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Story, William Ferguson

Monterey, California. U.S. Naval Postgraduate School

A SHORT HISTORY OF OPERATIONS RESEARCH IN THE UNITED STATES NAVY

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William Ferguson Story

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THESIS

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William Ferguson Story II
Lieutenant, United States Navy
B.S., Naval Academy, 1962

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ABSTRACT

This thesis traces the history of the practice of and organization for operations research in the United States Navy. The author points out that operations research was being conducted in the U.S. Navy before operations research became identified as a separate science. From that point its growth, major accomplishments and organizational changes are described. The final part of the thesis outlines the organization through which the Navy conducts its operations research and systems analysis at the present.

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CHAPTER I

ORIGINS

The practice of operations research in the United States Navy did not become common or continuous until the advent of the Second World War. There have been isolated examples of military operations research, however, since the beginning of time.

In the third century B.C. King Hiero of Syracuse called on Archimedes to apply his scientific talent to help break the siege of Marcellus the Roman. It appears that Archimedes, after considering the problem, became hardware oriented and started inventing engines of war. (As a good operations researcher he should have been studying operations in order to optimize their effectiveness instead.) In 212 B.C. Marcellus took Syracuse. Archimedes was put to death by Roman soldiers in spite of orders to the contrary issued by Marcellus who may have wanted to make use of Archimedes' talents himself. It was a long time until another scientist allowed himself to become embroiled in the cauldron of war.

In 1694 Sir Issac Newton foresaw the need for analysts at the operational level. He stated his views in a letter as follows: "If, instead of sending the observations of able seamen to able mathematicians on land, the land would send able mathematicians to sea it would signify much more to the improvement of navigation and the safety of men's lives and estates on that element."[1]

Gradually more complex weapons of war came into use and some men began thinking of warfare as a science rather than as an art. One

such man was Marshal of France, the Marquis de Vauban who was Louis XIV's engineer and military operations research analyst (although the term did not yet exist.) Vauban wrote tactical guides for the construction of fortifications such that defensive fire would be more effective. He also wrote a tactical doctrine based on geometry, for attacking fortifications. This emphasized the best use of local terrains and advancing zigzag trench systems.

Although much of Vauban's efforts were directed towards the building of better machinery which is not operations research, he did apply the scientific method to operational situations and thereby improved the utilization of existant weapons. These scientifically oriented efforts to optimize the output or utilization of an existant system do qualify as operations research. He was a scientist at the Operational level which, as we shall see, was one of the basic precepts of operations research when it was first conceived of as a separate (science). Vauban's most important contribution to modern warfare, however, was to show that it might best be considered a science and not an art. It has taken a long time for this concept to be widely accepted, in fact there is still controversy on the point.

Until the year 1845 instruction for Naval officers in the United States Navy was largely conducted on board ship and an officer's formal education was considered complete once he reached the rank of Lieutenant. A result of this policy was that the officers of the Navy were excellent seamen but had little background to approach warfare in a scientific manner. Finally in October

1845 the Naval Academy was established at Fort Severn, Annapolis, Maryland. From that day on the advent of operations research in the Navy was almost inevitable.

During the Civil War Secretary of the Navy Gideon Wells requested scientific help from the National Academy of Sciences. The Academy had been incorporated by an Act of Congress in 1863 to act in an advisory capacity to the government on scientific matters. The Navy in its haste to clothe its ships with iron during the preceding war years had neglected to compensate the ship's compasses properly. It was mainly to the correction of these ships' compasses that the gentlemen of the Academy addressed themselves. The seed was sown, however, the Navy could and would call on the outside scientific community to help solve its operational problems.

Toward the end of the 19th century and in the beginning of this century the Navy became much more conscious of the role of science, not only in the form of weapons technology but also in considering the conduct of war. This was a result of the scientifically-educated Naval Academy officers reaching the top of their profession. Several of these men were remarkable and are worthy of mention in the history of operations research in the Navy.

Admiral Stephen Luce headed a Board which in 1884 effected the establishment of the Naval War College at Newport, R.I. His concept of the curriculum included courses in international law, mathematics, languages, astronomy and hydrography. (The technical portion of the curriculum was taken over by the U.S. Naval Postgraduate School in 1909.) Its main purpose, however, was the

"systematic study of military operations by land or sea, applying the experiences of history to contemporary conditions and to the particular theaters in which the nation may be interested." [2]

Rear Admiral Mahan was one of the first instructors at the War College. It was his writing that convinced Navies throughout the world that Naval warfare was a subject to be studied and analysed and that lessons could be learned by studying of History (Past Operational Data).

Rear Admirals Luce and Mahan in effect were advocating and conducting operations research for they were studying and using operational data in a scientific manner in order to increase the effectiveness of an operation, in this case the operation was the projection of sea power.

A third officer, Rear Admiral Bradley A. Fiske, who was several years junior to Admiral Luce instituted many technical changes in the Navy during his long career and was a champion of the scientific approach to war. It was Admiral Fiske who, as senior aide to Secretary of the Navy Josephus Daniels proposed and obtained the establishment of the office of Chief of Naval Operations in 1914. For the first time there was one officer who was responsible for the operation of the Navy and the efficiency of the fleet. It was under this officer that the study of Operations naturally fell and has principally continued until this day.[3]

CHAPTER II

THE NAVAL CONSULTING BOARD OF THE UNITED STATES[4,5]

Secretary of the Navy Josephus Daniels and Admiral Fiske disagreed sharply on the efficiency of the Navy and its state of readiness for war. Admiral Fiske was retired and later reprimanded for his continued insistance that the Navy was not ready to face the war that was raging in Europe.[6] By July of 1915, however, Mr. Daniels did feel that the Navy needed some help from the civilian scientific community. At that time he stated in a letter to the famous Mr. T. A. Edison that the Navy had no organization that was set up to devise "new things" or to perfect the naturally inventive ideas of the American people. He therefore asked Mr. Edison if he would be willing to head a board that would advise the Navy and correct this deficiency. Mr. Edison accepted and Secretary Daniels then wrote to the secretaries of the 11 largest engineering societies in the United States asking that they each propose 2 men to be members of the board headed by Mr. Edison.[7] This maneuver assured the board an interdisciplinary character which we will see came to be one of the hallmarks of an operations research group. All perspective members of the board agreed to serve without pay, a feat which more recent secretaries have not been able to reproduce.

The first meeting was held on October 7, 1915. Although Mr. Edison was elected as Chairman he did not act as the chief executive officer because it had been understood between Mr. Edison and Secretary Daniels that it was his inventive talent that was wanted

and not his administrative and executive ability.[8] It was also decided that the board should be called The Naval Consulting Board of the United States. It is a shame that the words "Operations Research" did not exist in the scientific vocabulary of the time because as we shall see a title using them would be much more appropriate to describe the work that the Consulting Board was to do.

At a meeting on November 4, 1915 at India House, New York (which this writer remembers as having an adequately stocked bar) it was decided to split the Board up into several smaller committees which were as follows:[9]

Chemistry and Physics
Aeronautics
Electricity
Mines and Torpedoes
Submarines
Ordnance and Explosives
Wireless Communications
Transportation
Production, Organization, Manufacture and Standardization
Ship Construction
Steam Engineering and Ship Propulsion
Lifesaving Appliances
Aids to Navigation
Public Works, Yards and Docks

Many members were on several committees.

In spite of the sound advice of Sir Issac Newton quoted in Chapter I, Secretary Daniels decided to attach the Naval Consulting Board to his office rather than to the office of the Chief of Naval Operations. In other words the Consulting Board was not really a group of "scientists at the operational level."

One of the first problems with which the Board came to grips was the organization of industry for the impending war. The Board

realized that the country had tremendous industrial potential but no one was sure of who could and would produce what in a wartime economy and industry itself suffered from a lack of uniform engineering specifications. The Board took "inventory" of industry, drew up tentative war production proposals, and set forth a standard set of specifications that industry would have to meet in the manufacture of many items. This made it possible, for example, for one company to have to make only several different types of metal tubing rather than the myriad formerly required to fit in non-standardized similar products of its different customer companies. This not only reduced the different number of repair items needed to be kept on the shelf but also saved industry millions of dollars in the purchase of component parts.

On the 29th of August, 1916 the Congress finally legalized the Naval Consulting Board of the United States and allowed it a budget of $25,000 per annum.[10]

At this time the Navy was struggling with the problems of whether or not to oil-fire naval vessels given the limited supply of oil in the world. The Consulting Board pointed out that more oil might be discovered and that even if it were not the tactical advantages of oil-firing ships were so great that the Navy could not afford to continue with coal-fed boilers.

Many other problems of a technical nature were considered during the period of the Board's life. Several examples are: extensive work on underwater sound apparatus, proposed work on machinegun sights, better optics for range finders. We, however, are more interested in the deliberations of the Board which we would call operations research.

In the summer of 1917 Mr. Edison went to Washington to study the sinking of allied vessels by submarines. He hoped that there he would find adequate data on sinkings. This data did not exist in a neat collected form so Mr. Edison and his assistants had to organize and prepare for display the existing data, i.e. to develop their data base.

After compiling the data on coastal shipping and studying it Mr. Edison found that only 6% of the merchant vessel sinkings had occurred at night, and that the ship owners and masters had been sailing their vessels over the same coastal routes that had been used before the war. Furthermore it was evident that in spite of their losses they were not changing their pattern of operations.[11]

Once he had determined these facts Mr. Edison developed a plan to correct the situation. This plan was as follows: merchant vessels should travel in the danger zone only at night; they should take routes that were different from their previous ones, during the day ships should anchor in protected shallow water ports so that the submerged submarines could not approach them. At nightfall the ships were to get underway and head for their next day's anchorage along the coast on the way to their ultimate destination.[12]

In the presentation of his conclusions Mr. Edison made a chart indicating the shipping flow from French and British ports for a previous year. He then plotted all the harbors that had shallow water and were well protected. In this manner he indicated the routes and stop-over ports that would make his proposed plan usable.[13]

The above results were submitted to the Secretary of the Navy, and were probably forwarded to the Admiralty in London. Unfortunately

there is little indication that the recommendations of the report were ever used.[14]

After submitting this report in November 1917, Mr. Edison submitted a similar one on U.S. Coastal Shipping in December 1917. In order to complete this he had to obtain his own data on shipping. He did this with the aid of harbor masters, customs officials and similar groups.

In his study of convoy routing and methods of avoiding detection Mr. Edison made use of simulation techniques and a "definite range law", both of which are recognized today as operations research tools.

> Mr. Edison also made a pegged board covering a chart of the channels and coasts of England, Ireland and Scotland. This chart was laid in squares of 40 miles each, which is approximately the visibility of smoke from a cargo boat as seen from a submarine in the center of the square. Each square was provided with a peg and a peg hole. One person had the problem of taking into British or French ports, say 30 vessels. His opponent had a similar pegged board with 13 pegs representing submarines. The first player routed his ships to the various ports at various hours, while his opponent placed his submarines at points where he thought most likely a vessel would come into his visible area, which was then considered sunk. It was found that by following certain methods these 30 vessels could be brought into port with a surprisingly small number having been seen by the submarine.[15]

Mr. Edison worked on the problem of convoy zigzag maneuvers. His conclusions were that for convoys travelling at less than 10 KTS, (not unusual in those times, or even during WWII), zigzagging was useless, in fact even harmful. Mr. Edison said that it was harmful recognizing that the true measure of effectiveness was cargo carrying capacity and that zigzagging at slow speed led only to a loss of our total cargo carrying capacity by lengthening the duration of the voyage.

The above problems are operational problems; operational data was operated on in a scientific manner in order to minimize the number of ships sunk in one case, and to maximize the cargo carried in the other. Thus Mr. Edison's work qualifies as operations research.

What was the outcome of all of this?*

It was surprisingly little and this is probably because the Edision Board was a civilian board advising a civilian, the Secretary of the Navy. Had the board been at the operational level perhaps more of the Board's O.R. results would have been used by the operational commanders and tangible success would have led to the continuance of the Board after World War I.

* Even 50 years later the following quote leaves one wondering about what might have been in the mill: "Everyone expected that the Board would evolve some invention that would conquer the Central Powers with one fell swoop, and had the War lasted another year an important and confidential device not discussed herein would probably have justified this in a degree at least."[16]

CHAPTER III

THE INTER WAR YEARS

Between the world wars there was little work that could be characterized as operations research in the U.S. Navy. During these years the scientific analysis and evaluation for the Navy was conducted by Naval Officers with scientific talent. Three such men were Admirals Lee, Parsons and Blandy. (After the war Admiral Blandy was in charge of the U.S. atomic bomb tests at Bikini.) Their work was handicapped by two considerations: first, they had no outside help so that their work was limited by their abilities and backgrounds; secondly, normal career patterns often interrupted their work.[17] This state of affairs continued until after the United States' entry into the war in 1941.

Meanwhile in Europe and particularly in England during the late thirties modern operations research was beginning to take shape. At the urging of A.P. Rowe and Wing Commander Hart, RAF, an operations research group was set up within Fighter Command. One of the first problems attacked was the production of a total air defense plan for the British Isles with particular regard to the best utilization of the newly commissioned air defense radar stations. The deliberations of this and other early groups were so successful that in 1940 demand for them was becoming more widespread.

Professor P.M.S. Blackett of Manchester University, later a Nobel Laureate, and a former Naval Officer gathered together a group to help solve some of the problems encountered in the Anti-aircraft command. Professor Blackett's work was successful and he later

formed a group often referred to as Blackett's Circus. This group studied many problems for all of the Services. Thus by 1941 all three Services in the United Kingdom had operations research sections at the same level.[18]

In 1941 Professor Blackett wrote a paper called "Scientists at the Operational Level." This paper which explains the purpose and reason for scientists at the operational level is considered by most to be the cornerstone and starting point of modern military operations research. In particular it was responsible for the starting of the major O.R. group in the U.S. Navy as we shall see in a following chapter. Because of its importance, "Scientists at the Operational Level" is included in its entirety in Appendix I.

How the reports of operations research in England and Professor Blackett's paper reached the United States is not completely clear, it appears, however, that it was due in major part to the efforts of James Conant of Harvard and Shirley Quimby of Columbia University, both of whom were in England during the early days of operations research,[19] and both of whom were involved with early operations research in the U.S. Navy.

