

NAVCOM # 1
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NAVAL SURFACE COMBAT STUDY

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1. PURPOSE

To construct an internally consistent methodological framework which will provide the following information regarding naval surface craft and their functional systems:

Major inadequacies, if any, in current capability:

Requirements to counter credible postulated enemy threats,

Levels of performance required of proposed new systems,

Relative desirability of alternative proposed new systems.

The methodology ultimately resulting from this effort is expected to be broad enough to accommodate all factors bearing on system design and force mix. The planned breadth of coverage will result in the following limitations:

a) No explicit and quantitative answer as to the absolute desirability of a propounded system ("figure of merit") will result. Available evidence, both qualitative and quantitative, will be developed and presented in such a fashion as to enable informed judgment.

b) Mathematical solutions in many instances will have to be approximate, because the number of variables involved will preclude rigorous treatment. Sensitivity of the answer to the approximations made should be established in each case.

c) There will be some practical limit to the level of detail which can be accepted as input. It will be necessary to provisionally accept certain concepts (e.g., "probability of kill") as being useful and amenable to quantification by detailed study deferred to later date.

d) As is normal in any quantitative analysis, the worth of the answer will depend on the credibility of the inputs. Sensitivity studies will assist in establishing the worth of the answer.

2. DEFINITION OF FIELD

The study of tactical warfare is considered to be far too complex for treatment as a whole, therefore that study has been divided into functional areas, of which Naval Surface Combat is one. The definition presented herein is intended to delimit the subject matter of this study - it is not, obviously, the only possible definition of Naval Surface Combat.

Naval Surface Combat is treated as a subdivision of tactical Sea War, which has been defined as non-nuclear war to control sea area and/or diminish the capability of an opposing naval force. A naval force (distinct from "Navy") has been defined as the subset of military elements operating on or under navigable waters, though dependent on land bases.

Prior to World War I, Sea War could rather readily have been separated, for purposes of analysis, into the interaction between surface fleets and the various effects of these fleets on land operations. At least four modern developments have been instrumental in drastic alteration of the situation:

- 1) The advent of the nuclear weapon,
- 2) The increasing range and offensive capability of aircraft,
- 3) The increasing effectiveness of submarines, and
- 4) The improvement in target detection capabilities and communications.

Control of sea areas is now closely linked with control of the air and control of the undersea; in fact it may be completely dependent thereon. Nevertheless, in an attempt to initially simplify the analysis, we separate the Sea War from the Air War above it and divide the sea war itself into two functional areas - Naval Surface Combat and Anti-Submarine Warfare. Naval Surface Combat studies the interaction between those elements operating on the sea surface. It also considers the effect on this interaction of postulated land, air, and submarine capabilities. It can furnish no final answer to problems of Force Mix or Naval Strategy until studies have been performed in other functional areas bearing on Sea War.

3. GENERAL APPROACH

a) Overall Evaluation

The performance characteristics and other properties of proposed systems can be expressed in numerous ways - some qualitative and some quantitative. It is not desirable to simplify by eliminating from consideration any of these properties. For instance the "human engineering" of a system - especially if it is defective - may be more important than the lethality of the warhead or the rates of fire theoretically attainable. For this study the various pertinent system characteristics and properties are to be subsumed under six general heading, as briefly discussed below.

1) CAPABILITY

This heading covers the general effectiveness and/or rate at which the system can perform its primary function. In the case of weapon systems the capability is expressed in terms of "target kill" which is broadly defined as denial or degradation of the functioning of hostile elements. Useful quantitative measures of capability can normally be developed.

2) VULNERABILITY

This heading is the inverse of the previous; it represents the capability of all hostile systems to prevent the functioning of the system under consideration. One exception is made to this rule; enemy counter-measures applied after launch of a weapon are treated as a degradation of CAPABILITY.

Some quantification of VULNERABILITY and of its effect on system worth can be achieved by two-sided simulations or by application of capability models from the enemy's viewpoint. Effort will not be expended on such processes in this study, however, (IN)VULNERABILITY requirements will be established by comparison with other friendly systems. Unless the vulnerability of the system to credible countermeasures, combined with its worth in terms of damage to the enemy's interest, are sufficient to make it a preferred target, it will be considered acceptable from the point of view of VULNERABILITY.

The credibility of the postulated countermeasures, and their consistency with enemy force structure and operation must be carefully examine. It is only too easy to assume an enemy

"ten feet tall"; the real problem is to establish the height for which it is reasonable to prepare.

The headings of CAPABILITY and VULNERABILITY will be those principally considered in establishing requirements or assessing concepts. The remaining headings are more directly of interest in the processes of system development and evaluation.

