

## INTRODUCTION

To record and bring attention to the early years of operations research analysis and the Military Operations Research Society (MORS), the MORS Board of Directors created a Heritage Committee in 1992. The Heritage Committee uses two main methods for disseminating the history of operations research analysis. One is to conduct a Heritage Session at the yearly MORS Symposium; the second method is to publish oral histories provided by prominent MORS members. This document contains the oral history of one of the most distinguished members of MORS: Wayne Philo Hughes, Jr. Wayne Hughes is currently the Dean of the Graduate School of Operational and Information Sciences at the Naval Postgraduate School (NPS) in Monterey, California. The purpose of the interview was to gain insight into Dean Hughes' background, his motivation for studying Operations Research analysis, his early experiences in operations analysis, and his ideas regarding the development and future direction of MORS. The interview was conducted in three sessions: 31 March 2003 at the Naval Postgraduate School, Monterey, California, and 9 June 2003 and 11 June 2003 at United States Marine Corps Base, Quantico, Virginia.

**MIKE GARRAMBONE:** Today is Monday the 31st of March 2003. It is 15:30 and I am in the office of Wayne P. Hughes, Jr., Dean of the Graduate School of Operational and Information Sciences, at the Naval Postgraduate School, Monterey, California. Sir, I'd like to start with some basic questions about your background. Where were you born and raised?

**WAYNE HUGHES:** I was born in Charleston, Illinois, on 30 May 1930. I grew up in the Midwest and fell in love with the sea by reading stories. Most great naval officers came from inland states, from individuals like Nimitz who came from Texas, Arleigh Burke who came from Colorado, and Ernie King who came from Ohio. I guess if you live too close to the sea, then you know better than to go to sea. But if you come from the Midwest you have this romantic view of the Navy. Well, I went off to the Naval Academy in 1948 right out of high school (Hirsch High School, Chicago IL 1944–1948), graduated from USNA in 1952, and started my career in destroyers.

**MIKE GARRAMBONE:** Did your parents influence this naval career choice?

**WAYNE HUGHES:** Well, I'm a junior. My mother's name was Nancy Gay Case. She came from Indiana and my father came

from Ohio, so we truly were Midwesterners. And, no, they didn't have any inkling that I had this love of the sea. I come from a big family of teachers. Actually, there were lots of teachers throughout my family.

**MIKE GARRAMBONE:** I assume they must have given you some terrific insight into your teaching career very early.

**WAYNE HUGHES:** Yes, indeed they did.

**MIKE GARRAMBONE:** Any brothers and sisters?

**WAYNE HUGHES:** I'm an only child.

**MIKE GARRAMBONE:** Tell us about your early schooling.

**WAYNE HUGHES:** Most relevant to these discussions, when I was in high school, I liked mathematics and geometry. When I went off to the Naval Academy, I found I preferred naval history, foreign policy, and literature, and so I already lived in this world of great tension between what we consider the hard and soft sciences.

I went to the Naval Postgraduate School from 1962 to 1964 ten years later; I was right back into the mathematical and analytical side of things. So I have lived with a foot in both camps—I guess I'm a dilettante. I like everything, but that means I can't be very deep at anything. The same thing is true of having one foot in the Navy and one foot in the analytical community. It is like having one foot in broad and interdisciplinary kinds of studies and the other foot in knowledge like most academics have to have, with a lot of depth in some particular field.

**MIKE GARRAMBONE:** Was there anything in high school that led you down this path?

**WAYNE HUGHES:** In a few words, it was dumb luck. In my senior year of high school I was going to Purdue University because my mother went there. About half-way through my family got to talking about the Naval Academy with a neighbor. I mentioned that I'd really like to go to the Naval Academy, but I thought it was beyond my reach, and he said, "Oh, I'll get ya' a nomination." He didn't actually help a bit, but he got me working on it myself, and with a little luck I got in with a Congressional appointment in the fall of 1948.