So far the history of operations research has been traced from the Third Century B.C. until just before the United States' entry into World War II. At no time, however, has operations research been concisely defined. By now the reader should have an idea of the scope of military operations research from studying the methods

and goals of early operations research.

Operations research has been defined in many different ways by many different people. Almost all of the definitions are partially correct but none of them are complete. Since the science of operations research has been applied to a continually wider field, so the definitions of operations research have changed and become broader. As the history of operations research in the Navy unfolds the reader will see how new sciences and areas of interest have been added to the field of operations research.

Thus, after finishing this work the reader should have a good idea of what operations research is even if he is unable to put in very concise terms. This problem should not distress the reader since even men who are acknowledged operations researchers don't agree on a single definition of operations research.

In case the reader still feels uneasy and would like the security of a written definition, there follows a list of definitions of operations research, all of which are good, none of which is complete. They will suffice, however, especially for the early period of operations research.

"Operations research can be called the scientific analysis of problems involving any form of action with a view to making that action more efficient." James Bready

"Operations research is the art of giving bad answers to problems to which otherwise worse answers are given." Thomas Saaty

"Past operations are studied to determine the facts; theories are

elobrated to explain the facts and theories are used to make predictions about future operations." Professor P.M.S. Blackett

"Operations research is the study of the optimization of achievement of the purpose of an organization." Thomas E. Oberbeck

Shakespeare might have been writing about the above definitions, instead of about a wound, when he wrote in Romeo and Juliet "Tis not so wide as a church door nor so deep as a well but 'twill suffice."

CHAPTER IV

THE FIRST OR GROUP AND ITS ACCOMPLISHMENTS

The underwater mine considered by Naval officers at the beginning of the Second World War as a purely defensive weapon to be used only in small doses was later employed in large quantities by another service under the direction of a Naval officer-scientist, and became one of the most decisive and effective offensive weapons in the fight against the Empire of Japan.

It all began in January of 1942 when about 50 scientists started meeting in seminars at the Naval Ordnance Laboratory. The seminar was under the direction of Dr. Ellis A. Johnson, a geophysicist who was later to become the director of the Army's ORO. Others in the group were Thornton L. Page and George Shortley, both of whom later became assistant directors of ORO; also James Martin and Dr. L. E. Hoisington. This group studied the operational problems of offensive mining. Their first work was the study of operational mining of ports and mine sweeping using war gaming techniques.[20] With Dr. Johnson's guidance the group soon began studying all the aspects of mining, tactical, strategic and economic. The results produced by this group were so promising that on 1 March 1942 the group was officially recognized and named the NOL Operations Research Group.[21] Although it was the first group with the key words "Operations Research" in its title in the U.S. Navy, it remained unique for only one day as will be seen in the following chapter.

Dr. Johnson was able to think on a larger scale than most

contemporary mine warfare experts, and it was due to him that the group expanded its thinking about a few mines laid around a port and started to study the implications of laying tens of thousands of mines along whole coastlines.[22] In considering all the aspects of mine warfare, particularly the economic factors, this group was conducting operations research in a more sweeping manner than would generally be adopted for 10-15 years. At some time during the early days of this group the idea of laying a mine field around the coast of Japan was brought up over coffee in the cafeteria of the Washington Naval Gun Factory.[23]

The office of the CNO (OPNAV) felt that since this new group was studying operations it should work for them. In 1942, however, OPNAV did not have the physical room so, as a temporary measure, the NOL Operations Research Group was transferred to the Bureau of Ordnance. Finally in the summer of 1943 the group was transferred to OPNAV and found its final moorings as a part of the Mine Warfare Section of Base Maintenance. Throughout the war the group continued to look at mining problems using OR techniques, particularly in such areas as mine settings, effectiveness and minefield patterns. At first this group was headed by Prof. Bitter of MIT, then by Shirley Quimby who had helped bring Operations Research to the United States, and finally by Walter C. Michaels from, of all places, Bryn Mawr College. After the war this group atrophied and died. Its tasks were taken over by the yet-to-be mentioned Operations Evaluation Group and Weapons Systems Evaluation Group. During its life in OPNAV the remenant of the earlier NOL group was always a part of the structure that it advised rather than an outside consulting group; this made it an exception

among Navy wartime operations groups.[24] In actual fact, this group had little influence on any of the large operational decisions made during the balance of the war.[25]

Meanwhile in August 1942 Dr. Johnson and George Shortley from the NOL Operations Research Group donned uniforms and headed for the Pacific Theater. Dr. Johnson claims that he was invited to get into uniform because he was too much of a thorn in the Navy's side as a civilian.[26] In the Pacific these men were to become customers for some of the earlier work that they themselves had done at the Naval Ordnance Laboratory. They became the first strategic OR group in the Pacific. First they worked for CINCPAC in Hawaii and later in the war CDR. Johnson became Director of Mining for General Curtis Le May's 21st Bomber Command.[27]

In March 1944 a group called the Mine Modification Unit was set up as part of MINEPAC in Hawaii. This group had many NOL Weapons Effectiveness experts and helped with on-the-spot problems as well as relaying information on effectiveness back to NOL and the OPNAV group. Throughout the balance of the war this group worked on the OR aspects of mining and served as an advanced technical feedback station to the continental producers of mines. The Mine Modification Unit also studied intelligence and past effectiveness of mines; from this data it made recommendations to the operational commands on settings for mines to be used against the enemy. At the end of hostilities most of the members of this group returned to civilian life and the Mine Modification Unit faded away.

In July 1944 the Allies captured the island of Tinian from the

Japanese. At last the U.S. had a base from which General Le May's giant B29s could reach all parts of the Japanese home islands. Now the plan that had been discussed over coffee in Washington in 1942 could be put into effect. The plan was code named Operation Starvation; its objective was to destroy the Japanese seaborne transportation network by saturation mining. Dr. Johnson moved to Tinian in his capacity as mining director for General Le May; close on his heels came the Mine Modification Unit and the advanced mine assembly depot from Oahu.

The first task undertaken by Dr. Johnson was a study of the attrition of the delivery aircraft. At that time bombing raids on Japan were being conducted from high altitudes and large formations in daylight. This was producing a loss rate of about 10%. After studying the statistics Dr. Johnson proposed that mining be conducted by single aircraft flying at night below 5000 feet using radar navigation. The advantages of this tactic were that ballistic drift of the dropped ordnance was lessened, the strain of formation flying was eliminated; advantage was taken of the Japanese lack of night fighters and of a radar warning system. This proposal was submitted to General Le May on 29 January 1945. Thereafter most of the bombing raids, as well as the minelaying sorties, were carried out using these tactics. Aircraft losses were reduced to about 1/10 of their former level.[28] (An order of magnitude improvement is the goal of the Operations Researcher.)

Finally, in March 1945 the mines were ready for laying.

Between March and August 1945, 12,053 mines were laid in Japanese waters using less than 6% of the total strength of the 21st Bomber Command whose primary mission was the bombing of Japan. During this operation only 15 minelaying aircraft were lost compared to some 606 Japanese merchant ships sunk, an exchange ratio of over 40.1.

The effect of Operation Starvation on Japan was tremendous. Figures 1 and 2[29] show the Japanese sea traffic in March 1945 and August 1945, i.e. before and after the mining campaign. The width of the lines is proportional to the daily amount of shipping over the various sea lanes. It can be seen that after mine laying Japanese shipping was reduced to a mere trickle.

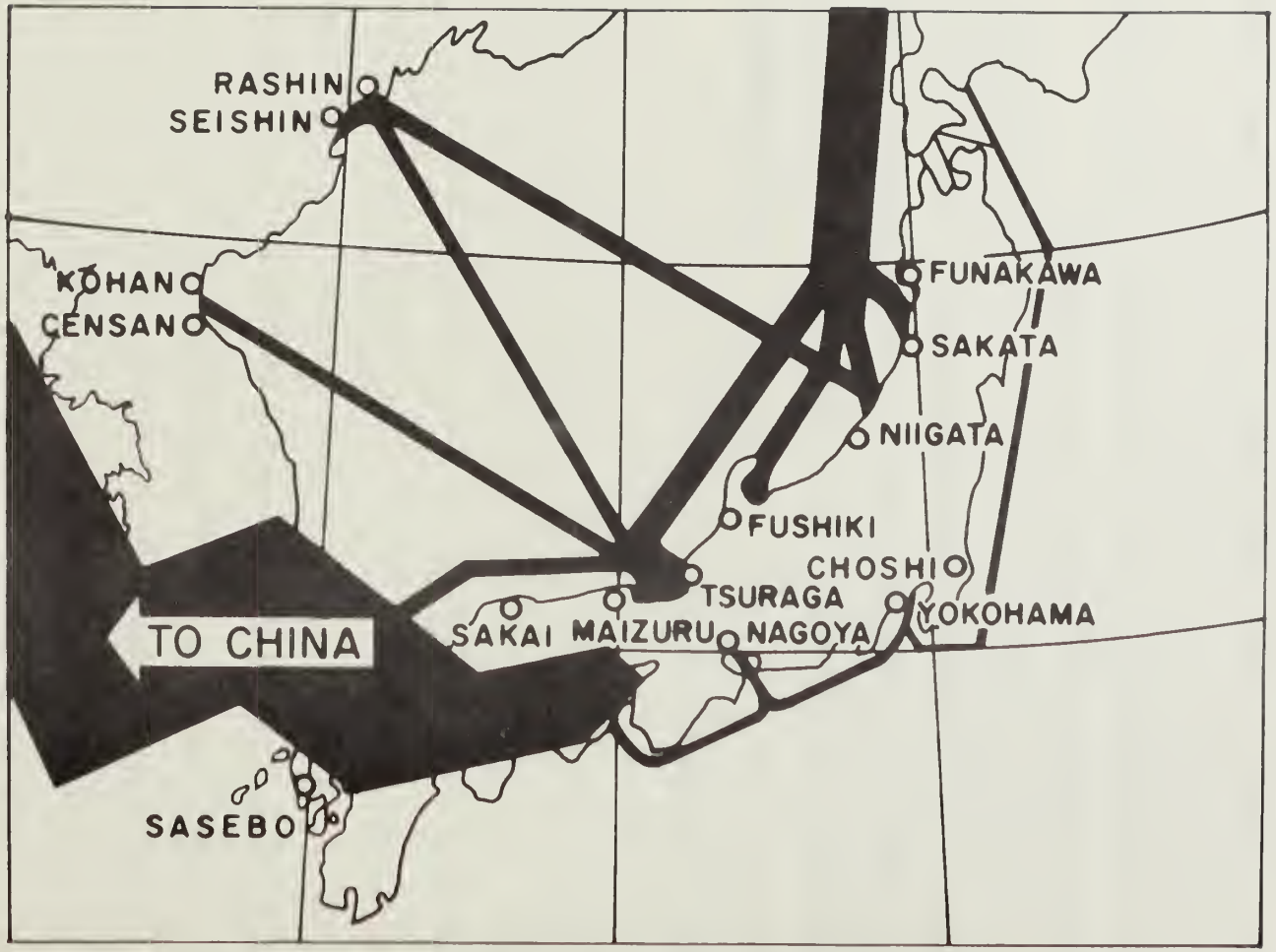

Fig. 1. Japanese traffic situation, March 1945.

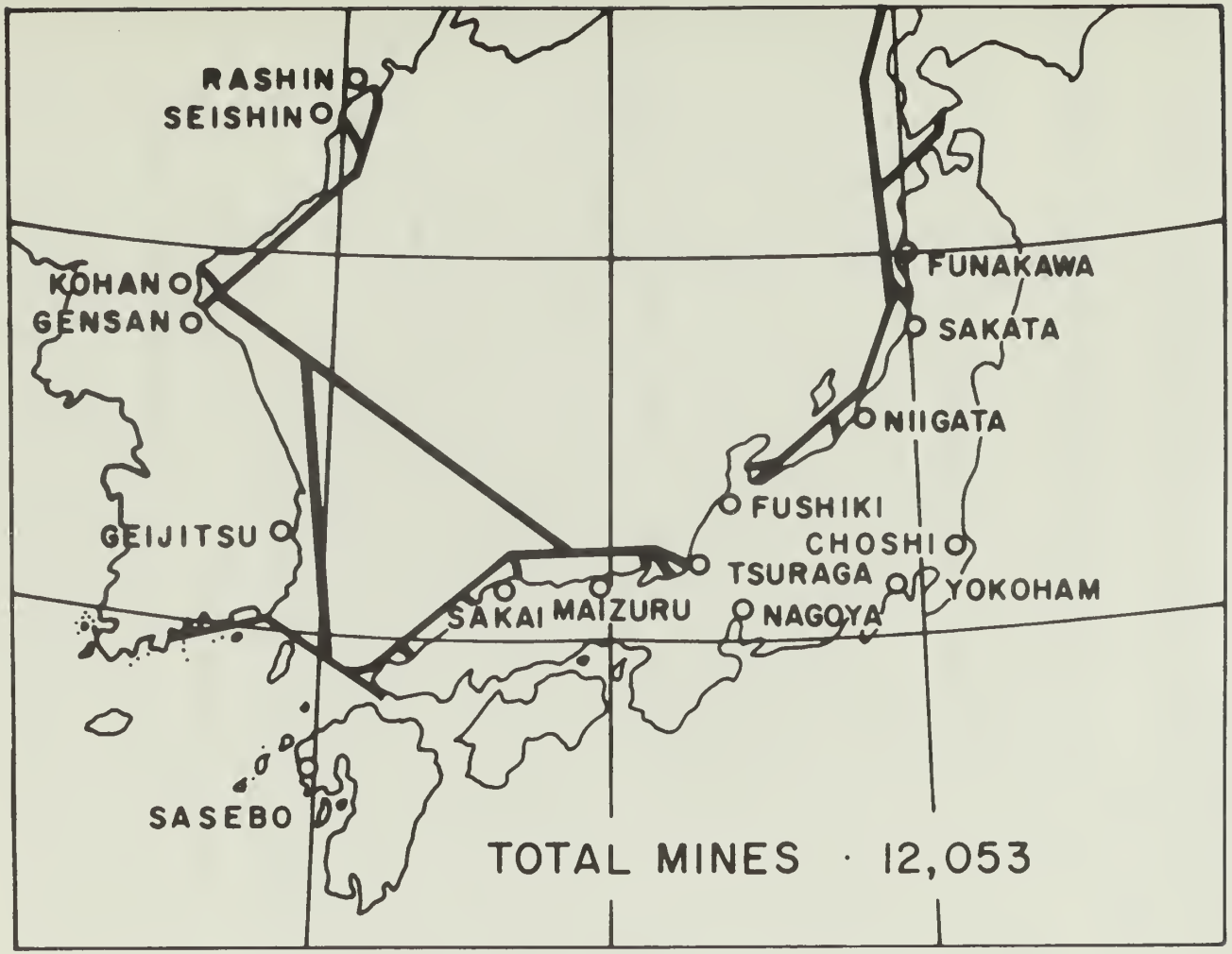

Fig. 2. Japanese traffic situation, August 1945

How did the enemy feel about Operation Starvation?

