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Limited War Gaming

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LIMITED WAR GAMING

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by

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War Gaming. When most of us think of war gaming, we think of the war gaming that was done in World War II and earlier, particularly in Germany and Japan, that involved models, sandboxes and large deck areas on which forces were moved. Such games involved elaborate sets of rules, computation tables, and umpires who evaluated the outcomes of conflict situations. This type of game is still being played in our own time; but military gaming in America today encompasses many other techniques used to study military problems. Some of the methods used are the classic ones used in World War II and earlier. For example, one can still find being played today, a Kriegspiel similar to that which Von Reisswitz introduced into the Prussian Army in 1824. There are, as well, many new methods being used presently in military gaming that are quite different. Even a World War II war gamer would be surprised at the use of the modern computer and game theory.

Historically, Kriegspiel goes back to the game of chess, but the type of game we used in World War II was invented by Prussian War Counselor von Reisswitz, and his son, a Lieutenant in the Artillery of the Prussian Guard early in the 19th century. It used a sandbox, blocks of wood, and a book of rules. Because of the problems associated with the degree of reality which the game reflected, rigid and free forms of the game developed. Rigid Kriegspiel emphasized reality, and free Kriegspiel emphasized ease of play. We still have both forms today. In rigid gaming, rules, dice, and calculations were necessary in order to determine the outcome of conflict interactions. In free play, the game umpire evaluated outcomes based on his experience and judgment. Since World War II, it has been the electronic computer that has radically altered gaming. The classic Kriegspiel derived from military studies, but the digital computer was developed in an academic environment to help solve scientific and engineering problems.

Game theory, on the other hand, had its origins in economics and mathematics (von Neumann and Morgenstern, *Theory of Games and Economic Behavior*). The theory of games has been applied to military problems, particularly the zero sum–two-person game.

All three types of gaming are still going on today. For example, the Navy Electronic Warfare Simulator here at the Naval War College derives primarily from the classic Kriegspiel, although it has a number of automatic features. In contrast, naval military gaming at the Johns Hopkins University Applied Physics Laboratory is almost entirely associated with the electronic digital computer, and the features of the classic war game are almost completely absent.

In limited war problems here at the Naval War College, classic gaming techniques are used with opposing teams and a control group, and an assist by the facilities of the NEWS. Limited war situations have also been gamed on computers and studied using mathematical game theory.

Experience has shown that the benefit to be obtained from gaming can best be described by the word *insight*. The war game forces the human player, or analyst, to think about unexpected situations and to face problems of which he may not have been aware. It also constitutes the kind of test that gives primarily negative results–it will tell you what will not succeed. However, if a tactic, or strategy, does succeed in the game, this does not mean that it will work in real life. It has yet to pass the ultimate test of combat.

Two important variants of military gaming are 'political gaming' and 'business gaming.' In political gaming, we carry out political maneuvering, and conflict is diplomatic rather than military. One could, for example, invent a Berlin political game in which one team is made up of representatives of Western governments and the opposing team is composed of players representing East Germany and the Soviet Union. Various moves in the game might include such things as the stopping of allied or Soviet convoys on the Autobahn or applying diplomatic pressure elsewhere, short of armed confrontation. In business gaming we usually have two firms which manufacture the same product and are in competition with each other. Typical moves in business games include price-cutting and increasing advertising expenditures to increase sales at the expense of one's competitor.

As regards computer applications, some early work was done on large simulation models which were developed for strategic warfare. The advantages of the digital computer were that the writing of the computer program led to a better understanding of the problem; and in some cases, it was possible to obtain relatively accurate solutions.

To illustrate the complexity and flexibility of a large-scale computer simulation, there is described in the Appendix a convoy-submarine battle model developed recently by the Center for Naval Analyses.

It is also possible to combine the classic and computer techniques as illustrated in the following example.