**MIKE GARRAMBONE:** What did you study at the Naval Academy?

**WAYNE HUGHES:** Everybody studied the same thing then. The only choice one had when I went to the Naval Academy was language. It was common curriculum for everyone then. I came back in 1957 to 1960 and participated in a curricu-

# Military Operations Research Society (MORS) Oral History Project Interview of Wayne P. Hughes, FS

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lum revolution in which we broke free from this rigid system. The first thing we did was allow validation of previous studies and that meant that electives were now possible and that led to different year groups going to class together, which meant you couldn't march to class anymore. This one idea—validation—broke an enormous logjam. At the same time we stiffened the courses, especially in science and engineering, to more of a college curriculum. When I went there, the Naval Academy was an awful lot like a late nineteenth century academy.

**MIKE GARRAMBONE:** How so?

**WAYNE HUGHES:** It was like a high school level academy where you study, recite, and make sure you knew your lesson, but it didn't particularly emphasize whether you had absorbed the material beyond the next day's recitation. It imbued knowledge more than it imbued the capacity to reason. Education has to teach how to think and understand multifaceted problems.

**MIKE GARRAMBONE:** Was it more like an engineering school?

**WAYNE HUGHES:** After the change it was closer to an engineering school, a very good engineering school. Before the change I would say the intent was that it be an engineering school, but engineering characterized as design of boilers and turbines. After the change there was an understanding of thermodynamics, fluid mechanics, and more of the courses that a college undergraduate would take. For instance, in my Plebe year, one of the courses that we took was drafting—mechanical drawing we called it. It was an extraordinary course, and one of the subjects I did very best at, but it was obsolete in a college environment.

**MIKE GARRAMBONE:** In my own thoughts I relate to you as a grand teacher of tacticians. Can you tell me what tactics was like at the academy then? Were there any similarities with the teaching of tactics of today?

**WAYNE HUGHES:** The tactics then were kind of "hands-on" tactics. We went out in a small patrol craft called YPs (yard patrols), which were just big enough that a dozen midshipmen could man them. We could maneuver up and down the Severn River and try different formations using the signal book and radiotelephone procedures. We did have a CIC drill because we had some very good CIC mockups that were installed during World War II. CIC stands for the Combat Information Center, the

combat direction center where we fight our ships.

**MIKE GARRAMBONE:** Were these powered or sail?

**WAYNE HUGHES:** The YPs were diesel engine powered. The CIC was ashore in Luce Hall. We also memorized things like the signal flags, and flashing light Morse Code. We learned in Naval Ordnance and Gunnery how a fire control computer worked, the old mechanical computers that used analog systems of cams instead of digital type computers.

**MIKE GARRAMBONE:** System of cams?

**WAYNE HUGHES:** Cams that were shaped like integrals and stuff like that.

**MIKE GARRAMBONE:** That's a different form of tactical stuff.

**WAYNE HUGHES:** The closest we came to a course in tactics per se was in the naval history course. The civilians liked to emphasize the strategy and policy aspects more than tactics in naval history. I went back to USNA to teach naval history and played a small role in the big curriculum revolution that took place from 1957 to 1960. I taught naval history then while I was working in the Superintendent's office.

**MIKE GARRAMBONE:** You must have had some interesting students.

**WAYNE HUGHES:** Yes, in fact there were a couple who later became flag officers. But keep in mind, not all my students were going to become members of the Operations Research community.

**MIKE GARRAMBONE:** Could you mention some of your early mentors?

**WAYNE HUGHES:** After I graduated, an early mentor who was very instrumental in my taking Operations Research was Commander Leslie L. Youngblood. He was the executive officer of my first ship, the USS Cushing (DD797). He had worked with Forrest Sherman when they were both on the Battleship Missouri. He told me that the up and coming graduate education to take was a new curriculum being started at the Naval Postgraduate School. This was in 1953 and Les Youngblood said the only curriculum a line officer ought to consider was the Operations Analysis curriculum. Youngblood was a Rhodes scholar, an intellectual, and the guy who first showed me that there was more to being a naval officer than being an officer of the deck, a division officer, and a navigator. I took note, because I was a navigator on my first ship.