"The result of B29 mining was so effective against the shipping that it eventually starved the country. I think that you probably could have shortened the war by beginning earlier." Captain Kyuzo Tamura, IJN.[30]

Prince Konoye stated that the mining had results comparable to the total bombing campaign.[31]

The men who planned, executed and did much of the technical work involved in Operation Starvation were, for the most part, alumni of the original NOL Operations Research Group. Although that group and all of its offspring did not survive long after the war it was the first modern operations research group in the Navy, and did supply much of the talent for the Army's postwar operations research effort. Furthermore one of its charter members directed another Service in one of the most successful campaigns in the Pacific, the conception, planning and execution of which were all the produce of OR methods. Finally the work of the original group foreshadowed the strategic type of OR that has grown up since WWII, first at Rand and then throughout the military establishment.

CHAPTER V

THE MAIN LINE

Eastward bound convoy ON67 was beating its way towards Halifax at 1730 on February 21, 1942 when the convoy rescue ship intercepted a high frequency signal from a transmitting U-boat. The destroyer USS Lea was vectored out by the convoy commander to chase down the bearing. After an hour of search, in accordance with the standing antisubmarine doctrine, the Lea was ordered to rejoin. Shortly after the start of the midwatch the U-boat again made its presence known, this time by torpedoing two ships silhoutted against the full moon. The convoy continued onward since a change of course could only be ordered by CNO. Between midnight and 0645 on the 24th of February four more ships were torpedoed. Later in the day U-boats were sighted on the surface 15 miles ahead of the convoy, but instructions forbade prosecution of contacts at that range. Finally at noon on the 24th the escort Commander sent a message to CNO requesting permission to change the convoy's course 68^{o}. After seven hours delay permission was granted. Even this radical course change did not shake the trailing U-boats. Several more U-boats were sighted and attacked, however, none were sunk. Finally ON67 reached Halifax. Almost everything had gone wrong. The prescribed doctrine had not achieved results, the sonar had not made contact, depth charge attacks had not borne fruit, and the reliance on CNO for new orders had proven unweildy and restrictive.[32]

Failures of the sort experienced by ON67 had caused Capt. Robert B. Carney to write a letter on 27 January 1942 suggesting that an

antisubmarine warfare group be established within the Atlantic fleet, "located where the dope can best be collected on the spot while it is hot, free from any other duties, working from practical experience, and furthering the aims of COMINCH without further cluttering up COMINCH's own staff....Such a unit commanded by the right officer would work in perfect harmony with fleet training and at the same time furnish hot material for the Atlantic Fleet and its task forces daily engaged in Anti-Submarine Warfare."[33]

The "right officer" turned out to be Capt. Wilder D. Baker, a forceful and erudite Kansan of the Naval Academy Class of 1914 and a destroyer Squadron Commander. The right place was Boston. Captain Baker had been studying the ASW problem since November 1941 with the help of four of his squadron staff officers. Finally on 2 March 1942 the ASW study group as recommended by Capt. Carney was formally established within the Atlantic Fleet. While Captain Baker was searching for a way in which to attack the ASW problem he came across Professor Blackett's famous paper "Scientists at the Operational Level."[34] This resulted in a request to Dr. John Tate of the National Defense Research Committee for help in organizing "a group of men of outstanding reputation with broad vision and receptive minds who would preserve the atmosphere of scientific research to analyze anti-submarine operations."[35] Dr. Tate called on Professor Phillip Morse of MIT, a physicist who is famous for the Morse Potential in Nuclear Physics, to form the new ASW group.

In early conversations with Dr. Morse, Capt. Baker states that

he was "in some ways like an infant going to a skilled pediatrician--I could not describe my symptoms, but fortunately he was able to diagnose some of them and start the treatment."[36]

Professor Morse commenced to recruit other members of the group, such as George Kimball, and the civilian side of the outfit was placed under the wing of Columbia University to preserve a certain freedom from military pressures imagined or real. At first the Group was nicknamed "Bakers Dozen" although there were only seven scientists in it; then the name Operations Research Group for Anti-Submarine IMprovement was considered but the acronym proved impolitic. Anti-Submarine Operations Research Group (ASWORG) was settled on in May 1942. In the meantime the major part of the Group moved to Washington to be closer to the headquarters of COMINCH.[35]

ASWORG and its lineal descendents have constituted the mainstream of operations research in the United States Navy from its birth until the present day. Therefore a large part of the remainder of this paper will study ASWORG, its descendents, mutations, triumphs, failures and additions through the years.

ASWORG attacked the ASW problem from all sides. It collected combat reports, sifted intelligence, looked at equipment and its use, set up liaison with the British operational research group, and studied the ASW doctrine. The result was the publication on August 9, 1942, only 9 months after Pearl Harbor of the first manual of standardized ASW search and attack procedures in the U.S. Navy.[37]

ASWORG expanded beyond the original seven scientists. Dr. Morse and Columbia University recruited members with backgrounds in physics,

chemistry, geology, the insurance industry, mathematics and many other fields. ASWORG became a truly interdisciplinary study group with members chosen for their ability to apply the scientific method rather than to use a particular scientific tool. Dr. Morse insisted from the beginning that members should not take credit for combat triumphs that their studies had helped engineer because they were not making the operational decisions.[38] This tactic kept ASWORG in the good graces of the operating Navy as much as did the sound advice that was being cranked out to the operating forces at an ever-increasing rate.

At first ASWORG confined itself to studying ASW problems in the North Atlantic. One of the first conclusions drawn from operational data was that the number of ships sunk was independent of the convoy size. Consequently in 1943 the convoy sizes were greatly increased: convoys of over 100 ships became the rule rather than the exception. The overall losses of merchant ships in the Atlantic took a sharp plunge.

On 5 December 1942 Captain Baker left ASWORG and took command of the battleship North Carolina. It had been his work which had cleared the way for the entry of civilian scientists into the Department of the Navy. By the time that he left ASWORG was healthy and respected. In July of 1944 the TENTH FLEET (an administrative organization) was formed to coordinate ASW operations. ASWORG then consisting of about 40 scientist became an advisory part of this new organization.

As ASWORG was growing it became necessary to send its members to the field from time to time to gather data. This led to the policy

of sending representatives to various far flung commands. At first these representatives were sent mainly to ASW commands or for liaison with the British, but as the ASW problem decreased, other operational commanders began asking for them and for help in establishing their own operations research groups. In October 1944 ASWORG was transferred to the readiness division of COMINCH's staff and renamed Operations Research Group (ORG). ORG was still a civilian group, not under Navy control, but advising the Navy on operational problems. Unlike ASWORG, ORG addressed itself to the whole spectrum of Naval warfare problems in all theaters. The ORG field representatives took on six basic types of assignments.[39]

1. Liaison an example of which was the assignment of an ORG member to British Operational Research Groups.

2. The Staff assignment is one in which the ORG representative acted as an advisor to a particular staff. He was also used as a collector of data for the parent organization, ORG.

3. The Training type of assignment was when a representative was assigned to a training command in order to help devise training techniques that would optimize operations performance.

4. Operational assignments were when a representative was assigned to advise on a specific operation.

5. Experimental (operational) assignments were made to units that were trying to develop better operational procedures by experimentation, e.g., Anti-Submarine Development Detachment Atlantic Fleet.

6. Experimental (equipment) assignments were made to keep abreast of new developments in hardware.

Each type of representative was sent to help his foster organization but also acted to keep ORG informed and primed with useful data.

An example of the success of an ASWORG/ORG representative in the field is the work that finally led to the closing of the Mediterranean to German U-boats. By the end of 1943 Allied losses in the Atlantic were on the decrease; however, losses in the Mediterranean were still climbing. Conventional ASW tactics seemed to have little effect. The ASWORG representative to Admiral Hewitt's staff at Casablanca suggested that Allied forces be concentrated at the Straits of Gibraltar in order to close the U-boat's entrance to the Mediterranean. He also proposed the patrol patterns to be used and acquired the new Magnetic Anomoly Detectors (MAD) for the theater patrol aircraft. In January of 1944 all was ready. British and American forces were positioned around the Strait waiting for a U-boat to attempt a transit. The patrol aircraft began to fly their new barrier patrols. The destroyers waited to strike. On February 24, U-761 was detected by aircraft and sunk by destroyers while trying to enter the Strait, and on March 16, U-392 and U-731 were also sunk. The door had been shut and shipping losses declined.[40]

There were many other tactical areas that were examined and a partial list might include.[41]

Blockade operations in the South Atlantic (After implementing ORG designed searches, 3 blockade runners were caught in 48 hours.)

Development of ship ASW search patterns.

The determination of the best tactics for a surface unit to use against a Kamikaze attack. (Exactly opposite for small and large ships.)

Desired accuracy in Naval supporting fire. The fact that great accuracy was not always necessary led to the development of the highly effective rocket ships.

Convoy anti-aircraft doctrine was proposed and outlined by Dr. R.F. Rinehart.

The determination as to whether the Germans had developed countermeasures to our radars was highly important. By analizing the change in sighting rates of submarines by aircraft the analysts at ORG were able to advise the operational commanders whether a countermeasure or a new enemy tactic was degrading our use of detectors.

Study of ship noise to help develop a countermeasure for accoustic torpedoes. This led to the employment of foxer gear.

This list could go on and on, however, it is sufficient to indicate that the studies led to enough good results that by the end of the war the operating Navy was impressed with the fact that operations research should be continued in peacetime. Bakers Dozen which had started with seven scientists working on ASW problems in Boston, was now a group of 73 and had representatives all over the world studying almost all types of Navy operational problems. Columbia University was no longer the parent of ORG. The contract was now handled through the Office of Field Services of the Office of Scientific Research and Development. The annual cost was a comparatively miniscule $800,000, probably providing one of the best cost-effectiveness ratios on the market at that time.

In the summer of 1945 the Navy was thinking about its structure in peacetime. The Operations Research Group was not left out of this

thinking as is evidenced in a letter of 19 August 1945 from Fleet Admiral E. J. King to the Secretary of the Navy recommending continuation of ORG in the postwar organization. (See Appendix II).

It is not always best to first evaluate new tactics in the heat of actual battle where mistakes often cost lives and can cuase a change in the tide of war. Knowing this, and possibly not trusting all the recommendations of ASWORG/ORG completely, the Anti-Submarine Development in the Atlantic (ASDEVLANT) unit was created. The purpose of this unit was to test some of the new tactics and often to generate data that could not be obtained in the heat of battle. A sister organization, Surface Anti-Submarine Development in the Atlantic (SURASDEVLANT) soon arrived on the scene. These two units were indispensible to the operations of ASWORG/ORG. Their importance was recognized, and after the war, Admiral King decreed that a new unit, the Operational Development Force (OPDEVFOR) should be set up. Instead of generating data on just ASW operations OPDEVFOR (later OPTEVFOR) would be set up to test all kinds of equipment and tactics, nautical as well as aerial. This organization has continued almost unchanged up to the present, and continues to be a major source of data for various Navy OR groups.

Admiral E. J. King, in his final formal report to the Secretary of the Navy, which was in effect a report on all U.S. Navy endeavours during the latter part of the war, dealt with OR at length. He stated that the complexity of modern warfare made it necessary that scientific methods be used not only in the production of machinery but also in the direction of war. He continued.

> The application, by qualified scientists, of the scientific method to the improvement of naval operating techniques and material, has come to be called operations research. Scientists engaged in operations research are experts who advise that part of the Navy which is using the weapons and craft--the fleets themselves. To function effectively they must work under the direction of, and have close personal contact with, the officers who plan and carry on the operations of war.[42]

Admiral King then went on to tell the Secretary that the Navy had an operations research group. He said that OR work had fallen into two main categories, one of which was the analysis of warfare from a purely theoretical point-of-view and the other being the analysis of operational data. The changes that these studies had caused in operational procedures had often increased our effectiveness by three or four times. Admiral King continued to point out some of the more startling successes and ended with the following paragraph. "The Operations Research Group, to be renamed the Operations Evaluation Group as more closely descriptive of its function, will be continued as a part of the naval organization at appropriate peacetime level."

In those days the CNO informed the Secretary of what he had done and sould do. It is somewhat ironic that this method of establishment if OEG and control of the Navy was laid to rest several years later by the arrival of a group of men in the Department of Defense whose main management tool was a mutation of the science of operations research.

CHAPTER VI

1945-KOREA

At the end of hostilities Prof. Morse returned to MIT. The Navy, however, seemed loath to let him rest in peace. Partly because of Prof. Morse, the Navy approached MIT with the proposal that it take over the management of the Operations Evaluation Group (OEG). It is a safe assumption that Prof. Morse played a major role in persuading MIT to take on the contract.

On 1 November 1945 the contact was closed. The purpose of the group, as stated in the contract, was to provide liaison between the operating fleets and the research and evelopment laboratories, and to conduct studies for the Deputy CNO (Fleet Operations and Readiness) on the following subjects.