3) COMPATIBILITY

COMPATIBILITY includes all relations of the system under consideration with the natural environment and with other friendly elements and systems. Of especial interest under this heading are the requirements for support from these other elements or systems. The nature, quantity and timing of support requirements are to be compared with the functional capability of supporting systems in the projected force structure. If the candidate system imposes no major unusual demands it is judged compatible; if not, the nature and scale of effort required to satisfy these demands must be quantified as part of the total system manpower cost. For naval systems, of course, the most stringent compatibility requirements are often imposed by the element - ship or airplane - in which the system is to be mounted.

The above headings comprehend all those characteristics bearing on combat effectiveness of the system - the matters of interest to a tactical commander. Unfortunately the tactical commander has not been in a position to design and procure his own arms since the days of chivalry. These functions are performed by procurement agencies, which attempt to balance off combat effectiveness against certain completely valid concerns of their own.

4) COST

This consideration will not be approached from the angle of "cost effectiveness", since neither dividend nor divisor can be well enough calculated to make "cost effectiveness" a useful decision tool (though it may well linger for a time as a political weapon). COST (or more accurately, PRICE) however, is a valid consideration since the sums available for expenditure will be established by echelons above the actual procurement agency, to include the American people and their legislative representatives.

In the contemplated work on Requirements FOR systems, COST will not enter the picture. In the subsequent work (Requirements ON, concept generation, and system evaluation) an

attempt will be made to establish comparative cost by estimated effort required for development and production.

Post-production costs (operation, maintenance, training, etc.) are better measured by manpower investment. This approach will be used to the extent that single system demands can be distinguished from the general manpower investment in the appropriate functional fields.

5) PROGRAM FEASIBILITY

The general questions here are:

"Can the proposed concept or system be implemented through design, production, and deployment phases in time to achieve the expected benefits to national defense?"

The only aspect of this question to be treated in this study (for concepts and candidate systems) is an identification of existing technology gaps and some estimate of the probable time for closure.

6) GROWTH POTENTIAL

The properties included under this heading are those bearing on answers to two fundamental questions:

"Is the conceptual or candidate system of a type which may be expected to be effective under widely varying conditions and have capability to meet presently unforeseen requirements?"

"Will the necessary development program give collateral benefit to other desirable military developments?"

b) Levels of Analysis

The above categorization is believed to give some capability for ordering the manifold questions that can be propounded regarding any new concept or system. As earlier stated, the degree of concern with various system qualities varies with the level of the individual or agency involved (e.g., Tactical

Commander versus Procurement Officer). This phenomena will be approached by organizing questions and data into the following levels of analysis:

- I Naval Force Structuring
- II World-Wide Naval Strategy
- III Operational Area Naval Strategy
- IV Engagement Analysis
- V Duel Analysis
- VI Capability Analysis.

In the long-run the input-output parameters operating between levels will be identified and defined. Initially, however, it will be necessary to concentrate on one level at a time. Inputs from above to the chosen level will be assumptions as to conditions and environment; inputs from below will be estimates of attainable system or force characteristics. As previously noted, the Force Structure and Strategy levels cannot be well-answered based on this study alone.

LEVEL I. Naval Force Structuring

This level of analysis, which is intended to represent the organizational and procurement side of the Chief of Naval Operations (CNO), is influenced by still higher levels of interest and authority, commencing with the Department of Defense (DoD). These latter levels are represented by assumptions, primarily political and budgetary, of which the following are key:

- a) Investment in forces designed for non-nuclear Sea War will continue at roughly the current level for the indefinite future.
- b) Disarmament negotiations will impose no constraints on the nature or employment of non-nuclear naval systems.

The first assumption avoids the question, "How much is enough?", which is unanswerable anyway. No investment will guarantee success in any armed conflict, and extra insurance always appears desirable.

World-wide deployment requirements and overall naval capability relative to the largest postulated enemy naval force do bear on this question.

A major factor in naval force structuring is the investment in current inventory. Naval force elements, particularly ships, are replaced only with major expenditure of time and money. Therefore, there is greater resort to modification and improvement of existing systems than in the other services.

The output from this analysis level to the next lower is the inventory of friendly naval elements presumed available.

LEVEL II. World-Wide Naval Strategy

This level of analysis represents the operational side of CNO. It accepts as input the force inventory output of Level I, together with assumptions as to the mission imposed on the Navy.

It is assumed that under cold-war conditions the Navy may be assigned "Show-the-Flag" missions which hazard naval elements beyond the limits of normally prudent strategy.