**MIKE GARRAMBONE:** What ship was that?

**WAYNE HUGHES:** It was the USS Cushing. It was about the fourth USS Cushing, DD 797. The ship was named after the destroyer that was sunk at the first night battle of Guadalcanal and I still occasionally go to Cushing reunions in which my ship's crew and the crew of the one that was sunk gather together. Now some come from the present Cushing, which is a Spruance class destroyer. But my Cushing was a Fletcher Class and the CIC in it was something that had been invented by J.C. Wylie, "Bill" Wylie, who had been on the original Fletcher on the night it was sunk at the first night battle of Guadalcanal. He was then in another battle. Fletcher survived both battles unscathed while we were losing ships right and left and somebody figured out that the effective use of radar made a lot of difference. So they called Wylie back to Pearl Harbor and interviewed him to see what was going on. He developed the destroyer CIC doctrine before there was a destroyer CIC. Then they sent him back to Washington, where he designed a CIC that just fit into the captain's in port cabin. You could just squeeze in around the DRT (dead reckoning tracker) and there was the radar in one corner and the sonar in another corner and everyone was jammed into this CIC like sardines in a can.

**MIKE GARRAMBONE:** What were your duties on the ship?

**WAYNE HUGHES:** I started out in the gunnery department. Within about three months, the executive officer made me his assistant navigator, and after another six or nine months I became the official navigator while still an ensign. It's a pretty remarkable story that the captain and exec would trust an ensign to be the navigator of a destroyer. That lasted for most of my time on board, and then, since in your first duty station you should be broadening your career base, I went to the engineering department for the last nine months of my two years on board. Then I went to the mine force.

**MIKE GARRAMBONE:** Was this related to your OR interests?

**WAYNE HUGHES:** It was about that time that my second connection with Operations Research arose. I found in the wardroom an old OEG (Operations Evaluation Group) publication, *Anti-Submarine Warfare in World War II*. The first half of the book was a narrative history of the Battle of the Atlantic with a lot of data in

it. The second half of the book was about Operations Research techniques. I could see that some of those Operations Research techniques had been adopted in the tactical publications we were using; that just grabbed me. I really thought that it was the sort of thing that every naval officer who expected to fight should know. It was the essence of tactical thinking with a quantitative twist.

**MIKE GARRAMBONE:** So your interests came from the early days?

**WAYNE HUGHES:** Yes, even before I went to the Naval Postgraduate School I knew that Operations Analysis meant tactical analysis. OK, lets not jump too far ahead now; we were going on to my next duty in the mine force. There, I was executive officer for eleven months and then became one of the first commanding officers out of my class, a commanding officer of the minesweeper USS Hummingbird (MSC 192), based first out of Charleston, South Carolina and then Yorktown, Virginia. I can tell you that command of a minesweeper was a heckuva lot bigger challenge than command of a destroyer.

**MIKE GARRAMBONE:** Why would you say that?

**WAYNE HUGHES:** I realized it when I had my destroyer command. At that time as a commander, I had at least five officers and maybe six who had more experience than I did when I was commanding officer of my minesweeper. In fact, at the low point of my wardroom's experience in the Hummingbird, the other three officers had a total of eighteen months. My executive officer had only one year in the Navy. One officer had six months in the Navy, and one officer had just reported aboard, this being his first assignment.

**MIKE GARRAMBONE:** So you're the senior man with two years?

**WAYNE HUGHES:** I'm the senior man who by this time has four years of experience, all afloat.

**MIKE GARRAMBONE:** You say the job was challenging and more difficult?

**WAYNE HUGHES:** We had an administrative check-off list that was as big and onerous as the one for destroyers. It was literally a couple of inches thick and you parceled that out among your three officers and your leading petty officers, and this small handful of people had to go through all the administrative things that fifteen officers and fifteen CPOs (Chief Petty Officers) would deal with in a destroyer.

We were as heavily “over administered” as a destroyer was. Now operationally in mine-sweeping we did a lot of formation steaming. Occasionally we ventured out alone, but usually we would steam in formation of four or five ships operating together. Well, if you’re steaming in a formation, whether you are a hundred and forty-four feet long, which is what we were, or three hundred and eighty feet long, which is what a destroyer is, or even six hundred feet long, which is what a cruiser is, the intricacy of the maneuvers are not much different. Next, by putting the minesweeping gear in the water you now are in effect maneuvering a system. You have a ship plus maybe moored sweep gear, maybe magnetic sweep gear, maybe acoustic sweep gear, maybe several of them at the same time. With sweep gear in the water, you are less maneuverable than an aircraft carrier.