1. Analysis of past operations.

2. Analysis of the degree to which new equipment meets military requirements.

3. New tactical doctrine based on the above subjects.

4. Formulation of new requirements.

5. Analytical study of strategic requirements.[43]

Although the group was to report to the office of the CNO, the Office of Naval Research paid for the contract. This weird arrangement came about because OPNAV has no contract fund allotted to it for research and development. Although ONR paid the fiddler it was unable to call the tune. OEG worked for and advised the operational side of the Navy rather than its research branch. MIT did not want a political change

or a similar event to leave it high and dry without a contract. MIT also felt, rightly, that if OEG were established on a year by year basis, recruiting would be difficult. To allay these fears MIT was given a 3 year "forward funded" contract for $375,000 per annum.

Shortly after the contract was signed separate correspondence established a provision for members of the group to take academic leave. This made OEG much more competitive in obtaining scientists. In the postwar years, 20% of the OEG staff were authorized to be on academic leave at one time, however the actual figure remained about 5%.[44]

The advantages that the Navy obtained with this contract were many: it permitted members of OEG to maintain their academic ties and aided in the recruiting of new members; it offered the chance to tap the great intellectual potential of the Institute in times of need, the concept of the scientist away from the pressures and restrictions of the military was maintained. (Whether these pressures exist and are stifling is not important here, but the fact that most civilians believe that they do exist is important.) Finally, the Navy had, via this contract, the political asset of an unbiased scientific advisory group backed by one of the greatest colleges in the country.

What MIT gained from managing a group in Washington, 500 miles from the banks of the Charles, is hard to say; and it appears that MIT at times wondered why it had this strange bedfellow. Nevertheless, the contract was signed.

During the pre-Korea period the group was made up of about 30 scientists and was quartered in the Pentagon which led to constant

worries about eviction and moves. Approximately one-fifth of the members were on field assignment and one-fourth of them were assigned to the Scientific Analysis Section (S/A). S/A was a subgroup of OEG whose purpose was to provide analytical assistance to any desk in OPNAV that might request it. They were in effect OPNAV's private pool of field representatives, and many of the "shops" in OPNAV did and still do take advantage of their talents. The remainder were part of the main body or on leave. See Appendix III.

The group was controlled by a Director who was responsible to the Navy for its performance. He was aided by an Assistant Director and a number of "project leaders." The OEG continued on in this manner, expanding as such groups will, until the beginning of the Korean War.

1946 was spent recapitulating what had happened in the tumultuous preceding five years. Reports on major areas were issued. An example of this was Anti-Submarine Warfare in World War II (a historical account of the Anti-Submarine war, examining the tactics used and their effectiveness.) Two reports of lasting importance were published. Methods of Operations Research by Morse and Kimball, outlined some of the OR methods used during the war. This book has been used effectively as an introductory textbook ever since, and the methods presented in it are still valid and applicable. Many of these methods and techniques were either new or had not been applied to operational problems before. Before long, many people began to think of operations researchers as people who applied these tools and methods to problems, for example almost any work that was based on probability or statistics was in danger of being called operations research. The same

applied to many other methods such as gaming. This is a much more restrictive definition of OR than those previously discussed and therefore will be rejected as insufficient. Even today, however, there continues to be a large number of misinformed people who define OR by the tools used in the investigation of the problem. Koopman's Search and Screening which outlined some of the search theory developed during the war has been a starting point for most of modern search theory. In fact in many sub areas of search theory it is still the best text available. In 1946 OEG also published 55 studies dealing with specific tactical or theoretical problems,[45] e.g. Zig-Zag Plans. These works, expounding lessons learned during the war, were not the only ones that were done within the naval establishment in 1946 but they were among the best and were about the only ones that were produced using a scientific method, i.e. operations research.

By 1947 the analysis of World War II was nearly finished and what remained could be left to the memoir writers. Since there was no wartime pressure to work on specific problems and come up with "quick fixes" OEG was at leisure to examine the broader aspect of naval policy. Much of its work was of a strategic nature rather than tactical. It had become obvious that the identification of the measure of effectiveness of an operation was one that often needed a strategic outlook.

During the war ASWORG had studied the ASW problem from the point of view of how to sink the most submarines. In calmer postwar reflection it seemed as though this might not be the real measure of effectiveness. OEG began to study the whole arena of war at sea and

found that instead of submarines sunk, tons of cargo delivered/time, might be a good measure. (Mr. Edison had reached the same conclusion 30 years previously.) Therefore, in order to increase effectiveness it might be better to reduce the turnaround time of the ships, or to decrease their passage time, rather than to expend so much effort sinking submarines. Many measures were considered and various trade off analyses were conducted. After working on the problem OEG decided that it was merely a subset of a larger problem which involved other threats to shipping such as mines and aircraft. Just prior to the Korean war the group summarized its findings on the problem in a report, Measures for the Protection of Overseas Transport. This report tried to set up a rational ordering of R and D programs and to call attention to gaps or inequities in existing programs.

Although OEG was not the only Navy group conducting what could be classified as OR during this period it was the only one whose chartered purpose, methods and results made it an OR Group. Any operations research conducted in the Navy outside OEG was done by mistake, or on a very intermittant basis, or in name only because a parent organization thought that it should have an OR Group. There were no lasting results from other groups which have been handed down and are clearly classifiable as operations research.

CHAPTER VII

KOREA

The start of the Korean war changed the leisurely atmosphere at OEG to one more in keeping with the emergency on hand. Academic leaves were cancelled. The recruiting effort was increased. The trends towards the study of long-range broad-scope problems were reversed. The research program was redirected towards solving the urgent problems related to the war.

The commanders in the field began calling for OEG help almost as soon as the war began. The field representative system, which had been so successful in World War II, was reinstituted. During the Korean war there were 6-8 analysts seconded to the operational commanders at all times, and in Hawaii there was a miniature evaluation group of three men attached to CINCPACFLT Staff.

Although OEG was ready and able to send analysts to the operational commands, and it was probably the best usage for them, their departure caused problems for the central group. Before the war had broken out OEG had settled down to a fairly well laid out research program. With analysts being continually rotated to the field this program was nearly impossible to follow particularly because no man could count on finishing a project that he had started. With much of its talent scattered about the Pacific OEG was not always able to put the best men to work on a poject in Washington. Not the least of the organizational problems caused

by the war was that the rotation and field assignments caused more than one member to leave the group for a less strenuous existence.[46]

In Korea one member of the group was killed when the aircraft in which he was flying crashed in enemy territory. Tragedy that this was, it was probably a lesser one than letting the analyst fall into enemy hands. Because the analyst must be able to see his problem in the proper context, he must have facts relating to many sensitive fields. His capture would have provided enemy intelligence with a windfall. From that time on OEG did not allow its representatives to so jeopordize themselves or their country.

Administratively OEG had little trouble taking the wartime expansion and change of pace in its stride, and its organization remained essentially the same until the end of the war.

Korea was the first time that the Navy used its aircraft predominately for supporting our forces in combat ashore. The chance to document and analyze this type of employment for naval aviation was to prove invaluable in later years.

In general OEG's work fell into two categories during this period.

1.	Tactical problems such as.	choice of weapons for naval attack aircraft. close air support. naval gunfire support.
2.	Strategic problems such as	blockade tactics, their use and efficiency. interdiction of land transportation.

Statistical Aspects of Port Operations was a study published

after analysing the wartime operation of the port of Yokohama. The study made use of a class of new methods which have now been collected under the title of Queuing Theory. The report recommended that the number of berths vacant be increased in order to decrease the turn around time of an arriving merchantman. The technique was tried and dramatic results were obtained in increasing the flow of shipping through Far East ports. Even more importantly this paper pointed the way towards practical uses of Queuing Theory in other areas of operations such as communications networks, air defence systems, etc.

During this period another technique that was used more widely than before was Gaming. Solutions to problems such as the optimization of armament for fighter bomber duels, design of minefields and optimal mine countermeasures were obtained using Game Theory. Sequential analysis was used in studying network or flow type problems.

By the end of the Korean war the group had grown in size, influence and prestige. Its morale was high and it had demonstrated that it could respond to an emergency. Equally as important, there were several new and powerful tools in its bag of tricks and it had some fresh combat data with which to work which might be usable in proving the Navy's case that modern warfare had not made the Navy a force with a past, but no future.

CHAPTER VIII

GROWING LIKE TOPSEY

The period from the end of the Korean war until the early '60s was one of great expansion of the operations research in the Navy. Possibly even more important from a scholastic point of view was that the science of operations research began to change and evolve toward its present form, i.e., a science that incorporates economics to a large degree and looks at strategic problems as well as tactical ones. The great expansion mentioned above can be attributed to many factors. Officers assuming higher command had seen OR at work for more than a decade and were impressed. Some of the early luminaries in the field were now in positions of great power, e.g., Admiral Robert B. Carney was CNO. Russia's entry into the nuclear "club" made national defense extremely expensive, and it was imperative not to make costly mistakes using the old trial and error methods of decision making. Competition for money from other services who had answers provided by OR organizations such as Rand had to be countered. Operations research became "fashionable" and many organizations felt that they had not arrived unless their lily was gilded by an OR group.

This factor caused a major personnel problem for OEG. So many commands and even the Department of Defense were asking for field representatives that OEG became somewhat unstable. Moreover, some of the scientists did not like the constant rotation and consequently left the group.

The Office of Naval Research was at a loss to understand why it was not deeply entrenched in the field of operations research. Early in 1953 ONR made a move to correct this seeming deficiency in its own organization by asking MIT to conduct an operations research program for ONR. MIT was unwilling to set up a separate group in Washington and since MIT had always been uneasy in its partnership with the Navy it was reluctant to take on the job in any form. In the end MIT's objections were beaten down and in June 1953 a contract was drawn up whereby scientists from OEG would be rotated to a group at ONR for work on problems generated by ONR. This group was called the Operations Research Group (ORG) and was established in ramshackle WWII temporary buildings. ORG eventually expanded to a staff of 8 men (see Appendix III), however, their achievements were never momentous. From the start in 1953 there was trouble between ONR and MIT/OEG. It seems that ONR had a tendency to interfere with both the administration of the group and in the actual work of the scientists.[47] Simultaneous with the establishment of ORG was the formation of a small group in OEG whose purpose was to keep track of Navy expenditures. This R and D review section was eventually transferred to ORG where it continued to turn out useful reports that indicated to OEG and ONR exactly where the Navy was spending its money, consequently implying the current value that the Navy was putting on various projects. By comparing these statistics with its own findings, as to where effort (money) should be applied, OEG was able to tell whether the Navy's present investments were being made in the most beneficial manner.

As the strains between OEG and ONR became more intense the morale of ORG dropped. ORG was moved to sumptuous new quarters, with little effect on morale. The scientists were not given properly challenging problems and there was even some pettiness in ONR's application of pressure which involved withholding of needed documents from OEG. Finally MIT/OEG decided that it must all end. Consequently the contract was ended on April 30, 1957. The R and D review section continued for another nine months, however. The parting of ways was by no means completely harmonious.[48]

There were few noteworthy results from ORG during its short life, but its existence did have several effects: First, it incurred a certain rivalry between OEG and its exchequer, ONR, which was neither helpful or seemly; secondly, it strained the relations between OEG and its parent organization, MIT.

In the post-Korea fight for the budget the Navy's chief competitor often had studies conducted by the Rand Corporation to back its positions. Naturally there arose a clamor, both from within and outside the Navy, to set up an organization similar to Rand for the Navy. The Navy approached this problem by appointing an ad hoc committee within OPNAV to study the situation. This committee recommended that a new desk in OPNAV be set up to study Navy long-range requirements. Early in 1955 the CNO, Adm. Robert B. Carney, created the Long Range Objectives Group (OP 93) to be headed by Radm. (later Admiral) Griffin. Its functions were to study subjects of interest to the Navy 10-15 years in the future, including:[49]

a) the responsibilities of the Navy

b) the tasks that must be performed to carry out those responsibilities.

c) the effect of world technology as effecting the performance of these tasks.

d) the capabilities required to perform these tasks.

e) the optimum weapons systems and techniques for achieving these capabilities, and their adaptability to and effects on established strategic concepts.

f) required composition of forces.

OP 93 was, in addition, authorized to acquire civilian scientists to help it in its broad task. The charter of OEG was sufficiently broad to qualify it to help on these problems. (See Appendix IV). However, there was much pressure against employing OEG. The reasons for this were many and varied, however the major ones were: many people in the Navy felt that OEG was good at small scale problems but was not necessarily replete with titanic strategic thinkers, OEG was too often subject to pressure from the Navy and this pressure would be ruinous to the sober reflection for which the Navy was searching.

MIT was again approached and asked to set up a separate organization in Washington to help OP 93. This MIT refused to do. Two separate organizations in Washington were more than even MIT could manage. Finally MIT/OEG agreed to set up several scientists taken from OEG as a group called the Naval Warfare Analysis Group (NAVWAG) (See Appendix V). This group would be managed by the Director of OEG but treated as a separate entity or division. It was hoped that

this might somewhat impede the expected rush by OEG scientists to join the new group studying the "Big Picture." The contract was signed on 30 December 1955 with funding of $35,000 for 6 months which was soon found to be grossly inadequate. Through its early years NAVWAG had many administrative difficulties mostly caused by inadequate funding arrangements with ONR. However, it continued to grow and fill a need. OP 93 became a place for rising stars, successful alumni include Adms. Griffin, Rivero and Ricketts. This was no small factor in increasing the interest of Naval officers in OR.

Although OP 93 and NAVWAG were supposed to study long-range problems their physical situation in Washington and their abilities eventually drew them into the position of helping solve any of the short-range problems which crop up so frequently in Washington. In 1958 the question of the usefulness of aircraft carriers was becoming more and more interesting to the Air Force and even to the Polaris oriented Naval Officers. OP93/NAVWAG did not have the answers to many of their questions. Therefore, Secretary of the Navy Gates wrote to the Naval Research Advisory Committee asking for help with this problem, and also for suggestions as to what the Navy should do to be better prepared to answer probing questions on long-range matters. Dr. C.G. Suits, Chairman of NRAC and a Vice-President of G.E., suggested that the Navy set up an organization to take over the long-range studies assigned to NAVWAG and that NAVWAG concentrate on the mid-range situation.[50] Secretary Gates turned the problem and recommendations over to the CNO. Admiral Burke sent out orders to have Radm. Hooper flown back from his command in the Carribbean to

head a new group. He then gave Adm. Hooper almost a blank cheque in the foundation of this group, but insisted that it be set up away from the pressures of Washington in order that it would not get mired down as had NAVWAG.