Consider a limited war in which an air-ASW barrier has been set up. This operation can be simulated on a digital computer and information can be obtained on a computer printout on the probability of detection of transiting submarines. At some time during the game it is learned that a carrier aircraft is down at sea in another area. Previously stored in the computer in addition to the ASW barrier program is another program which simulates a search and rescue mission. This program is run, and one obtains a probability of success of the search and rescue mission. At the same time, a human player representing the VP commander is faced with the decision of whether or not to remove VP (ASW patrol aircraft) from the ASW barrier and send them to the area of the downed aircraft to engage in search and rescue operations and, if so, how many aircraft to reallocate to the search mission, when to send them, and how long to keep them diverted. This decision can be a very difficult one to make in wartime. It has morale and humanitarian aspects. Military judgment is very important. The implications of degrading the ASW barrier must be considered in terms of the enemy submarines which might penetrate the barrier at this time and the potential damage they might do. Therefore, in the game a decision can be made by a human player using his military judgment and perception.

Briefly, mathematical applications can be based on game theory or Lanchester's differential equations. Lanchester's 'square law' states that the fighting strength of a force is proportional to the square of its numerical strength multiplied by the fighting strength of one of its units.

A final area is laboratory simulation of military systems. Such systems involve many men and many machines in complicated interaction. The basic idea here is to take a number of military officers and place them in a computer laboratory in which they are faced with decisions they would have to make in the course of their normal duties. For example, the largest such laboratory is at the RAND Corporation in Santa Monica, California, where for a number of years, a logistics laboratory has been in operation. The operation of the Air Force Logistics System is simulated and Air Force officers make decisions concerning logistics and supply. The results of these decisions are analyzed by a computer which can simulate several months or years of activity and present the civilian analysts and the military officers with the implications of their decisions. The purpose of such a laboratory is to enable the civilians to observe and learn from the military officer in an artificially created military environment.

In summing up, it is unfortunate that there is a confusion of the various types of gaming. For example, there are some who may think because there are electronic devices and a number of blinking lights associated with the NEWS, that the NEWS games at the Naval War College are therefore computer games. NEWS games are not computer games, but are classic war games with the NEWS providing a replacement for the sandbox or chess board and model ships used in the last century. Unfortunately, even if a computer were available, years of game preparation and months of training of personnel may be involved before a simulation program can be developed and checked out.

Having briefly explored some military gaming background, I wish to devote the remainder of this paper to classic gaming of naval operations in a limited war in Southeast Asia appropriate for the NEWS, or a simple tactical trainer, or the chart-maneuver method.

Scenario. The first job in gaming is to review the scenario for the limited war. The scenario should make sense in terms of what is already known about the area, the political and military environment. In the war game scenario one has a capsule political conflict situation which deteriorates and leads to limited war. Thus via a war game scenario it is possible to distill the mountain of material, both classified and unclassified, from intelligence reports, newspapers, magazines, and scholarly articles, to produce the essence of the conflict in the area in which the military commander has an interest and thus allows him to be informed on the

political and military environment in which he will be fighting. Once the fighting begins, he remains informed via intelligence reports. He should get the information he needs to do his job in the war, and should not be concerned with extraneous information that will not affect the conduct of his part of the war effort.

As a naval officer he is particularly concerned with the sea power of his enemy or those who may later ally themselves with his enemy. He is further interested in the geography of the areas of possible conflict. For example, an attack carrier striking force is interested in being in a position to use its offensive air power while remaining as secure as feasible against enemy air and submarine attack.

To summarize then, the scenario should answer the following questions for a player:

1. What is the nature of the limitation on him? Are his country's policies, strategy, and tactics designed to keep the war limited—are there restrictions on the use of the force available to him?

2. What is the nature of the limitation on the enemy? Does the enemy desire to keep the war limited, and if so, what are *his* self-imposed restrictions?

3. What alliances and treaties can be relied upon? Which friendly countries will support him in his conflict, and to what extent (what forces can he expect to augment his own)?

4. What alliances, treaties, and augmentation forces will the enemy have?

5. Will the player be able to demothball ships to augment existing active forces? (Can he reactivate decommissioned naval vessels?)

6. What friendly or allied ports and port facilities will be available to him to support his operations? (What foreign countries will allow him the use of their port facilities?)