**MIKE GARRAMBONE:** An aircraft carrier?

**WAYNE HUGHES:** That is right, even less maneuverable than an aircraft carrier. There you are, with all your gear in the water, maybe in formation, perhaps in a sort of a “V” formation, and along comes a merchant ship. Now even though you’ve got your signal in the air, either a day signal or night signal, that says you’ve got minesweeping gear in the water and they must stay clear from you, you can’t count on that. What I’m indicating is that in many ways a minesweeper command demanded more seamanship and foresight than command on a much larger ship.

**MIKE GARRAMBONE:** Was this done often?

**WAYNE HUGHES:** When we operated in the York River we used to make two landings a day. We would get underway with students on board and we would go out in the river and throw the gear in the water. The students would learn how to put the minesweeping gear in the water and recover it. We’d come in about twelve o’clock, tie up, and that class would leave the ship. At about 1:00 or 1:30 another class would come aboard and we’d get underway, to do it again, and come in and make another landing about 5:30 in the afternoon and then that class would go ashore. I don’t know of any better way to learn ship handling than to get underway twice a day and make landings twice a day. And it just so happens that these were tricky waters too, because the tidal currents are pretty strong in the York River.

**MIKE GARRAMBONE:** What was the timeframe for all this activity?

**WAYNE HUGHES:** This all took place in 1956 and 1957. I took command in January of 1956 and gave up the ship in July or August of 1957. As I mentioned earlier, I started in Charleston, South Carolina. I had command out of Charleston for about half my tour, then the whole division swapped with a division that was in Yorktown and we became a school ship. It was there when we did the things that I’ve been describing.

**MIKE GARRAMBONE:** So you spent a lot of time maneuvering and learning how to search for stuff. This seems like some of the events discussed in early writings of Operations Research.

**WAYNE HUGHES:** If you consider that the best analyst is an able officer who has operated a lot and has seen in our tactical publications the fruits of analytical work like the bent line screen and what was called operation Rum and Coke, then you have a strong tactical planner. The Rum and Coke operation is a re-orientation of an ASW (anti-submarine warfare) screen based on signals that caused a screen to reform at an angle from the way you were previously going. If you can see the logic of a formation and the mathematics of station keeping, and understand the problems of relative motion, then you have to think that tactics is science as well as art.

**MIKE GARRAMBONE:** You talk about maneuver as a major planning process that you have to think about well in advance. It appears you were concentrating on the dynamics of movement you encountered at sea?

**WAYNE HUGHES:** Yes. After my tour at the Naval Academy, I was the Operations Officer of another destroyer that operated with a hunter/killer group. There were lots of times when you would go after a submarine in what was called a search attack unit with a couple of ships to try and find and destroy an exercise submarine. After simulating our attack, we would have to rejoin and take our station. If you come back and take station from “ahead,” then you may have to do a turn that is approximately a hundred and eighty degrees. Well, imagine the time it takes to turn a ship. It takes about two and one-half minutes. During the turn, the movement of the rest of the formation is substantial and so is your own transfer, which is the off-access movement, and it can be substantial too. It is as big as a turning circle of

the destroyer. The “maneuvering board” we used doesn’t solve that problem. The maneuvering board tells you what course and speed to take when you’re going directly into the station without accounting for advance and transfer.

**MIKE GARRAMBONE:** What did you do in these special cases?

**WAYNE HUGHES:** I developed a little algorithm I called the turning ellipse. It was all geometric, no mathematics at all. But it worked like a charm and I taught everybody in my wardroom, then wrote it up and had it published in one of the tactical pubs. When I got here to the Naval Postgraduate School years later I decided maybe I ought to see what the mathematical formula really was. It turned out that I was describing a mathematical cycloid. Its proper name would’ve been the tactical cycloid, but that didn’t have any buzz to it.

**MIKE GARRAMBONE:** It sounds like you did applications thinking first and then worked out the theory later.

**WAYNE HUGHES:** Yes, I think art comes before science, and science is merely a representation of the dynamic structure and institutionalization of what the practical wisdom of people over the course of history develops. For example, geology was invented because people wanted to know where the coalfields were. Astronomy was invented because people found out that the seasons could be predicted by the stars and several centuries later that they could also be used to find and keep track of their locations.

**MIKE GARRAMBONE:** Are you saying that there seems to be a need that draws things together, or a form of strife that creates a circumstance for people to learn things?