Adm. Hooper sequestered himself at the War College at Newport, Rhode Island. He took with him a half a dozen young Naval Officers and an international relations expert, Prof. Reitzel. The group was formalized on 31 March 1959 and was christened the Naval Long Range Studies Project (NLRSP). For almost a year nothing was heard from NLRSP. Finally its first study was completed. Long Range Estimate of the Situation was a book of about 200 pages which attempted to describe the world situation in 1975. All in all it was good work. It predicted the splitting of the USSR and China, and the polarization of NATO around France and the United Kingdom.

In 1961 NLRSP was reorganized, renamed and relocated. In Cambridge, Mass., the new Institute of Naval Studies (INS) began to take on a more academic flavor than it had as NLRSP in Newport. The ratio of civilians to Naval Officers increased steadily, and management was eventually contracted out to the Institute of Defense Analysis. There was also a change in the type of problems studied. They were less of the social, economic and political nature and more of the technical type. In many ways this reduced the uniqueness of INS. In his book, The Admiral's Lobby, Vincent Davis states:

> Some officers thought that one particular civilian employee of the Navy Department was a powerful empire builder who had managed to undermine the important original functions of NLRSP in his dual capacity as

> the director of two key agencies: the Naval Warfare Analysis Group (NAVWAG) and the Operations Evaluation Group (OEG).[51]

In June of 1958 OEG set up a new branch called the Applied Science Division (ASD) in Cambridge, Mass. Its stated purpose was to monitor upcoming developments in science, particularly from a technological point of view, and to report on their implications to the Navy. In fact another major reason for its establishment was to allow the scientists rotated to ASD to have a chance to mingle in an academic atmosphere for the duration of their tour. The Navy, however, ended all this when early in 1962 it directed OEG no longer to consider ASD as one of its field activities but belonging to INS. This was not such a great change because shortly thereafter INS merged into the OEG structure as will be seen in the next chapter. The use of ASD as a point of contact with academe, however, was terminated in this move. At its peak strength ASD consisted of 20 OEG scientists.

In 1952 at the Tenth Decimal Conference, Deputy Director of OEG, Dr. M. L. Ernst, stated "In equipment requirements we are interested in making the most of our limited budgets."[52] Since that time costing had become much more important even when equipment is not being considered. There was a large and powerful segment of the extra Navy OR community that felt that most things in life could be made commensurable to dollars by some means. This group's center was at Rand. Throughout the years when OEG had needed an economist they had hired one on a temporary basis. By the end of the fifties this appeared to be a very unsatisfactory way of doing business. A

short term economist never got the feel of the true nature of OR, and with the trend towards more and more costing OEG had a almost continual string of temporary economists. For some time OEG sought a permanent economist, finally after a decision was made to set up a separate economics branch Dr. Enke (ex Rand, as were most good costing men) was hired. Thus in January of 1960 the new economics branch was established. OEG had acted none too soon. Within a year Robert S. McNamara would be Secretary of Defense and every bit of costing ability that the Navy had would be sorely needed. This particular branch continued and expanded until 1963 when it was incorporated into NAVWAG. (See Appendix III).

From time to time in the past OEG had called on outside consultants, mostly ex OEG members, to help with specific problems. There were rarely more than 2 or 3 employed at any one time. Early in 1960 OEG changed its policy. A permanent board of 110 consultants was set up. Every effort was made to include the most able and respected men in science in this group. The purpose was twofold. first, to get good advice when needed, and secondly, to ease the recruitment problem by pointing out to younger men that some of the greatest scientists in the country were affiliated with OEG. This board continued until the next major reorganization of operations research in the Navy, and it appears that it fulfilled both of its intended purposes.

By glancing at the chart of Appendix III the reader can quickly review the major OR efforts in the Navy at the beginning of the 60s. It looks complicated, and it was. Fortunately, there was little

duplication of effort. Truly OR in the Navy had grown like Topsey and with so many groups it was nearing an unmanageable situation. This lays the groundwork for the following chapter which deals with the reformation of an unweildy conglomerate.

CHAPTER IX

CONSOLIDATION

In 1963 the Navy attempted to gain reconsiderations for the building of a second nuclear aircraft carrier of the Enterprise class. In response to the Secretary of the Navy's memorandum on the subject to the Secretary of Defense, Mr. McNamara wrote: "I do not feel that the subject of nuclear propulsion for surface warships has yet been explored sufficiently to permit a rational decision."[53] Furthermore he directed the Navy to undertake a comprehensive quantitative study of the situation. Two months later Secretary of the Navy Korth returned his findings. These met with little more enthusiasm than before. Mr. McNamara's reply stated "Your memorandum does not provide me with the information I need in order to reach a decision of this important subject.[54]

Obviously the Secretary of Defense was a man with new ideas. It was confrontations like the one above that had caused the Navy to reevaluate its decision-making processes. The arrival of the new Secretary of Defense in 1961 was a traumatic experience for the Navy. No longer could the CNO march down to Congress and demand a new battleship. The Secretary desired and demanded that each recommendation and decision be backed by a thorough scientific and economic investigation that clearly indicated it to be the best alternative. This was a form of operations research in that it was optimizing an output for a specified input. However, since Mr. McNamara's measure of effectiveness and inputs were often in units of dollars instead of more nebulous units, operations research began to evolve into a more economics oriented

science. Some types of operations research remained essentially the same, especially in the field of optimal tactics; but those studies that had significant costing in them (and there was an ever increasing number of these) came under a new heading. Systems Analysis.

Systems Analysis techniques often deal with broader questions than do those of classical operations research. Besides costing, another difference is that a problem studied with these techniques is most often looked at as a subsystem of a larger system and the interation ramifications are analysed. Classical OR might deal with the problem of optimizing Destroyers ASW search procedures whereas systems analysis might look at the value of the destroyer as an ASW System in a war at sea.

After struggling along trying to answer the questions posed by the office of the Secretary of Defense with help from the hydra headed OR organization that existed at the beginning of the sixties the Secretary of the Navy called on the Naval Research Advisory Committee for advice. Their suggestion was that the Navy make an effort to consolidate the Naval organizations whose primary purpose it was to conduct OR and Systems Analysis. The Secretary of the Navy went about this, as could be expected, by asking MIT to assume the management of a merged OEG-INS structure (OEG meaning the composite of its various parts. MIT took advantage of the new move to retire from the Navy OR picture entirely. It was really more interested in the technical aspects of research.

As a successor to MIT the Navy selected Franklin Institute of

Philadelphia. Why was Franklin Institute chosen. According to the Philadelphia Inquirer of September 20, 1962 and the Philadelphia Bulletin of October 5, 1962 there were strong implications that there was questionable conduct by a member of the Secretary of the Navy's staff. One week he was negotiating a contract for several million dollars with Franklin Institute and the next week he was a well paid employee of the Institute. He did not last long, but Franklin Institute remained the contract manager for nearly 5 years.

On March 31, 1962 the contract was signed. Franklin Institute was to manage a new entity called the Center for Naval Analyses. CNA was made up of three basic divisions. The first was OEG which continued to work on the "classical" OR type problems and continued to supply scientific analysts to OPNAV. OEG began sending representatives to the Marine Corps on a more formal basis than it had before. These analysts increased annually in number and worked with the Chief of Staff for R and D, eventually this effort would grow to a full fledged division of CNA. Since simulation and the use of digital computers in general was becoming a very important part of almost all OR work a computer division of about 12 people was set up to cater to the needs of all the divisions of CNA. The second division of CNA was NAVWAG, which split from OEG and became a more independent branch to study mid-range problems; NAVWAG absorbed the old economics branch of OEG. The third division of CNA was INS which was still situated in Cambridge, Mass., and had absorbed the Applied Science Division of OEG earlier that year. The role of INS was still to study the

long range situation of the Navy. The OEG branch continued to do most of its work for OP 03 (Fleet Ops and Readiness) whereas the rest of CNA responded to the desires of OP 090 (Director of Navy Program Planning.) CNA was not allowed to generate any work of its own, but was required to work only on areas requested by the Navy. Before each fiscal year began the Management of CNA and various desks in OPNAV as well as ONR meet to map out the work schedule for the following year. The board of 110 consultants was abolished. This organization remained stable for nearly 3 years.

In the meantime operations research/systems analysis activities sprang up throughout the Navy. Mr. McNamara made it clear that the Department of the Navy had better begin to manage itself using his methods or else the office of the Secretary of Defense would do it. Consequently there was a headlong rush at almost all staff levels to set up operations analysis branches. Many groups and individuals that were so termed had no idea of what either OR or systems analysis was or was supposed to be. Nevertheless they persevered, collected vast amounts of data, a large amount of which was neither reliable nor pertinent. This collected data was often mangled in a completely unjustifiable manner and produced a result that was either obviously wrong or so facile as to make a mockery of the science of operations research and systems analysis. This headlong rush into a new field by untrained novices had one very unfortunate effect: the officer who was at sea sailing a ship was overburdened by ridiculous demands for data from all quarters; after working hours

to generate this data there were few tangible good results that could be seen. This served to create a backlash against OR and systems analysis that still exists. In many wardrooms the terms OR or SA will bring forth sneers of derision, however, few officers can say what either term means or how better decisions should be made without using techniques similar to those of OR/SA. There were and are those who, not understanding the help that these new methods can bring them, consider them useless and reducing the importance of the Naval officer.

The load of studies to be carried became so great that it could not be adequately dealt with by the Department of the Navy or by CNA, therefore many of them were contracted out to private industry. Some contracts were let by OPNAV through ONR, and CNA even subcontracted some of its work. Most of these private companies started out in the field with very little experience or facility in OR. This is painfully obvious in reading some of the studies done in the early sixties. The high standards set by Secretary McNamara and the irresistable force of economic competition soon led to a marked improvement. Today some of the finest studies are ones conducted by private contractors, and most of the poor performers have been eliminated from the field. Industry's talents are an essential part of the overall OR effort in the Navy.

Returning to the progress of CNA. CNA and its various divisions continued to expand until 1965 when another reorganization took place. The management of CNA felt that a group much like the old ASD should

be formed, that is a division that would keep an eye out for upcoming scientific developments that would affect the Navy. Accordingly, a new branch was formed called the Systems Evaluation Group. In part SEG's charter read as follows:

> ...initiates and improves methodology, models and data for the purpose of analytically relating systems performance characteristics to the systems physical characteristics and systems cost....maintains liaison with the Navy laboratories and conducts formally directed studies and projects with focus primarily on technical issues.[55]

The other major change was that the group of analysts seconded to the Marine Corps was formalized into a division of CNA called the Marine Corps Operations Analysis Group (MCOAG). MCOAG's charter read "MCOAG furnishes analytical services for, participates in, and contributes to the overall study effort of the Marine Corps, embracing current, midrange, and long range problems."[56]

Although CNA was the main OR/SA organization for the Navy many of the desks in OPNAV had set up study groups consisting of officers with formal training, and often the OA trained officers were at CNA only as a dodge, i.e., the OPNAV staff had already filled all of its legally allowed billets and needed to put its overage somewhere. In spite of this the Navy did not have any real "in house" unit capable of high caliber operations research or systems analysis, and CNA, though good, had too slow a reaction time to be able to help in solving the day to day crises that come up in the Pentagon. CNA and the management of Franklin Institute were often at odds. The Institute was not really research oriented and rarely saw problems in the same light as OEG or the other divisions. It has been said

that in spite of Franklin Institute rather than because of it, some good studies were produced by CNA.

The problems with Franklin Institute led the Navy to seek another contract manager and the lack of an "in house" capability for OR/SA at the OPNAV level led to the final changes which give us today's organization.

CHAPTER X

PRESENT

By 1966 OR/SA had taken root firmly throughout the Defense Establishment. Almost all proposals as well as counter proposals were required to be backed by a strong quantitative study. The Navy had a capability at CNA that was qualitatively more than adequate, however its reaction time was long and there was a finite volume of work that could be done by one group. In order to overcome these deficiencies and to help coordinate OR/SA throughout the Navy the CNO decided to set up a Systems Analysis Division on his staff. This division would be able to produce studies for him on short notice without going outside of the Navy. Radm. Elmo Zumwalt, a quickly rising star in the Navy, one of the youngest and most able flag officers was chosen to be Director of this new division in the fall of 1966. The director of the division, the Systems Analysis Division (OP 96) operates under the Director of Navy Program Planning (OP 090). The analysis capability of OP 96 is normally used in solving the immediate working problems that face the Navy. Additionally it has four missions.[57]

1. To provide the CNO with a systems analysis capability to evaluate the relative effectiveness of alternatives in programs and program proposals. To this end, the division analyzes various force levels, weapons systems, personnel and support requirements and develops criteria for appraising the relative effectiveness of alternatives with respect to these areas. Additionally, it assists in the evaluation of programs and proposed changes, the balance of

individual programs, the overall balance within the total program and its relation to Navy Plans.

2. To manage the CNO Study Program and to coordinate this program with other Navy Department study efforts. The Navy Study Program sets forth specific areas that are to be analyzed and designates the study group responsible for the effort. The Study Program is quite explicit. Each study proposal is identified in the following manner:

a. By a clear statement of the objectives of the study, including any questions that must be answered.

b. An estimate of the professional man-years, civilian and officer, required to attain the study objectives.

c. Required study completion date.

d. Anticipated use of the study product and the gains which the Navy can expect to derive from it.

e. Specific identification of the responsible study group.

3. To review and evaluate study results. Once the Study Program has been approved, OP-96 closely monitors study progress. Five of the six groups with OP-96 are involved with this effort. The General Purpose Warfare Group (OP-962) has cognizance over subjects pertaining to surface, sub surface and anti-submarine, and tactical air warfare. OP-963, the Strategic Warfare Group, monitors studies relating to strategic offensive and defensive warfare and chemical, biological, and radiological warfare.