7. What allies does the enemy have and what ports and port facilities will *he* have available to him? (Even though one begins by fighting only one country, what are the possibilities that the enemy's forces may be supported and augmented by countries allied with *him?)*

8. Will one's own Navy be able to provide the shipping to meet the lift required, or will it be necessary to charter vessels from commercial sources in one's own country, or friendly countries, to supplement the existing troop and cargo lift?

9. What are the possibilities for rapid construction of close-in minor repair facilities ashore close to the operating area?

10. What is the prepositioned supply situation? Are supplies prestocked ashore near the conflict area? If so, what does one have? Where is it? How long would the supplies be expected to last, and can one resupply stocks ashore?

Missions. After the player is thoroughly familiar with the background describing the political, geographical, and military environment in which he will play your role, he then reviews his mission.

If he represents a major sea power, his mission has such elements as:

(1) Control of sea areas vital to the success of operations in the theater and denial of their use to the enemy.

(2) Location and destruction of enemy naval forces.

(3) Establishment and maintenance of lines of communication for the support of own forces.

(4) Providing trooplift when and as needed.

(5) Assisting own Army and Air Forces in their operations.

The enemy, of course, will attempt to counter and defeat the success of one's missions either through large-scale air and naval operations, or if he is a minor sea power, by harassment by submarine actions, guerrilla type activity, and minor counterblockade operations.

Orders of Battle. In preparing naval orders of battle in gaming we are interested in the naval elements we plan to utilize or maintain in reserve for future utilization. For a Southeast Asian game, for example, it is important to contrast with the carriers, cruisers and destroyers of the SEATO forces, the submarines and

the small craft of indigenous forces, the junks and sampans which may be armed and provide mobility along the coast and interior waterways, and the motor torpedo boats which may have a surface-to-surface missile capability.

Strategy. Consider the situation where own naval strategy is primarily offensive in character. As such it would contain the following elements:

(1) Destroy enemy naval forces at sea and in port using

carrier task groups

ASW barrier patrols

air and surface bombardment

(2) Deny use of the sea to the enemy by blockade using

carrier task groups

submarine patrols

coastal sweeps by light air forces

guerrilla type operations at sea and ashore

raids by surface forces

mining of harbors

(3) Assist operations of ground forces and land-based air forces by using ship and shore-based aviation in

interdiction

close support

reconnaissance

sea patrol

supply operations

(4) Keep advanced naval forces at full strength by drawing on naval forces from other areas.

(5) Select a major base for support of naval forces with a secondary base as backup and other minor bases to furnish flexibility.

(6) Augment forces to fullest practicable extent by use of vessels and shore establishments of friendly nations within the limits set by those nations.

The enemy's strategy would be to advance *his* own ends on the land while attempting to defeat or blunt your naval strategy.

Tactics. Next consider the tactics which he would employ in carrying out strategy:

(1) Attack carriers (CVA) operate at sea in conventional formations, well protected at all times by strong screens of destroyers, within striking distance of their objectives, but beyond the assumed range of enemy fighter aircraft. Combat Air Patrol (CAP) is either in the air at all times or on the deck ready for instant takeoff.

(2) ASW carriers (CVS) operate as hunter-killer (HUK) groups and conduct ASW operations patrolling waters where submarines might be encountered. They also accompany transport groups to provide ASW protection and assist in repelling possible attack by enemy surface forces.

(3) An underway replenishment group (URG) is maintained at sea to provide logistic support to own naval forces—this group includes oilers, ammunition ships, and other stores ships. These ships shuttle between shore bases and the combatant ships at sea.

(4) Submarines on barrier patrol and on-station patrol are submerged except for periods when they charge batteries on snorkel. Some firing doctrine is established to determine what targets a submarine will attack. Submarines may also be used on special missions. Nuclear submarines may or may not be played in the game.

(5) Transport Groups and Replenishment Groups steam under the protection of surface screens and carrier task groups whenever such groups are available.

Plans. Next look at plans. By reviewing the plans one can see what sort of requirements are placed on own forces. Forces are moved in accordance with the plans, and the NEWS, a tactical trainer, or the chart maneuver method all provide a display of the movement of forces. (Figure 1 is an illustration of the manner in which force movement is displayed in the NEWS by projection on a 'master-plot' screen). Plans should be consistent with the capabilities of forces; but there may be inconsistencies. For example, it is inconsistent to plan to move a carrier task force through a strong-air or submarine barrier and not expect it to be detected. In a free umpiring game, the umpire might inject something unexpected to test your plan as well as your reaction.