**WAYNE HUGHES:** Either one, but I don’t want to over-dramatize. I think the message to operations analysts is that we are practitioners. We are in a practical science and we must not get too enchanted by the theoretical side. To be useful, we must always keep our roots in the practical side.

**MIKE GARRAMBONE:** What exactly brought you back to school?

**WAYNE HUGHES:** It was in the ground of my being that I should have a graduate degree.

**MIKE GARRAMBONE:** Did you know this when you were first teaching at the Naval Academy?

**WAYNE HUGHES:** I was accepted at the Naval Postgraduate School when the Superin-

tendent of the Naval Academy talked me into going there instead. Instead of going to Monterey on my first shore tour, I came here on my second shore tour as a Lieutenant Commander in 1962 to 1964.

**MIKE GARRAMBONE:** You served as an instructor at the Naval Academy from 1957 to 1960. What did you do at the Academy?

**WAYNE HUGHES:** I taught and I worked on a curriculum revolution in which we, as I like to say, brought the Naval Academy out of the nineteenth century and into the twentieth century in both course content and pedagogy.

**MIKE GARRAMBONE:** You were trying to emphasize more of the hard sciences and also more mathematics to support various forms of tactics?

**WAYNE HUGHES:** Yes, but there’s a certain irony here. When I went back to the Naval Academy I found I liked the social sciences and humanities best. I also enjoyed subjects like naval history, ethics, and English literature. The reason I got called back to Annapolis for duty is that I wrote an essay saying there are only two kinds of Naval Academy graduates: those who never want to see the place again, and those who want to come back and straighten it out someday. I said I’m in the second category and here’s, by damn, what you ought to do. The Superintendent Rear Admiral Bill Smedberg, read it and said, “Now there is a young officer I need to get back here.” The strange part of this was that I was trying to make a case for more naval history, more naval tactics, more of the things that would go under the title naval science. It was the farthest thing from my mind at the time was that we needed to straighten out the engineering sciences.

I couldn’t have been more wrong as it turned out. I watched some really nifty naval officers, mostly captains, overcome the resistance of the existing faculty to upgrade the way we were teaching, especially the science and engineering subjects. It dawned on me that we didn’t have room in the current curriculum to add more social sciences and humanities. Actually what we advocated was to cut down on things like teaching boilers and the old Mark IA Fire Control computer to make room for engineering science. We also freed up some classroom time by allowing validation credit for courses that students had taken earlier. Anyway, I was there when this first great revolution took place and even claim to have a small hand in it.

**MIKE GARRAMBONE:** Did they think you were a rogue?

**WAYNE HUGHES:** Oh, yeah. I mean, I'd go over and mix it up with the naval history faculty who were some of the most prestigious fellows on campus. Of course they viewed me with suspicion because I was up there in the Superintendent's office. They thought there was a conspiracy going on to upset their traditional ways. Academics are some of the most reactionary people walking. They want to change everybody's life but their own.

**MIKE GARRAMBONE:** Now might be a good time to tell me how you got into Operations Research.

**WAYNE HUGHES:** There were two reasons. One was the advice of my Rhodes scholar executive officer and the other was reading *Anti-Submarine Warfare (ASW) in World War II*. From that I went and found *Search and Screening*, the great classic by B.O. Koopman. I didn't know the mathematics used in that book and I'm still not sure I do now, but I knew that Koopman was on to something. And so I came out here to the Naval Postgraduate School for two years when the Operations Research department did not yet exist. At that time there was only an Operations Analysis curriculum. The timeframe for this was from 1962 to '64 when the backbone of the curriculum were gentlemen like Doc Torrance and Peyton Cunningham. There was a new chairman of the program named Tom Oberbeck and there were a whole flock of new professors arriving, most of whom have now retired. When I came back 20 years ago, many of them were still here, but none of them are still on the faculty now except Bob Read. They were about my age, but they are all retired except for me.

**MIKE GARRAMBONE:** What did they have you doing when you first got here as a student? You had been out of school for ten years.

