.

Reliance on manual backup capabilities is another practice that interacts with design for survivability. Manual backup is often assumed to be a firm necessity in highly automated systems. But it can mean crippling penalties on any attempt to automate hull, machinery, and electrical systems, and it is by no means universal in advanced systems. How should we decide how much manual backup is enough?

Survivability topics were raised by other teams as well. Generally these had to do with force-level concerns. At ship level, the more survivable a ship becomes, the more ready it is to go in harm's way. But at force level, the balance of susceptibility and capability factors bears on mission Go/No-Go decision making. It may be worthwhile to provide a force level display of survivability posture, addressing mine threat information and Go/No-Go criteria for landing operations.

## COORDINATION & SYNTHESIS TEAM

The workshop concluded with a summary of results drafted by Coordination & Synthesis Team members. Following the workshop, this group continued to identify areas of shared concern to all mission teams. Those areas represent the nucleus of a general task environment for warfighting control. This environment must accommodate any mission team, providing operator interfaces and information flows as necessary to permit the available resources to be utilized effectively. In addition, it must help to reduce time and cost to get new technologies into the Fleet. These are key elements of a strategy for making a ship into an integrated "system of systems." Areas of special interest are shown in the figure below. The text continues with a summary of results.

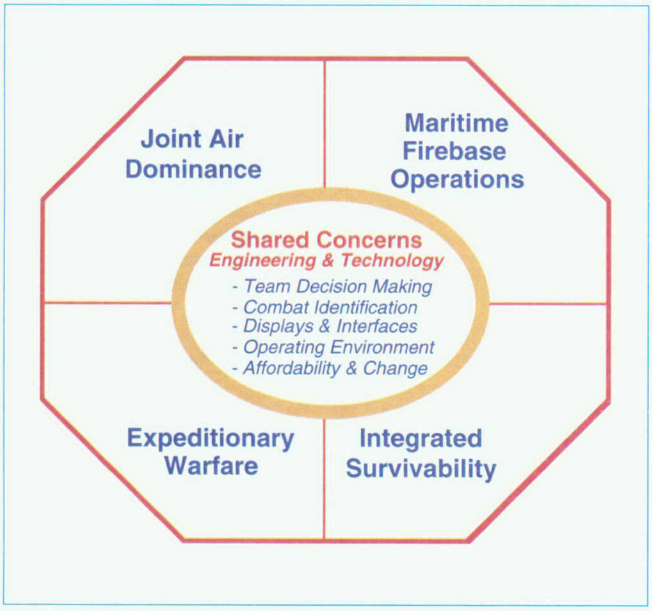
### Warfighting Control Vision

Eventually, advanced warfighting systems are expected to become networks of mission teams and component equipments extending across many platforms and locations. Command spaces will be designed for multipurpose use, with layout and functionality tailorable to any necessary mission or task. Each mission team will bring essential computer programs on board, configure sensor networks to support operations, load the mix of weapons desired in launchers and magazines, conduct test and training exercises en route, and begin mission operations on arrival in the conflict zone. All but mission-unique assets will come from a family of common watch stations, interfaces, computers, displays, and networks applicable across ship types. Open system design will make changes and upgrades faster and easier. This involves a view of the initial system configuration as the nucleus of a more advanced baseline, ideally equipped with "hooks" to accommodate future change.

Incompatibilities in the control structures provided for different mission teams and tasks will be eliminated. This depends on adoption of a standard interface between the ship's information plant and the display heads, designed to allow any watch station, at any shipboard location, to perform any function required. The aim is not to make all man-machine interfaces the same but to provide standards-based capabilities that allow tailoring to the needs and skills of the different operators and tasks. In addition, common application programs will be developed in such areas as track data management, mapping and charting, mission planning, data archiving, training, and readiness management.

### Operating "In the Loop"

To the extent that warfare systems involve joint assets, future surface ships will have to operate "in the loop," sharing information effectively across theater command elements as well as air and ground components. Adoption of a joint approach to doctrine, mission planning, and situation awareness will be necessary. This holds as much for joint air dominance and maritime firebase operations as for expeditionary warfare. It applies to force survivability as well, since mission Go/No-Go decision making will depend on the ability of all air, naval, and land force elements to carry out essential mission tasks.




FOCUS ON SHARED CONCERNS

### Readiness Management

Workshop results also suggest a need for readiness management is emerging at force and warfare system levels. This involves modeling current capabilities and using performance data to construct a feedback loop from operations to configuration management. To the extent that joint assets are involved, readiness may have to be addressed at theater level. Examples cited at the workshop are as follows:

- Joint air dominance involves a composite warfare system in which surface combatants, manned aircraft, land-based SAM sites, wide area surveillance networks, and other assets are coordinated to achieve maximum coverage and flexibility. The problem of readiness management comes to the fore when, for example, a SAM site ashore loses power unexpectedly. It may be necessary to adjust overall force posture quickly to close a "window of vulnerability" created by such an event.