Operations. Planning and operations are the areas which provide the greatest insights in war gaming. When one conducts an operation in a game, one can determine the feasibility of plans. In gaming naval operations one *tests* plans. It is at this stage that one tests the decisions which formed the basis of plans and thereby hopefully eliminates the bad decisions. In addition, during operations, unforeseen events may occur and decisions may be called for that were not planned.

Let us now look at some typical limited-war operations. In Figure 1, projected on the NEWS master-plot screen, we can observe an attack carrier striking group moving into position off the coast. Enemy submarines are active, and there is some interaction. A running account of the status of forces is displayed in tabular form on either side of the screen. Carrier attack aircraft are opposed by enemy interceptors. In addition to submarine attack, the carrier group is also subjected to air attack. One should anticipate damage and possible loss of ships of the striking groups.

Aerial mining is conducted, a coastal blockade is enforced, and enemy surface and submarine forces are attacked. The enemy also suffers damage and loss of part of his forces.

The losses each side incurs are determined by the umpire and his judgment must be accepted. The player's experience should allow him to plan and conduct operations in the light of whatever losses he incurs. One can consider the umpire's decision as the verdict of fate and make the best of it. Planning is on the basis of the possible, but one should also be ready to act when the improbable occurs.

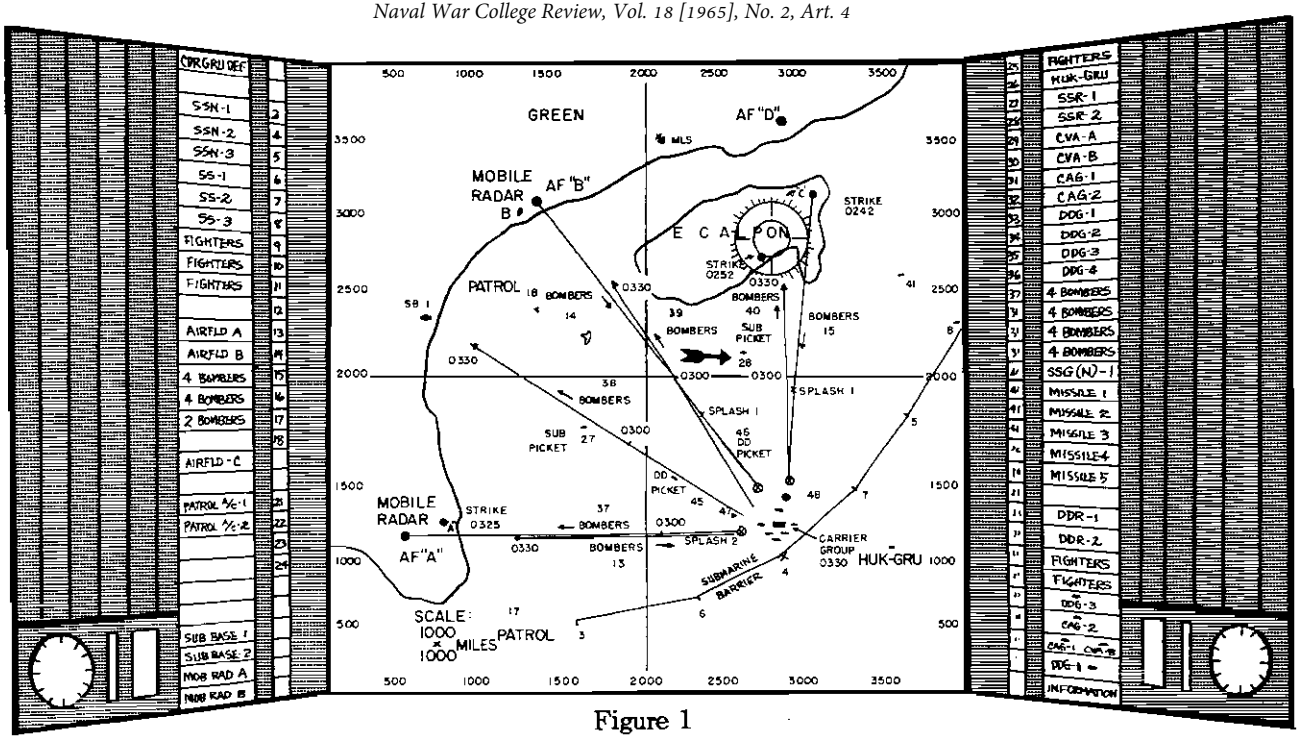

Figure 1

Attack Carrier Striking Group engaged in limited-war operations as projected on NEWS master-plot screen.

In closing, I wish to relate a story from British naval history[1] which illustrates in a humorous vein, the importance of the unusual in warfare, the sort of thing that a good umpire will inject into a game.

During the uneasy peace which succeeded England's interminable wars with Spain at the beginning of the last century, a Captain Smyth of the Royal Navy made a survey of the Mediterranean. He received a courtesy visit from a Spanish captain who gave him a silver tray as a souvenir of his visit. King's Regulations which had been drawn up in detail by Mr. Samuel Pepys, the famous 17th century diarist, who was also Secretary of the Admiralty for a time, made no provision for reciprocation in kind or for charging such gifts against petty cash, so Captain Smyth decided to give his Spanish visitor his own handsome leather-bound set of the Nautical Almanac. This work had been compiled under the direction of Thomas Young, a versatile scientific genius of the time. Unfortunately, Young apparently did not supervise the work very closely. It had been compiled for many years by elderly clergymen from Cornwall who lived on seven figure logarithms, did all their work by hand, and were only too apt to make mistakes. It was notoriously unreliable. For example, it omitted February 29th entirely on one leap year and no Englishman ever dared use it.