Studies of support areas; logistics, personnel, and communications, command control, are the responsibility of the Warfare Support Group, OP-964. The Military and Political Intelligence Appraisal Group, OP-965, covers studies in the areas of Naval intelligence, relationships with the intelligence community, psychological warfare, surveillance systems (space, surface, and sub-surface), and the relationship of future Navy roles in the world environment. The four monitoring groups receive feedback from studies conducted by CNA from CNO Project Officers who are assigned to each major study effort. Controlled through the Studies Management Group, OP-966, these officers provide the link between CNA and OPNAV. Their duties include providing CNA with military advice and guidance concerning Navy policy, strategic, tactical, and operational concepts as well as advising OP-96 on study progress.

4. To implement studies by CNA for the Director, Navy Program Planning. OP-96 serves as a point of contact with CNA. In addition to the previously mentioned functions of establishing study requirements and reviewing intermediate and final reports, OP-96 prepares the annual Study Program budget estimates for the CNO which includes the CNA appropriation.

Five of the six major groups with OP-96 have been mentioned above. The remaining one, the Program Analysis Group (OP-961), performs internal administrative and liaison duties. It is responsible for insuring the smooth functioning of the internal OP-96 program management system and its interactions with other OP-96

groups and OPNAV Force Sponsors.

OP 96 grew quickly, both physically and in influence: by 1968 the Division had approximately 50 officers assigned as well as another 20 or so working at CNA in the Operations Study Group (Studies Management Group.)

The latter part of the sixties saw a dramatic increase in the number of OR/SA jobs at various operational levels. Many of these were filled by OR/SA trained officers and some of the larger staffs made use of the OEG field representative systems. Most of the work done by these noncentralized groups was OR vice systems analysis, i.e. their work dealt with tactical problems at the operational level. The work of these small groups was significantly better than the work turned out when the first headlong rush towards OR/SA was made earlier in the decade. The reasons for this were: the Navy had time to build up the number of officers trained to conduct OR/SA in a proper manner; many senior officers were now able to pose their questions in a manner more amenable to good analysis; the Navy as a whole was feeling more at ease with the new methods used in OR/SA studies. These operational groups have contributed significantly to our effort in Viet Nam. Linear programming has been used for scheduling of replenishments. Search theory has been used to optimally design patrol craft search patterns. Regression analysis is used extensively to analyze aircraft losses. Many more examples can be cited but the important thing is that these beneficial proposals were made by OR teams in the field. This resurgence of good OA at the operational level

is encouraging, and the high caliber of work being turned out and its practical significance is convincing many former doubters of the value of OR/SA.

In spite of the lack of formal ties between the lower staff OR groups and those in Washington, there is much interchange of ideas and data, particularly through OEG representatives. In some cases such as in ASW exercises and missile firings, banks have been created that collect and store the data for Navy-wide use.

In August 1967 the Navy terminated its contract with Franklin Institute for the management of CNA and negotiated a new contract with the University of Rochester. Rochester was more research oriented than Franklin Institute had been and thus made a better management group for CNA. Morale at CNA rose quickly since the members were working for a management that understood their problems and had considerable research talent of its own. Several other changes were made with the new contract. CNA was allowed to devote 23% of its research towards Navy oriented projects of its own choosing. This lessened the feeling that CNA was a puppet on OPNAV's string, especially for the scientists at CNA.

After the change of management at CNA it was decided to assign more officers to CNA to participate as active members in the studies being conducted. Some of these officers act as project managers for CNO, i.e., monitor and report on the work of CNA. They report to the Assistant Technical Director, a Naval officer, who reports back to OP-96. The main reason for their presence however, is to infuse

some practical experience into the various study groups.

The final change was that a board of overseers was established. This board is made up of distinguished Naval officers and others who review CNA's actions periodically. The present organization of CNA has been built up and explained in the last few chapters. For a review, or possibly for a first enlightenment on the subject, the reader is encouraged to read Appendices III and VI. Once again it is important to note that a large amount of good OR/SA work is also done for the Navy by private industry.

Ever since March of 1942 operations research in the Navy has continually changed in organization as well as in philosophy. OR as first practiced was almost entirely the study of tactical or operational problems. As the years went by OR and Systems Analysis began to merge in definition and the outcome of this merger is a science that is used to study the broadest strategic concepts as well as operational problems. Organizationally there is to be a strong trend towards the Naval officer being a working member of the OR staff whereas at first OR was conceived of as civilian scientists working at the operational level. This is a good change provided the officers are fitted for the work (see educational supplement) and the scientists are in need of and ready to accept advice from seagoing officers. Undoubtedly operations research/systems analysis has not reached its final form in the Navy, if such a form exists. One thing is certain however, that it is here to stay and that it will make the Navy a stronger and more effective force than would otherwise be the case.

SUPPLEMENT I

EDUCATION AND EMPLOYMENT OF NAVAL OFFICERS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS

The role of the naval officer in operations research groups was generally one of an organizer and liaison man until the early 1950's. This was mainly due to two factors. First the educational background of regular naval officers did not provide them with the techniques that seemed to be the most useful in operations research. Secondly, the original concept of an OR team was one of civilian scientists working at the operational level, and some scientists felt that it should stay that way.[58] The reason for this feeling will be discussed subsequently.

When Admiral Robert B. Carney became CNO in 1950, he recommended that an OR educational program be established. Admiral Carney had been one of the leading figures in starting OR in the Navy and had clear concept of its usefulness as well as a conviction that the regular naval officer had the ability to operate on an OR team. It may be that he felt that the increasing scope of problems being attacked by OR methods might lead to a situation where the OR teams would be making or recommending tactical decisions without the benefit of an operational viewpoing. This would be doubly dangerous if the naval officer decision makers did not know or understand the processes that had led to the recommendation. As a result of the CNO's recommendation the Superintendent of the U.S. Naval Postgraduate School, Radm. Herrman, was directed to set up a one year curriculum in operations research and systems analysis at an appropriate civilian institution; M.I.T. was suggested.

The Superintendent of the U.S. Naval Postgraduate School sounded

out several civilian universities and met with no success. In December of 1950, he and the Director of OEG submitted a joint proposal that recommended the establishment of a six-term curriculum at the Naval Postgraduate School. After considerable discussion the Chief of Naval Personnel approved the recommendation with the stipulation that the curriculum might have to be changed if it proved to be too difficult for the naval officer who had not specialized in higher mathematics.

The Chief of Naval Personnel was not the only one who had doubts about the ability of the naval officer in the field of OR. Dr. J. Steinhardt, the Director of OEG, felt that the selection process for naval officers was not necessarily the one that would produce good operations researchers. He held that the educational period was too short and that frequent rotations to sea would not allow them to get past the apprentice stage. Furthermore he had doubts that naval officers could be objective in the face of pressure from higher commands.[59] In spite of these reservations the first class of nine officers commenced the curriculum in August of 1951. The course offered was the first formal course in operations research offered in the U.S. The curriculum was heavily oriented towards mathematics and the physical sciences and emphasized the techniques that had been used successfully in past operations research.

The first class graduated in January of 1953. Based on experience gained with this class, the Superintendent submitted a revised eight-term curriculum that led to a MS degree and included

an "experience tour" with a functioning OR group. Particular improvements in the new curriculum were (1) the inclusion of thesis work, (2) a greater coverage of proven OR methods, and (3) inclusion of work on digital computers.

The Chief of Naval Personnel approved this recommendation and the new curriculum was implemented in July of 1953. The second class which consisted of 15 officers was graduated in June of 1954. Since that time the size of the enrollment has varied from a low of four in 1957 to a high of one hundred and nineteen in the academic year 1967-1968. Some of these officers have been from the Supply Corps, Marine Corps, and the U.S. Army. In the meantime the OR/SA department came into being as a separate entity. The number and variety of courses offered increased steadily. The curriculum and department developed a high reputation in professional OR circles, the school was consequently able to hire and retain a high caliber faculty.

During its second class year the USNA class of 1962 was given the option of taking a pilot introductory course in OR/SA instead of a regular operations course. This pilot course was enthusiastically received by Midshipmen and was offered as a regular elective for several years. Eventually, the Naval Science Department incorporated required courses on OR/SA into its curriculum. With the new elective options at the Naval Academy it is now possible for a Midshipman to major in OR/SA and after graduation go directly to the Naval Postgraduate School for one year to get a M.S. degree. There are many officers, including the author, who feel that the Navy would be better served

in the long run if these young men went to sea immediately after graduation from USNA in order to learn something about the Navy.

Through the years the number of billets specifically designated for OR/SA trained officers has continually increased. Today there are approximately five hundred such billets. One finds naval officers conducting operations research in many different areas. The following is a partial list.

a. Research and Development: Naval Ordinance Test Station, Naval Ordinance laboratory, Naval Air Development Center.

b. Operational Evaluation: Air development squadrons, Submarine and Destroyer Development Groups, Staff Operational Test and Evaluation Force.

c. Operational Studies: OP-96, operational study group working at CNA.

d. Design and evaluation of Fleet readiness exercises.

e. Operational evaluations for operating commanders: CINCPACTFLT, FMFPAC, etc.

The requirement for OR/SA trained officers continues to grow. In order to help fill the need a six Quarter Bachelor's program has been established at the Postgraduate School and CNO has directed that when not on sea tours all OR/SA trained officers are to be employed in their sub specialty.

The Navy was the first service to establish OR/SA education for its officers and remains the service with the most officers who have a graduate education in this field. This situation will most likely continue and

there is now little disagreement that the Naval Officer's role on an OR/SA team should be one of a full fledged member. Therefore it can be assumed that the educational program for naval officers will continue and that it will remain essentially similar to the present one. On the other hand the employment of OR/SA trained officers will probably continue to expand and their talents will be applied to a continually enlarging set of Navy problems.

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APPENDIX I

Scientists at the Operational Level

A note prepared by Professor P.M.S. Blackett, F.R.S., in 1941

1. The object of having scientists in close touch with operations is to enable operational staffs to obtain scientific advice on those matters which are not handled by the Service technical establishments.

Operational staffs provide the scientists with the operational outlook and data. The scientists apply scientific methods of analysis to these data, and are thus able to give useful advice.

The main field of their activity is clearly the analysis of actual operations, using as data the material to be found in an operation room, e.g., all signals, track charts, combat reports, meteorological information, etc.

It will be noted that these data are not, and on secrecy grounds, cannot, in general, be made available to the technical establishments. Thus, such scientific analysis, if done at all, must be done in or near operation rooms.

The work of an Operational Research Section should be carried out at Commands, Groups, Stations or Squadrons as circumstances dictate.

2. SCIENTIFIC ANALYSIS OF OPERATIONS

To what extent is it useful to do analysis of operations in a more scientific manner than is done normally by Service specialist officers?

Experience over many parts of our war efforts has shown that such analysis can be of the utmost value, and the lack of such analysis can be disastrous. Probably the main reason why this is so, is that very many war operations involve considerations with which scientists are specially trained to compete, and in which serving officers are in general not trained. This is especially the case with all those aspects of operations into which probability considerations and the theory of errors enter. Serving officers of the highest calibre are necessarily employed in important executive posts, and are, therefore, not available for detailed analytic work.

Schedule of Typical Operational Research

The records of some war operation (e.g. air attacks on U-boats for the previous six months) are taken as the data. This is analysed as quantitatively as possible, and the results achieved are 'explained' in the scientific sense, i.e. brought into numerical relation with the other operational facts and the known performance of the weapons used. When this has been done, consideration is given to possible modification of the tactics to improve the

operational results.

The first step - that of collecting the actual data - is by itself of enormous importance, for it is not uncommon for operational staffs to be unacquainted with what is actually being achieved. An Operational Research Section is not in general concerned with 'hot news', though they should be prepared to so concern themselves if specifically requested to do so.

On the Validity of Deductions from Observations

A typical problem is as follows: a weapon A is calculated by a service technical department to be 50 per cent more efficient than a weapon B. Actual operations over a given period show, say, two successes for A and four for B. Does this prove that B is a better weapon that A?

Such points arise continually and require the highest scientific judgement to resolve. In particular a grasp of fluctuation phenomena (i.e. Poisson's Distribution) is required. If the average number of hits on some target in a given time is m, then (on certain assumptions) the chance that exactly x hits will be obtained in the same time is

$$\frac{e^{-m} M^{x}}{x!}$$

Value of Scientific Confidence and Numerical Thinking

The scientist in considering an operational problem very often comes to the conclusion that the common sense view is the correct one. But he can often back the view by numerical proof, and thus give added confidence in the tactics employed.

Or when two alternative qualitative views, 'A is best' 'B is best', are in dispute, he can often resolve this numerically into some such statement as that 'A is x per cent better than B in January and y per cent worse in June'.

In fact, the scientist can encourage numerical thinking on operational matters, and so can help to avoid running the war by gusts of emotion.

Operational Experiments

Since new weapons and devices are inevitably put into service relatively untested, the first few months of the use of a new device must be considered as an extension of its development trials. An Operational Research Section can function usefully here in a liaison capacity between the operational staff, the technical department which produced the device, and the development unit which tested it.

Further it is often possible, by collaboration between controllers and the staff of an Operational Research Section, to arrange operations on certain occasions so as to obtain data to clarify some doubtful point. For instance, the relative merits of different forms of anti-submarine sweeps by aircraft is a matter of (a) mathematical calculation, (b) test by actual operations, perhaps over a long period of time.

3. DISTRIBUTION OF REPORTS ON OPERATIONS

One of the functions of an Operational Research Section is clearly to write periodical reports on various aspects of operations. Except when secrecy questions prevent, these should be given a wide circulation, e.g., in the Air Force to squadrons to be read by the aircrews. In this way, the tactical education of the men on the job can be raised.

4. OPERATIONAL REQUIREMENTS

One of the most important duties of a Command is to state its requirements for new devices and weapons. Such requirements are passed, in general, through a department of a Ministry (which acts partly as a filter room, partly as a specialised department and party as a post office) to a Service technical establishment.

The only places in this chain where the real operational facts are known is at the Command Groups and Stations. Unless the operational requirement is considered scientifically at the Command jointly by the operational staffs and scientists, it is possible that the operational requirements decided on will not correspond (a) to the real need, (b) to the technical possibilities.

In other words, an Operational Research Section can act usefully by interpreting

(a) the operational facts of life to the technical establishments, and

(b) the technical possibilities to the operational staffs.

A considerable wastage of war effort has occurred through lack of this joint discussion.