It is assumed that the U.S. will not initiate the use of nuclear weapons at any time.

The output of analysis at this level would be the most desirable mix and disposition of naval elements (within the total imposed by Level I) for accomplishment of world-wide missions. This answer may be affected materially by the input "threat" - a description of the numbers, capabilities, and postulated employment of the naval elements of potential enemies. An investigation into preferred mix is expected to be less sensitive to "threat" assumptions than would be an attempt to design a total force to furnish a pre-established probability of success in mission accomplishment.

It may turn out that desired mixes for various operational areas (Level III) do not differ sufficiently to require any compromise at the World-wide level.

The principal tasks at this level of analysis will be:

- a) Formulation of World-wide missions for the Navy. The missions presently assigned by the Roles and Missions Document will be taken as a starting set; variations may be introduced if it appears they will have significant influence on

requirements. The primary functions of the Navy and Marine Corps are stated in the Roles and Missions Document as follows:

"To organize, train, and equip Navy and Marine Corps forces for the conduct of prompt and sustained combat operations at sea, including operations of sea-based aircraft and land-based naval air components -- specifically, forces to seek out and destroy enemy naval forces and to suppress enemy sea commerce, to gain and maintain general naval supremacy, to control vital sea areas and to protect vital sea lines of communication, to establish and maintain local superiority (including air) in an area of naval operation, to seize and defend advanced naval bases, and to conduct such land and air operations as may be essential to the prosecution of a naval campaign."

b) Scenario Development. Tactical war studies are presently supported by three different scenarios, which represent a spectrum of environment, intensity of conflict, and enemy capability. Two of these scenarios will be broadened to cover current naval operation. The Middle East scenario will represent a direct naval confrontation between U.S. and USSR in the Mediterranean Sea and Indian Ocean. The Southwest Asia scenario will represent naval operations of lower intensity against a USSR supported nation.

It will be necessary to develop a new scenario featuring operations on the high seas, rather than the restricted waters typical of the existing two. This scenario will feature use of Cuba as a USSR naval, air, and missile base. Such a scenario, whether or not considered credible, furnishes a tool for examination of both offensive and defensive Sea War in non-restricted waters.

c) Friendly Force Disposition. A critical situation, such as that represented by one of the scenarios, requires concentration of naval effort into one or more operational areas. At the same time, however, the Navy retains responsibility for its world-wide missions (LEVEL I) above). It will be necessary to postulate how many conflicts are to be engaged in simultaneously, and to sub-divide the naval resources available into those committed to each operational area.

LEVEL III. Operational Area Naval Strategy.

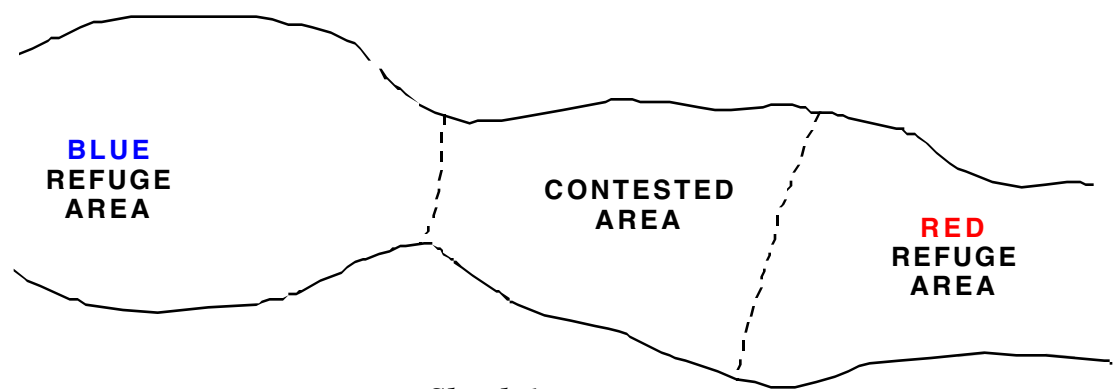
Studies at this level will be bounded by the following prescriptions, derived from higher levels of analysis:

- a) A description of the number, type, and capabilities of hostile naval elements committed to the area.
- b) A description of the number, type, and capabilities of friendly naval elements committed to the area.
- c) A specification of the area considered, to include reference to pertinent meteorological, topographic, and hydrographic data.

These boundary conditions will be generally adhered to since they enable quantitative study of interactions above the Duel Level. Variations therefrom may be made for sensitivity studies; e.g., "How are results altered if enemy strength is increased by a specified amount?"