The Spanish captain, however, was apparently unaware of its reputation and he sailed away with his gift—and was never heard from again. Captain Smyth returned safely home using Italian and French navigational tables.

And so history records how so apparently minor a thing as an incorrect logarithm led to one of the most sophisticated victories ever achieved by the Royal Navy.

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[1]B.V. Bowden, *Faster Than Thought*, London: Pitman, 1953.

APPENDIX

A COMPUTER SIMULATION FOR DETERMINING SEALIFT CAPABILITIES AND ATTRITION IN AN ASW ENVIRONMENT[1]

General. The prime purpose of this simulation was to investigate ASW capabilities and their effects on convoy defense.

The convoy-submarine battle was war gamed. In the battle simulated, the convoy is organized in its homeport; sails to its destination (or delivery) port in the face of fixed enemy barriers and patrol areas including mine, submarine, and aircraft opposition; is subjected to air attack while unloading, sails home along the same route to its homeport and is disbanded. A wide variety of play was permitted by having great freedom in selecting inputs.

This game was run on the IBM 7090 computer.

Convoys. In this game, friendly forces have to transit between homeport and delivery port and return. During this transit the convoy may cross up to two enemy barriers such as minefields, submarine or air barriers, as well as the patrol areas.

At certain times (which are inputs) a convoy is formed in the home port. The convoy is made up of three types of ships: cargo ships, ASW escort ships, and forward screen ships. Variations in inputs permit the forward screen to be composed of ASW ships, aircraft, sonobuoys, or submarines. Each convoy, when it forms, draws its required complement of ships from a port 'pool.' This pool is stocked by ships from returning convoys and by the shipbuilding input. If the required ships are available, the convoy sails toward its delivery port; if not, the game is stopped and a 'printout' is made of the game results to date including the event that caused the stoppage.

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[1]Center for Naval Analyses, Naval Warfare Analysis Group, *An Event-store Computer Program . . .*, Research Contribution no. 42, (Washington: 1 February 1964).

At one hundred miles outbound from its home port, all ships of the convoy, except the forward screen escorts, pass through an enemy barrier. The losses (if any) are recorded and subtracted from the convoy composition.

After having transited the first barrier, the convoy enters the enemy submarine and air patrol areas and becomes liable to sporadic attack.