Nothing in this Section or in Section 2 should be taken as implying that an Operational Research Section should be the only channel by which a technical establishment obtains operational experience- on the contrary the direct contact between a technical establishment and operational units is generally essential.

5. ORGANISATION AND PERSONNEL

An Operational Research Section should be an integral part of a Command and should work in the closest collaboration with the various departments at the Command.

The head of the Operational Research Section should be directly responsible to the Commander-in-Chief and may with advantage be appointed as his scientific adviser.

A considerable fraction of the staff of an Operational Research Section should be of the very highest standing in science, and many of them should be drawn from those who have had experience at the Service technical establishments.

An Operational Research Section which contents itself with the routine production of statistical reports and narratives will be of very limited value. The atmosphere required is that of a first-class pure scientific research institution, and the calibre of the personnel should match this. All members of an Operational Research Section should spend part of their time at operational stations in close touch with the personnel actually on the job.

6. NEW DEVICES

'New weapons for old' is apt to become a very popular cry. The success of some new devices has led to a new form of escapism which runs somewhat thus -- 'Our present equipment doesn't work very well; training is bad, supply is poor, spare parts non-esistent. Let's have an entirely new gadget.' Then comes the vision of the new gadget, springing like Aphrodite from the Ministry of Aircraft Production, in full production, complete with spares, and attended by a chorus of trained crews.

One of the tasks of an Operational Research Section is to make possible at least an approach to a numerical estimate of the merits of a change over from one device to another, by continual investigation of the actual performance of existing weapons, and by objective analysis of the likely performance of new ones.

The actual operational effectiveness over a period of time of any weapon can usefully (even if platitudinously) be considered as the product of three factors; the first $N(t)$ is the number in use, expressed as a function of the time; the second P is the scheduled performance of the weapon; and the third $S(t)$ is the average state of serviceability and training, i.e., the actual performance expressed as a fraction of the schedule. The probable form of $N(t)$ could be obtained from the production statistics of existing weapons. Relatively little is known of the form of $S(t)$, but probably a good first approximation would be to take $S(t) \propto (1 - e^{-t/T})$ where t is of the order of two months to one year according to the type of gadget. Some operational research might usefully be directed towards elucidating this function. One could then attempt a numerical estimate of the gain or loss involved in the change over from one device to another, and so attempt to avoid the unduly heavy costs of too rapid change over.

In general, one might conclude that relatively too much scientific effort has been expended hitherto in the production of new devices and too little in the proper use of what we have got. Thus, there is a strong general case for moving many of the best scientists from the technical establishments to the operational Commands, at any rate for a time. If, and when, they return to technical work, they will be often much more useful by reason of their new knowledge of real operational needs.

APPENDIX II

C-O-P-Y

UNITED STATES FLEET
Headquarters of the Commander in Chief
NAVY DEPARTMENT
Washington, D. C.

FF1/A3-1 19 August 1945

Serial: 6565

From: Commander in Chief, United States Fleet and
Chief of Naval Operations
To: The Secretary of the Navy

Subj: Continuation of Operations Research Group, Provisions for

1. Since April 1942 the Operations Research Group has been of service to the Navy as a scientific advisory group to the forces afloat and to the Commander in Chief, United States Fleet and Chief of Naval Operations, dealing with naval scientific evaluation from the point of view of the operational user of naval equipment. This group has been of active assistance in:

(a) The evaluation of new equipment to meet military requirements.
(b) The evaluation of specific phases of operations, i.e., gun support, AA Fire, from studies of action reports.
(c) The evaluation and analysis of tactical problems to measure the operational behavior of new material.
(d) The development of new tactical doctrines to meet specific requirements, i.e., A/S screens, for slow moving damaged ships, etc.
(e) The technical aspect of strategic planning.
(f) The liaison for the Fleets with the development and research laboratories, naval and extra-naval.

2. The Group carrying out this work consists of civilian scientific personnel under individual contract with the Office of Field Service of the Office of Scientific Research and Development, assigned to and responsible to the Commander in Chief, United States Fleet and Chief of Naval Operations. Previous to the formation of the Office of Field Service, the Group was provided through an OSRD contract with Columbia University.

C-O-P-Y

Enclosure (1)

Subj: Continuation of Operations Research Group, Provisions for

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The Group at present consists of about seventy scientists with a current annual operating budget of approximately $800,000.

3. This group does not concern itself primarily with the technical and scientific problems of research and development of new material. As the name implies, these personnel are scientific evaluators who concern themselves with the operational problems (material and tactical) of the Fleet. Their functions therefore, are properly a part of the seagoing command.

4. I feel that an uninterrupted continuation of this service into peacetime is necessary. Action should be taken at this time in order to preclude any discontinuity upon cessation of hostilities.

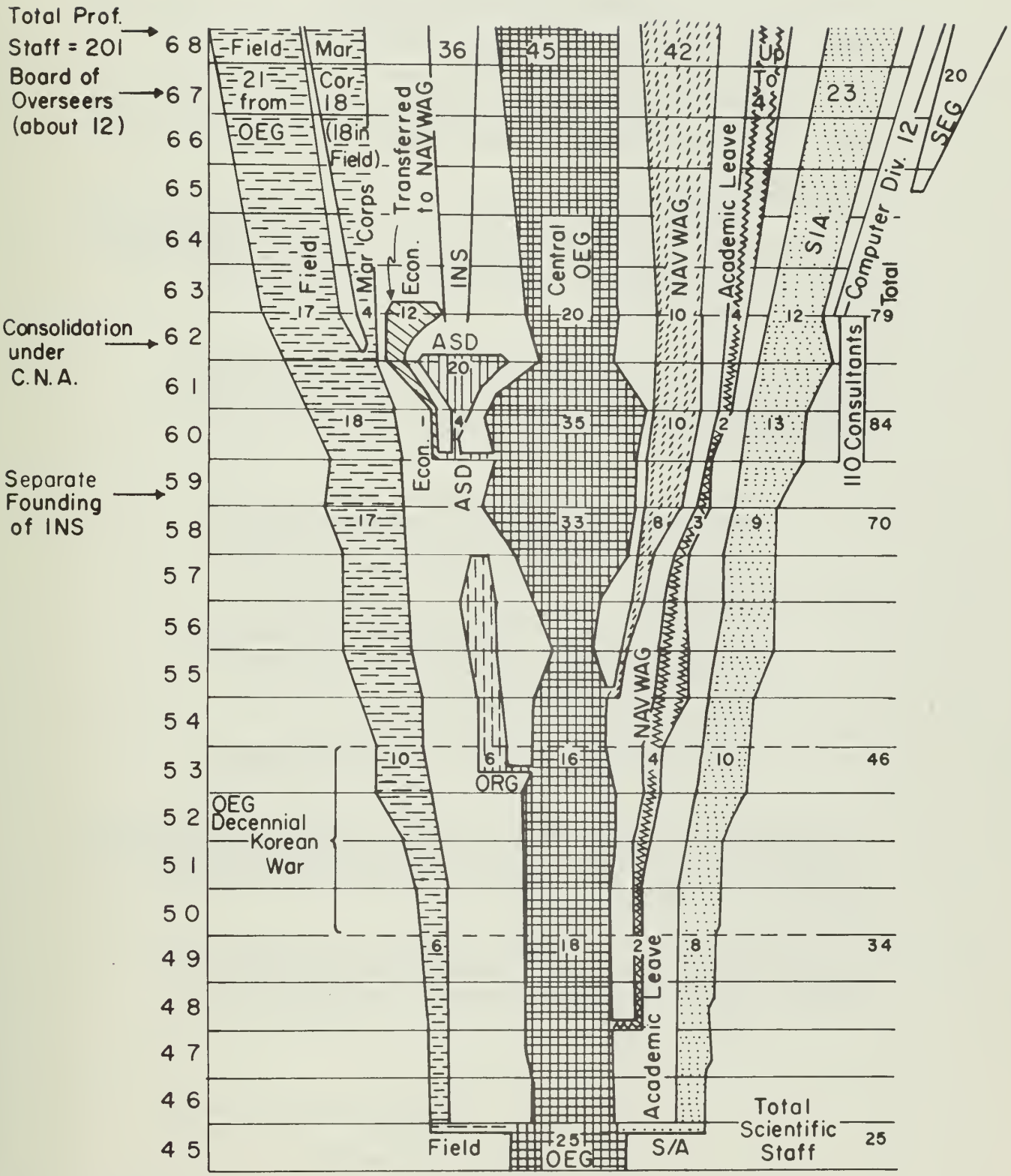
5. I therefore recommend that suitable provisions be made to continue this Group into peacetime at approximately twenty-five percent of its present size.

E. J. KING

Approved Aug 21, 1945.

/s/ Forrestall
Secretary of the Navy.

APPENDIX III



rowth of OEG/CNA and its associated research activities since 1945.

APPENDIX IV

OPERATIONS EVALUATION GROUP

SYMBOL: Operations Evaluation Group, DCNO (Op03EG)

POSITION: Operations Evaluation Group

GROUP: DCNO (Fleet Operations and Readiness)

TASKS AND FUNCTIONS:

1. To act as advisor to DCNO (Fleet Operations and Readiness) in all matters pertaining to those aspects (tactics or material) of Naval warfare under his cognizance to which operations analysis is applicable.

2. To act through its established tie-lines (Scientific Analysts), or on request and by the authority of DCNO (Fleet Operations and Readiness), as advisor to other parts of the naval organization (including the forces afloat) in all matters related to:

Evaluation of new developments to meet military requirements. Analysis of specific operations such as air or gunfire support activities, or the defense of task forces against undersea or air attack.
Analysis of tactical problems with relation to the effects of the introduction of new technology.
Development of new tactical doctrine to meet specific operational problems.
Analysis of enemy capabilities.
Technical aspect of strategic planning.
Liaison between the fleets and the development and research laboratories. Naval and extra-Naval.

3. To provide the forces afloat, through representatives assigned to them with such assistance as operations analysis can offer in making the best use of present and forthcoming equipment as operational circumstances permit.

4. To provide the Naval Research and Development Review Board with such studies of the Naval research and development program as may be required to ascertain the degree to which

Encl (1) to CNO ltr Ser
01Po3EG
7 Dec 1954

the program mathces, both in content and in emphasis, the present and probable future operational needs of the fleets.

5. To keep properly informed of all matters concerning operations, intelligence, new developments, and planning, as may be required for the proper exercise of advisory function in these matters.

6. To initiate such studies as may be required to maintain a state of readiness to act in an advisory capacity in the matters listed above.

Enclosure (1) to ser 01P03EG

APPENDIX V

C-O-P-Y

Subj: Naval Warfare Analysis Group

I. General Designation. The Naval Warfare Analysis Group (NAVWAG) is a group of civilian scientists established to act in an advisory capacity to the Chief of Naval Operations on certain long range problems of naval warfare planning.

II. Task and Functions

1. NAVWAG will act as adviser to Op93 in all matters pertaining to the long range missions, tasks, and requirements of the Navy to which the methods of operations research may be applicable.

2. NAVWAG will act on request and by the authority of Op93, as adviser to other parts of the naval organization in all matters related to:

   a. The analysis of tasks which must be performed to carry out the long range responsibilities of the Navy.

   b. The analysis of world technology as it affects performance of these tasks.

   c. The analysis of capabilities required to perform the tasks.

   d. The analysis of optimum vehicles, weapons systems and techniques for achieving these capabilities, and their adaptability to and effects on established strategic concepts.

   e. The analysis of required directions of weapons and vehicle development.

   f. The evaluation of required composition of forces..

3. By the authority of Op93, NAVWAG will participate in such committees and conferences of the Naval establishment that pertain to the long range planning problems of naval warfare and are necessary to the completion of the above tasks.

Enclosure (2) to
CNC serial 5193 dtd 29 Feb 1956

C-O-P-Y

4. NAVWAG will keep properly informed of all matters concerning operations, intelligence, new developments, planning, world technology and enemy capabilities as may be required for the proper exercise of advisory function in these matters.

5. NAVWAG will initiate such studies as may be required to maintain a state of readiness to act in an advisory capacity in the matters listed above.

III. Administration

1. NAVWAG, including scientific and such clerical personnel as may be required, will be established by contract with the Massachusetts Institute of Technology.

2. The Director of NAVWAG will report to the Director, Long Range Objectives Group (LROG, Op93). Their relationship is indicated below:

   a. In general, a close and intimate liaison between scientific (NAVWAG) and military personnel of the LROG will be maintained.

   b. Projects and priorities will be assigned to the Director, NAVWAG, by the Director, LROG.

   c. The Director, NAVWAG, will be responsible for the direction, progress, and completion of all projects undertaken by NAVWAG.

   d. NAVWAG, through the Director, will have the authority to generate its own projects.

3. The Director, LROG, shall be responsible for prescribing and maintaining effective liaison and information for the use of NAVWAG in properly fulfilling its tasks and functions.

4. The Director, LROG, shall be responsible for the distribution of all reports or studies rendered in connection with projects undertaken by NAVWAG.

C-O-P-Y

APPENDIX VI

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, D. C. 20350

In reply refer to
OPNAVINST 5000.29C
OP-966
Ser 77P96

15 JUN 1968

OPNAV INSTRUCTION 5000.29C

From: Chief of Naval Operations
To: Distribution List

Subj: Functions and organization of the Center for Naval Analyses and its relationships with the Department of the Navy

1. Purpose. To describe the functions and organization of the Center for Naval Analyses (CNA) and its administrative and operational relationships with the Department of the Navy.

2. Cancellation. OPNAVINST 5000.29B of 23 February 1965 is hereby superseded and cancelled.

3. Background.

a. As a result of the Naval Research Advisory Committee recommendation to improve the Navy Department study effort and a subsequent consolidation and reorganization of efforts in this field, CNA was formed on 1 July 1962. On 1 August 1967, the University of Rochester, Rochester, New York, became the contractor for CNA.

b. It is the policy of the Department of the Navy to have officers of the Navy and Marine Corps participate with CNA personnel in the study effort in order to:

(1) Inject operational experience, military judgment, and realism and help ensure relevance of all studies from their inception.

(2) Assist in providing answers and analyses for the current and future problems and programs of the Navy and Marine Corps.