The fundamental analysis to be made involves comparison of opposing strategies - given the inputs described, what are plausible strategies for the opposing sides and what sorts of engagements between hostile surface elements and other elements result?

Consider a restricted sea area with access at one or more points, as shown.



Naval surface elements have restricted range and must be periodically refueled and/or reprovisioned. Either the element itself or some reprovisioning element (tender) must operate from a shore base, which is defended against all forms of hostile action. The area which is thus defended is referred to in this analysis as a "refuge area". The refuge area obviously must include some friendly shore.

The operational area to be considered under each scenario will be defined so as to include a Blue refuge area, a Red refuge area, and some contested area between. Each side will, of course, seek to safeguard its own refuge area. In addition it will seek to extend its own refuge area or curtail that of the enemy for certain defined purposes (missions). These missions are normally closely allied with missions on or relative to the contiguous land areas.

For these missions opposing strategies will be described, and from comparison of these strategies a set of type engagements for the scenario will be drawn.

LEVEL IV. Engagement Analysis

The engagements developed by the above process will be defined in terms of:

- a) Location
- b) Participating elements on each side, to include land-based elements and sub-surface elements.
- c) Opposing missions
- d) Time or rate constraints, if applicable
- e) A definition of success for each side.

To calculate the probability of success for Blue, one must be able to model the interaction of elements having probabilistic definitions of capability in each of the prime adversary function; Fire, Maneuver, and Intelligence. Just how this is to be done is the most difficult methodological question of the entire study. The approach to be initially experimented with is one of Markov matrices. For small engagements the following will be defined: Initial state (condition of each element with respect to location, acquisition capability, maneuver capability, and fire capability); Alternative intermediate states and probabilities of transition

thereto (assuming good or "best" strategy by each sided); and Terminal states defining Blue or Red success.

It is highly probable that such an approach will be too ponderous for all but the simplest problems. Therefore, from the start an alternative formulation in terms of the potential of each element versus each hostile element will be made, and correlation between this and the Markov approach will be sought. We are not attempting to predict the outcome of type engagements by this method. Rather we expect to study the contribution to Blue probability of success or alternative possible improvements in potential of Blue elements.

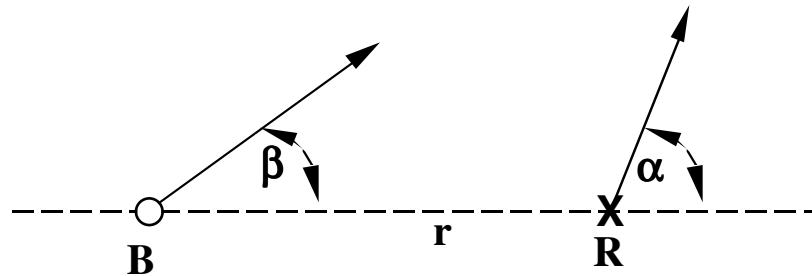
LEVEL V. Duel Analysis

A duel is an engagement between two elements, one from each of the opposing sides. The outcome is dependent on relative capability of the elements in fire, maneuver and target acquisition. It is also dependent on the tactic (attack or evasion) adopted by each contestant.

We assume it is possible to quantify for each combatant the following:

- p_i Single-shot probability of kill of the opponent
- τ_i Interval between shots
- ℓ_i Number of shots available
- v_i Maneuvering speed
- r_i Range within which p_i is realized

We describe the duel as follows:



Sketch 2

At time 0, Blue (B) and Red (R) are separated by range r . Red is on a course at angle α to the B - R line, Blue's course is at angle β . It is then possible (see Addendum hereto) to express as a function of r , α , β , and the above capability variables, the probability p_{i-j} that each will kill the other, given that courses are unchanged and dependent on target knowledge (the element ignorant of the other's presence has 0 probability).

With target knowledge, courses are very likely to be changed; a decision normally will be made to either Attack or Evade and α or β changed accordingly. A potential for kill of the opposing element is defined at all ranges - the potential is realized only after target acquisition and attack decision.

Duel analysis will examine the relative importance of the five performance variables listed above. It will also utilize these performance variables for calculation of potentials to be used in engagement level analyses.

LEVEL VI. Capability Analysis

This level of analysis establishes and substantiates the values of inputs to the duel level - namely, the p_i , r_i , τ_i , ℓ_i , v_i , listed above. Simplifying approximations will be required; the necessary examinations of sensitivity to these approximations are to be performed at this level.

p_i is really $p_{i,j}(r)$ - the probability that the i^{th} element on one side will kill the j^{th} element on the other side with one shot, given knowledge of the target and decision to fire. As indicated this quantity will normally vary with range r - to express it as having some simple functional dependence on r (often constant within r_i , 0 without) is a simplifying assumption.