Ships lost because of any reason are rated by type of ship sunk, method of sinking, and time of loss, are subtracted from the convoy, and are printed out at the end of the simulation. If these losses include ASW escorts or forward screen escorts, the convoy's ability to detect enemy submarines will be diminished. Each time ASW escorts and forward screen escorts are sunk, new lower ASW detection probabilities are calculated.

After passing through the enemy submarine and air patrol area, the convoy then passes through a second enemy barrier one hundred miles from its delivery port. After reaching the delivery port, the convoy unloads and stays in port a prescribed number of days. During this period the cargo ships are again liable to air attack. Of those ships sunk in an air attack, one half are assumed to be sunk before unloading and one half after unloading. The number of cargo ships ready for sea are then tabulated, and the convoy is ready to proceed home.

Proceeding home, the convoy follows the same route in reverse order, passing through the same barriers, the same patrol areas, and the same series of enemy attacks. When it reaches its home port, the number of ships remaining in the convoy are placed in a 'ship pool' by ship type. These ship pools will then be used to make up future convoys.

Submarines. The game was designed to handle several types of submarines. All the information describing the submarine types were inputs to the game. At the start of the war, the enemy submarines, chosen by type and number of each type, are placed in two predetermined 'game positions' selected according to the option of the player. The two game positions are 'on station' and 'in port.' For those submarines that start the game in port, a given number (input) will leave at a given time interval (input) until all have left for their stations.

While an enemy submarine is in port it may be susceptible to strikes at source. In addition, the submarine building rate creates

new submarines as the war progresses. As each new submarine or 'turnaround' submarine leaves port, it is given a full load of weapons and a time at which it must depart from station and return home. Both of these inputs vary with submarine type. Submarines that are on station at the start of the war are given a full load of weapons, but their time remaining on station is determined by a uniform random distribution. The enemy submarine barrier and patrol areas are a predetermined distance from the submarine home port.

While enemy submarines are in transit or on station, they can appear in any one of four areas along the convoy route, each area involving either good or bad sonar conditions. Each area is given a certain percentage of each type of submarine (input). A convoy must pass through each area in a fixed sequence. Either good or bad sonar conditions may be assigned to each area. If a given submarine is put into a certain area, the submarine derives both its detection and sinking probabilities with respect to the convoy, not only from its type but also from the sonar conditions in the area.

When an enemy submarine is in transit, it may be required to pass through as many as eight 'attrition' barriers before arriving on station. Each barrier can be used, or not used, as desired (input). In addition to having a probability of being sunk as it transits the barrier, the submarine also encounters a time delay as it goes through or around the barrier. Any time delay so incurred will, of course, cut down the remaining time the submarine can spend on station.

When the enemy submarine crosses an 'attrition' barrier consisting of ships, it not only has a chance of being sunk itself, but also has a chance of sinking a ship in the barrier. If the submarine does sink a ship in the barrier, the probability of detection for this barrier is decreased. The barrier ship sunk is replaced at some later time in the game (input) and the detection probability of the barrier is increased. In this way this type of barrier not only destroys some of the enemy submarines that must transit it, but is itself subjected to possible reductions in effectiveness. Also, as mentioned before, submarines which are detected by the barrier but not sunk, suffer time delays which reduce the time that can be spent on station.

As long as the enemy submarine is at sea, it becomes susceptible to being found and engaged by a HUK Group. There

are two different probabilities that there will be a submarine/HUK Group interaction; one applies when the submarine is in transit and the other when the submarine is on station waiting for a convoy. Should the enemy submarine be found by a HUK Group, the HUK Group will attempt to sink it and, in turn, risk itself being sunk by the submarine.

The time of arrival on station depends upon the speed of the submarine (which in turn depends on its type) and upon the time delays the submarine undergoes while crossing barriers and fighting HUK Groups. The submarine remains on station, or in its patrol area, until a convoy is encountered.

In general, if a submarine has detected a convoy, it will next try to penetrate the convoy defenses and sink cargo ships. However, an option is permitted, if desired, by which submarines will try to sink ASW escorts in an anti-ASW escort campaign.