- A system for tracking and dynamic control of ship-to-shore movement assets could add flexibility to expeditionary warfare. Juggling the demands for specialized assets such as heavy lift helicopters, fast surface craft, and amphibious assault vehicles may be necessary to respond to events calling for a change in movement plans. This will demand automated capabilities for tracking and rescheduling lift assets. Casualty evacuation could involve much more than changes in employment of lift assets. There is a corollary need for providing inputs to the Joint Casualty Tracking System.

- Readiness management in maritime firebase operations means tracking ordnance availability and projected coverage, which varies with unit location. Although a supporting arms coordination center has much of the necessary functionality, its mission scope is more narrowly defined than the maritime firebase concept. A capability for dealing with emergent time-critical targets will also mean better sensor-to-shooter cycle times than existing systems provide.

### Embedded Training

The genesis of a well trained crew is the shore-based training environment which provides naval personnel with initial in-depth instruction on shipboard systems and naval warfare techniques. But onboard training builds on this base without the cost of refresher training ashore. Computer modeling and simulation, for instructional purposes, is a rapidly developing field. Simulators have been developed to aid pilot training in every aspect of flying from mission training to emergency procedures. Future onboard training delivery systems will implement the concept of embedded training, in which realistic scenarios generated via stimulation are played out to exercise the entire crew, a selected mission team, or an individual. By presenting progressively more complex problems, future training systems will challenge mission teams and press them to achieve their full potential. Much of the required technology exists but has not reached production.

Through the power of visualization, simulation-based planning methods are creating new possibilities for coordination of mission planning across a joint operating force. By tailoring simulation and modeling tools to the actual operating area, and incorporating current intelligence, it may be possible to generate a visual rendering of mission plans on a synthetic battlefield. The notion of "just in time training" then becomes meaningful. This will allow joint and coalition forces to develop and execute a shared concept of operations with confidence.

### Automation

It is expected that future warfighting control capabilities will be achieved in part by major advances in automation. When we think of automation, we think first of reduced manning. But industry experience (in computer-integrated manufacturing) suggests that automation often has a down side. As it turns out, people drive flexibility; and a focus on technology rather than people issues can lead to inflexible systems. Since flexibility is a major consideration in building naval forces to deal with an uncertain future, we need a strategy that combines computers and people to yield systems with improved flexibility. For example, we might focus on ways of tailoring a ship's capabilities for a wide range of operational scenarios. However, a focus on operator interfaces promises leverage. If a ship is a weapon system, operator interfaces determine how effectively its resources are utilized to conduct warfighting operations. In addition, they may account for half of the software in major applications. While improvements depend on the cognitive performance of humans and are difficult to quantify, it is clear that new design tools and emerging technologies may permit dramatic changes in performance.

## REFERENCES


1. NSWCDD TR-95/152, *Total Ship System Engineering Vision and Foundations*, Dec 1995.

2. Hammer and Champy, *Reengineering the Corporation: A Manifesto for Business Revolution*; Harper 1993.

3. Davenport, *Process Innovation: Reengineering Work Through Information Technology*; McGraw-Hill, 1993.

4. Tapscott and Caston, *Paradigm Shift*; McGraw-Hill, 1993.

5. Johansson et al, *Business Process Reengineering: Breakpoint Strategies for Market Dominance.* Wiley, NY 1993.

6. Harrington, *Business Process Improvement: The Breakthrough Strategy for Total Quality, Productivity, and Competitiveness.* McGraw-Hill, 1991.

7. *Fire Support Functional Decomposition (RED BOOK), edition III (Final Revision)*; ATSF-FSC-3, May 1992.

8. Naval Warfare Publication (NWP) 22-2 (Rev B), *Supporting Arms in Amphibious Operations.*

9. Joint Publication 3-02, *Joint Doctrine for Amphibious Operations.*

10. US Marine Corps, *Operational Maneuver From the Sea: A Concept for the Projection of Naval Power Ashore*; released 4 Jan 1996.

11. OPNAV Instruction 9070.1, *Survivability Policy for Surface Ships of the U.S. Navy* (23 Sep 1988).

*On the back cover...*

*The Control Systems Advanced Concepts and Technology (CSACT) VOYAGER Laboratory at the Naval Surface Warfare Center Dahlgren Division provides a state-of-the-art environment for evaluating flexible total control system architectures.*