(3) Ensure that the analyses made in studies are presented in a manner which facilitates their use in the decision-making process.

4. Organization of CNA. CNA, with headquarters in Arlington, Virginia, is headed by a President who is assisted by a Vice President for

Administration and Staff Senior Scientists. CNA consists of the following operating groups, each headed by a Director who is responsible to the President:

a. The Operations Evaluation Group (OEG), with field representatives located with the various fleet staffs and commands.

b. The Institute of Naval Studies (INS).

c. The Naval Warfare Analysis Group (NAVWAG).

d. The Marine Corps Operations Analysis Group (MCOAG). MCOAG includes a sub-group at the Development Center, Marine Corps Development and Education Command, Quantico, Virginia, and field representatives.

e. The Systems Evaluation Group (SEG).

5. Functions of CNA

a. CNA is charged with conducting a continuing program of research, studies and investigations which will assist the Department of the Navy in making management decision in the application and development of naval capabilities and to assist the operating forces of the Department of the Navy with operational analyses to help improve current operational capabilities and to provide an operational data base for other studies and analyses which include, but are not limited to, the following:

(1) In accordance with a program developed by the Scientific Officer to CNA, the Marine Corps General Officer Representative (for MCOAG studies and for CNA matters relating to Marine Corps and Landing Forces) and CNA, studies and investigations are undertaken with regard to problems in naval warfare in the broadest sense. This program includes, but is not limited to, operational and logistic aspects of naval warfare, including those aspects peculiar to the landing forces; analyses of current Fleet and Fleet Marine Force readiness; proposals for naval and landing force applications of new developments and technology; studies of development and procurement; naval and landing force long-range requirements for equipment, material personnel and supporting services; and naval implications of nationa objectives, policies and resources. Approximately 72% of CNA's effort is devoted to this area of contract performance.

(2) In response to requirements initiated by CNA, the CNA staff conducts research, studies and investigations in areas which the

Navy and CNA agree are Navy-oriented. Approximately 23% of CNA's effort is devoted to this area of contract performance.

(3) In augmentation of the programs set forth in subparagraphs (1) and (2) above, CNA conducts fundamental unclassified research and studies in areas of long-range interest and potential use to the Navy at the contractor's Campus, Rochester, New York, or elsewhere. Such research, studies and investigations include, but are not limited to, research in economics, political science, social science, applied mathematics and the physical and engineering sciences. Approximately 5% of CNA's effort is devoted to this area of contract performance.

b. The specific functions of each of the operating groups are as follows:

(1) OEG maintains liaison with Navy laboratories, furnishes analytical services to the fleets, assists in the design of operational exercises to improve the acquisition of meaningful exercise data and conducts analyses and makes reports with respect to the proximate time frame on such subjects as the evaluation of the capabilities of new equipment to meet military requirements, the evaluation of specific phases of operations through an examination of action and exercise reports, the evaluation and analysis of tactical problems, the development of new tactical doctrines to meet specific requirements and the technical aspects of strategic planning.

(2) INS conducts studies, analyses and investigations of long-range naval problems and the future contributions of naval officers to national security and objectives. The INS program includes analyses of the changing nature of warfare and future threats to seapower, the implications and effects of advances of science and technology on seapower, the international environment and situations, including the possible use of force, resources and other economic factors affecting naval forces, implications of sociological factors in the naval warfare, naval functions, postures, and capabilities to support future requirements, means of attaining required naval capabilities and forecasts of likely enemy capabilities and the use of these capabilities in the sea environment.

(3) NAVWAG conducts studies of the mid-range period concerning such subjects as the tasks which should be performed to carry out the future commitments of naval forces, the effect of the state of technology upon the nature of these responsibilities and tasks, the capabilities required to perform the tasks, the optimum weapons systems and techniques for achieving these capabilities and their adaptability to and effects on established strategic concepts, the recommended direction of weapons development and cost effectiveness analyses of

of alternative mixes and levels of forces.

(4) MCOAG furnishes analytical services for, participates in, and contributes to the overall study effort of the Marine Corps embracing current, mid-range and long-range problems.

(5) SEG initiates and improves methodology, models, and data for the purpose of analytically relating systems performance characteristics to systems physical characteristics and systems costs, provides models, data, and knowledgeable personnel to projects throughout CNA, maintains liaison with the Navy laboratories and conducts formally directed studies and projects which focus primarily on technological issues.

6. Organization of the Navy Department with respect to CNA

a. In recognition of the nature of CNA's research and study effort and of the contribution that can be made through the injection of operational experience, principles of warfare, military judgment, and realism into the overall study effort, and to ensure the responsiveness of this program to the needs and problems of the Navy, there have been designated within the Office of the Chief of Naval Operations a Scientific Officer and a Deputy Scientific Officer who are responsible for CNA matters. There has also been designated within Headquarters Marine Corps a representative of the Commandant who is responsible for CNA matters relating to the Marine Corps and Landing Forces. These designations are as follows:

(1) Scientific Officer to CNA - Director, Navy Program Planning (Op-090).

(2) Deputy Scientific Officer to CNA - Director, Systems Analysis Division (Op-96).

(3) Marine Corps General Officer Representative - Deputy Chief of Staff (Research, Development and Studies), USMC.

b. In order to provide a close coupling between the Navy and CNA, the Scientific Officer assigns a naval officer as CNO Project Officer for each study conduct in accordance with paragraph 5.a.(1) above. In general, the duties of the CNO Project Officer are to provide strategic, tactical and technical inputs as some of the study inputs to be used and to monitor studies for the Scientific Officer. The assignment of CNO Project Officers is subject to the general acceptance of the President, CNA.

c. In addition to the assignment of CNO Project Officers, a group of naval officers is assigned to the Operations Study Group

(CNA) for participation in the study program at CNA. These officers report to an Assistant Technical Director for Naval Matters (ATDNM) at CNA. The ATDNM is a naval officer selected by the Navy and subject to the acceptance of the President, CNA. The ATDNM reports to the Scientific Officer for duty with the President, CNA, and he receives his work assignments from the President, CNA. Appropriately qualified officers in the Operations Study Group (CNA) may be given the opportunity to direct some of studies at the discretion of the President, CNA.

7. CNA/Military Organizational Relationships

a. The President, CNA, and the Directors of the CNA operating groups are responsive to the Scientific Officer and Deputy Scientific Officer with respect to planning, coordination, progress and quality of the analyses and studies. The Marine Corps Representative acts as the focal point for Marine Corps matters relating to CNA and effects coordination with the Scientific Officer on all such matters. In addition, in coordination with the Scientific Officer, he maintains close contact with, and provides military advice and guidance to, the President, CNA in connection with Marine Corps and Landing Force matters.

b. The Director, OEG, is responsive to the Deputy Chief of Naval Operations (Fleet Operations and Readiness) for the service performed by OEG.

c. The Directors, INS, NAVWAG and SEG are responsive to the Scientific Officer to CNA (Op-090) for the services performed by INS, NAVWAG and SEG, respectively.

d. The Director, MCOAG is responsive to the Marine Corps Representative for the studies and services performed by MCOAG.

e. The Chief of Naval Research, as Contracting Officer, is responsible for administration of the CNA contract with University of Rochester.

8. Responsibilities of the Scientific Officer to CNA. The responsibilities of the Scientific Officer include, but are not limited to, the following.

a. Represents the Chief of Naval Operations in CNA matters and acts as Study Sponsor for CNA studies conducted in accordance with paragraph 5.a.(1) by INS, NAVWAG or SEG.

b. Maintains close contact with, and provides military advice and guidance to, the President, CNA.

c. Determines the technical responsiveness and adequacy of CNA performance under the contract.

d. With the assistance of the Marine Corps Representative and key CNA personnel, develops and maintains a study program designed to cover the mid-range and long-range aspects of seapower in the broadest sense.

e. In conjunction with the Marine Corps Representative and Chief of Naval Research, prepares the annual budget for support of the CNA study program and all changes thereto.

f. Promulgates completed CNA study reports as directed by the Chief of Naval Operations and determines the necessary distribution therefor. However, OEG study reports shall be promulgated and distributed by the Deputy Chief of Naval Operations (Fleet Operations and Readiness.)

g. Consults with the Chief of Naval Research regarding any planned or actual departures from the effective CNA contract document.

9. Responsivilities of the Deputy Scientific Officer to CNA (Op-96). In addition to his general authority to exercise all functions of and for the Scientific Officer, specific duties of the Deputy Scientific Officer include, but are not limited to, the following:

a. In collaboration with the Marine Corps Representative and the Directors of the CNA operating groups, plans and recommends to the Scientific Officer the overall study program of CNA, assists in organizing study projects as requested by CNA, and ensures adequate guidance to CNA on a continuing basis.

b. Maintains liaison with the Marine Corps Representative as necessary to assure desired representation and coordination on all studies of joint Navy/Marine Corps interest.

c. Advises the Scientific Officer on CNA performance.

d. Acts as point of contact for the Scientific Officer in CNA matters.

e. Prepares the annual CNA budget estimate for the Scientific Officer.

f. Performs necessary administrative functions in connection with the CNA contract as delegated by the Chief of Naval Research, including certification as to technical necessity in appropriate cases, processing of security clearance requests, and certifications of need-to-know.

10. Responsibilities of CNO Project Officers at CNA. As principal representative of the Scientific Officer and the Deputy Scientific Officer, the CNO Project Officer s responsibilities with respect to the study include evaluation of CNA performance with respect to planning, coordination, progress and quality of the study, liaison between the Navy Department and CNA, assistance to the CNA Study Director and monitoring the study for the Scientific Officer. In these areas, he will accomplish specific tasks as follows:

a. Prepares the Study Directive, working with Op-96 and coordinating with CNA to ensure the feasibility of accomplishing the objectives desired.

b. Reviews the draft Study Plan, study group working papers and study reports, providing comments and recommendations to Op-96 and the Advisory Committee as appropriate. These comments should indicate whether the Study Plan, working papers, study reports and other official documents produced by the study group are consistent with the requirements of the Study Directive.

c. Maintains liaison with cognizant OPNAV offices, others interested naval activities, including the Fleet, and other Service and DOD activities (through appropriate channels) in order (1) to provide the CNA study group with data, experience and study inputs that these activities can make available, (2) to inform these activities of significant developments in methodology, significant assumptions and terms of reference used by the study group, problem areas encountered and results obtained, and (3) to advise these activities of study findings which affect established Navy doctrine and plans.

d. Ensures that regular, frequent meetings of the Advisory Committee are held.

e. Collaborates with the CNA Study Director in preparing presentations and briefings on study progress, findings and results as may be required. In this regard, he shall prepare appropriate announcements for such briefings and presentations and assist in preparing appropriate backup material for such presentations. In addition, he shall prepare appropriate minutes and memoranda for the record as may be directed by the Deputy Scientific Officer.

f. Assists in obtaining information which the CNA Study Director deems relevant to the study. To this end, assist in identifying activities where relevant information may be found, in arranging visits of study group personnel to such activities and in procuring documents pertinent to the study.

g. Provides to the CNA Study Director military advice and guidance concerning Navy policy, strategic, tactical and operational concepts (e.g., established Navy doctrine and plans), and technical information, and review ongoing analysis to ensure that the group is aware of official Navy concepts, strategy, tactics and technology.

h. Ensures that the CNA Study Director is fully aware of all directives and guidance provided by the Scientific Officer and the Advisory Committee.

i. Advises the CNA Study Director with respect to past and ongoing studies which are related to his study.

j. Advises the CNA Study Director with respect to the classification of information developed in the study.

k. In the case of warfare studies, develops with OPNAV a DIA-approved threat for suitable reference by the CNA Study Director in the study.

l. Ensures that Navy comments and recommendations are transmitted to the CNA Study Director in a timely manner so that he can assure their adequate consideration.

m. Reports periodically to the Deputy Scientific Officer on the progress and responsiveness of the study, the development of significant findings and the need for special assistance to the study group as such needs develop.

n. Ensures that research and development implications resulting from the analysis are clearly and adequately highlighted in the study report.

o. In the event of controversy between CNA and the Department of the Navy about the methodology, data, or conclusions of a study, assures that the study report contains all conflicting positions.

p. Upon completion of the final draft study report:

(1) Forwards sufficient copies of the study report to Op-96S with a recommended distribution list for OPNAV review.

(2) With the assistance of the Op-96 Study Monitor collates review comments and prepares a Navy position on the report, providing this information to the CNA Study Director for inclusion in the final report.

(3) With the assistance of the Op-96 Study Monitor, prepares a draft CNO endorsement and one-page summary in accordance with current instructions.

11. Responsibilities of the ATDNM. Specific duties of the ATDNM include the following

a. Maintains liaison with the Bureau of Naval Personnel, the Commandant of the Marine Corps and the Office of the Chief of Naval Operations in order to ensure the assignment of appropriately qualified personnel to CNA studies.

b. Assigns officers attached to the Operations Study Group (CNA) to CNA studies to meet the requirements of the President, CNA.

c. Supervises the performance of duty of officers attached to the Operations Study Group (CNA) and supervises other military and civil service personnel assigned to studies on a temporary duty basis.

d. Supervises the administrative aspects of the participation of the military and civil service personnel assigned to CNA studies, cooperating with the CNA Security Administrator to ensure that such personnel receive proper indoctrination into the CNA security system and are cleared of custody of all documents under CNA control prior to their detachment from the study groups.

e. Provides appropriate assistance to CNO Project Officers in matters relating to naval administration.

12. Responsibilities of Officers Attached to the Operations Study Group (CNA). Specific duties of officers attached to the Operations Study Group (CNA) include the following.

a. Participate in the conduct of the studies to which assigned as a full time member of the study group, performing such duties as may be directed by the CNA Study Director.

b. Assist the CNO Project Officer in obtaining valid study inputs from naval sources for use in the analysis.

/s/ B. A. Clarey
B. A. CLAREY
Vice Chief of Naval Operations

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ABSTRACT

This thesis traces the history of the practice of and organization for operations research in the United States Navy. The author points out that operations research was being conducted in the U.S. Navy before operations research became identified as a separate science. From that point its growth, major accomplishments and organizational changes are described. The final part of the thesis outlines the organization through which the Navy conducts its operations research and systems analysis at the present.

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