There are complex digital computer routines for detection and engagement of convoy ships by submarines which are too detailed to be described here.

After an enemy submarine has either expended its weapons, or has used its allowable time (whichever occurs first), it must return to its home port. On the way home, the submarine must traverse, in reverse order, the same 'attrition' barriers that it crossed on its way out to station. When the submarine arrives at its home port, it will stay there for a certain number of days (input) and then be resupplied and sail again.

The preceding description covers only one convoy round trip between home and delivery ports. The game can be extended to simulate a convoy trip from home port to a final delivery port with any number of intermediate stopovers.

Statistics. Three hundred and sixty eight inputs are required. A twelve-month war using about 200 submarines and a convoy sailing each 3 days, required between 2 and 3 minutes for each play. Inclusion of the HUK Group play increased this to 7 minutes per play. About 10 plays (interactions) were required to obtain reasonably reliable statistical data.

Output. The output gives friendly force losses and enemy submarine losses by number and type and the causes for the losses.

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BIOGRAPHIC SKETCH

Dr. Herbert Glazer

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Dr. Herbert Glazer is a native of Boston and a member of the permanent staff of the Operations Evaluation Group (OEG) of the Center for Naval Analyses. He received his A.B. (1948) and Ph.D. (1954) degrees in Chemistry from Boston University. His chemistry publications are on the electrical conductivity of organic chlorides in liquid sulphur dioxide and on the theoretical computation of electron distributions of simple molecules. Before completing the requirements for the Ph.D., Dr. Glazer did research in Cloud Physics for the Air Force Cambridge Research Center, where he was engaged in experimentations on nucleation (seeding). Also, during this period, he worked at the M.I.T. Servomechanisms Laboratory, on the construction of an adiabatic cloud chamber for the Air Force. Publications describing this work appeared in several meteorological journals. He also was a student in the M.I.T. Whirlwind Computer Course.

After receiving his Ph.D. degree in 1954, Dr. Glazer went to Columbia University where he held the Thomas J. Watson Fellowship in Applied Mathematics. His research at Columbia was on the computation of quantum mechanical wave function for the hydrogen atom on a computer that had just been completed at Columbia's Watson Laboratory for the Navy—The NORC (Naval Ordnance Research Calculation) which at that time was the largest and fastest digital computer in existence.

From Columbia, Dr. Glazer in 1955 became a staff member of the M.I.T. Operations Evaluation Group (now a Franklin Institute of Philadelphia contractor) and he is still a member of this group. His initial work with OEG was on visual detection and the evaluation of the F3H-2. He left the group late in 1956 to become manager of Operations Research for Touche, Ross, Bailey, and Smart in New York City. He remained with them for about two years during which he was engaged in research and published an inventory control and queuing theory in the retail field as well as a review of Air Force inventory accounting procedures. The book, *Scientific Inventory Management,* by Buchan and Koenigsberg, contains case histories of work begun by Dr. Glazer and

continued by the authors. In the years 1956-57, Dr. Glazer was an Instructor at The Graduate School of the Department of Agriculture, lecturing on Operations Research and also Associate Editor of the periodical *Quality Control and Applied Statistics.*

Dr. Glazer returned to the OEG late in 1957 where he concentrated on computer simulation and gaming, and logistics—The Selection of Air Cargo. The first fleet AAW digital computer game played on the NORC (at Dahlgren) was originated by him. In late 1959, Dr. Glazer went to the Far East as the OEG Representative on the Staff of the Commander Seventh Fleet, where he worked on AAWEX evaluation and also on Aerial Surveillance. On his return to Washington, in mid-1961, he worked primarily on problems of fleet readiness, prepositioned POL and ammunition requirements, and deployed fleet AE and AO requirements for limited war contingencies.

In the fall of 1962, Dr. Glazer returned to Columbia University, where he spent a year as a Visiting Scholar in the Computer Center, studying machine languages.

In June of 1963, Dr. Glazer was appointed to the Chair of Physical Sciences. He is a member of Sigma Xi, and The Operations Research Society of America, among others. His avocation is the study of the Japanese language and literature.