Types of "kill" also need definition - these run a gamut from merely blistering the paint to actually sinking the ship. In general we recognize three types of increasing severity.

K₁ - Target is rendered temporarily incapable of fire or maneuver or target acquisition and communication.

K₂ - Target is damaged heavily enough to require major repair involving land facilities.

K₃ - Target is sunk or damaged beyond replacement.

Normally we shall mean K_1 when speaking of "kill". A crippled ship or plane not only offers no further threat but also is extremely vulnerable to further attack and damage.

$p_{i,j}$ covers all events from successful launch through warhead detonation and its interaction with target components. It is dependent on the detailed functioning of weapon, launcher, and possibly command components, on environmental conditions along the flight path, and on enemy countermeasure actions. All these facets of the problem require simplifying approximation.

τ_i - the interval between shots - cannot be less than that imposed by the manual or mechanical processes involved in re-firing. τ_i may be lengthened above this minimum by the firing doctrine used. For major weapons, to avoid unnecessary depletion of capability, a "shoot-look-shoot" doctrine is usually sound. This makes τ_i equal to the flight time of the weapon plus some observation and re-fire time.

ℓ_i represents the allocation of ammunition to any given duel or encounter. This may represent the total ship-fill, or - more probably - a lesser amount set by doctrine or tactical decision based on the situation.

v_i will normally be a constant figure - the sustainable speed for combat engagement. Such other descriptions of maneuver capability as combat radius and turning radius may be occasionally used, but will normally be ignored.

The variables of target acquisition and of communication will not be examined in detail in this study; parametrically - varied assumptions will be substituted.

Addendum to NAVCOM 1
15 October 1970

NAVAL SURFACE COMBAT STUDY

-- QUESTIONS FOR ANALYSIS --

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With the approach to the design of the Naval Surface Combat Study described, the next step is to produce a list of detailed questions which may require answers in the final study report. A partial list follows.

Questions - Level I - Naval Force Structuring

1. What are the considerations in general which bear on a choice between modification and new construction?

Questions - Level II - World-Wide Naval Strategy

1. Are the Navy missions assigned by Roles and Missions Document still valid in terms of national objectives?
2. In regard to these missions, what areas and lines of communication are to be considered "vital"?
3. What does "general naval supremacy" mean?
4. What is to be considered the maximum threat? USSR Navy?
5. In a non-nuclear war, what are credible ground-rules re: ballistic missile submarines?

6. Will there be requirements in the future for the following interactions with land? Blockade? Amphibious Invasion, Helicopter invasion from Sea? Naval Gunfire? Reconnaissance? Clandestine Contact? Cargo Delivery?
7. What will be the maximum simultaneous requirement in these areas ? (To be added to that for control of seas.)
8. Is it possible that the surface fleet will be replaced by an undersea fleet? By aerial protection of convoys? By a combination of the two? By something else?
9. How does the potential for escalation to nuclear conflict affect strategy during a non-nuclear war?
10. How can the Navy engage in tactically unsound "show-the-flag" operations at minimum risk?

Questions - Level III - Operational Area Strategy

1. What is the possibility of keeping all enemy surface elements under observations at all times? How about capital units at least - down to 2000 ton empty displacement?
2. If the above is a possibility, how does preclusion of surprise affect operational area strategy?
3. Does the current Naval tactical information system for the fleet (NTDS) include such a monitoring?
4. How does one balance task force (fleet) capability as between surface, AAW, ASW, and counter-land capability?
5. To what extent, and how, are weather and sea state considered in operational area strategy?

Questions - Level IV - Engagement Analysis

1. How does one demonstrate (exemplify) the desirability of surface element specialization?
2. What is the range of desirable specialization?
3. What doctrine regarding ammo expenditure is employed by a task group?

Questions - Level V - Dual Analysis

1. How do ECM and ECCM capabilities affect Duel Analysis?

Questions - Level VI - Capability Analysis

1. How does one express ship-fill limitations?
2. How are operating capabilities and vulnerabilities to be made consistent, within any given time-frame, as between friendly and enemy, and between various classes of elements?
3. What is to be assumed as to present (future) P_{KILL} of warheads (parametric on weight) versus vessels of various classes?
4. What is to be assumed as to present (future) accuracy of naval guns and of missiles (dependent on guidance type)?
5. What is to be assumed as to the effect of weather and sea-state on elements' speed? Ability to perform primary functions (fire, launch aircraft) etc.?
6. What reaction times (including rates of performance) need to be defined? On what parameters are they dependent?