**WAYNE HUGHES:** It was hard. I found out that I may have liked mathematics in high school, but this was a different kettle of fish and I had to apply myself the first couple of quarters just to get up to speed in quantitative and mathematical methods. It was not an easy beginning, though it sweetened up the second year. There was a turning point in all of this, and this is important. Operations Research was the first curriculum at the School that had an experience tour. We called it a field trip then. You would go out for six weeks to a Navy

agency doing Operations Analysis (OA), or to the Center for Naval Analyses (CNA), or to industry like Lockheed at the time. In my case, I joined a real study group, but what I found out was, I knew a lot more from school than I realized I'd learned in my first academic year. I felt like I could hold my own as an analyst and could at least communicate with some great analysts.

**MIKE GARRAMBONE:** Let's hear about this study.

**WAYNE HUGHES:** It was a study performed in Arlington, Virginia. The year is 1963 and Secretary McNamara was trying to understand the nature of all the Services. The question at issue was whether we can defend the sea-lanes to Europe in a NATO war, given there are a lot of submarines in the Soviet inventory. We were talking about a large number of submarines, and a moderate to large number of systems for ASW protection. It is a complicated problem. Now as a student I didn't know this study was going on, and I was on my way to the Institute for Naval Studies in Boston thinking I was going to have a great vacation for six weeks, living in the graduate school dorm at MIT and doing some make work kind of stuff. I was there exactly two days when the commanding officer of the Institute for Naval Studies, a Navy captain and Medal of Honor winner named George Street, called me in and said: "Hughes, I'm gonna send you to Washington and you're gonna join the hottest, the most important study in the Department of Defense."

The name of the study was the Cyclops Study because Secretary of Defense McNamara had sent out one of his one-page taskers to all the Services which was a list of studies he wanted done, and study Number 1-I (one-eye) had to do with shipping in the Atlantic in a NATO war. Later on, we had Cyclops Two and Three, and we had War at Sea Studies One, Two, and Three. We even had a War at Sea Now Study. In fact, there followed a whole series of studies painting a picture of our ability to protect shipping and where appropriate, identify any weaknesses to expect in battles of the Atlantic. But the first study I was assigned to was the Granddaddy of them all.

**MIKE GARRAMBONE:** So much for the summer vacation!

**WAYNE HUGHES:** Yes, the vacation did not materialize. In fact, we had nominally about two months to do a study and I got there maybe

two or three weeks into the thing and they were already struggling. One of the "old greats" was the project officer for the study. His name was Joe Neuendorffer. A problem was that he was more analyst than a study leader and so we were already falling behind. While I was there, the Chief of Naval Operations (CNO), or the Secretary of the Navy, I'm not sure which, grew alarmed that the study was not going to be finished on time and so he replaced Joe as the lead with a much more administrative analyst named Jim Larkin. The Secretary of the Navy was Paul Nitze, and Jim Larkin was on his staff in the Office of Program Appraisal at that time. Nitze sort of sent his own man over because he knew that Larkin was more of a pusher.

When I got there, they had set up a Markov chain model of the submarines deploying, searching for their targets, finding their targets, closing on them, and attacking those targets as convoys. If a Soviet submarine survived that chain of events, he would go off and look for another convoy. It was a nifty model that forever impressed me as my first experience with something that was practical and useful in doing a campaign level analysis. The analyst who set up the model was Frank Houck. Frank was then at CNA. In addition, a young fresh-caught CNA analyst name Ken Bolin was there, and he and I were sort of kindred spirits because we were the guys down in the trenches that did the mathematical computations using this splendid looking Markov chain that involved a lot of calculations.

**MIKE GARRAMBONE:** Did you learn the Markov process at NPS before you went?

**WAYNE HUGHES:** I can't remember. I think I probably understood it in its abstract form, but the way we used it, how it worked, was pretty self-evident. I recall the notion of "memorylessness" was discussed among the analysts and whether the model was a sufficient approximation of the real submarine campaign to assume the Markov properties. I thought then, and still do, that it was fine, and there was no point in talking about odd situations where you treat the effects of past events, which would spoil the Markov assumption.

**MIKE GARRAMBONE:** How did things proceed on the study?

**WAYNE HUGHES:** I'd been there about a week when there was a big meeting. Joe Neuendorffer was still in charge and the study group, which consisted of about a dozen analysts doing different parts of the study. The

heart and soul of the study was what Frank Houck and Ken Bohlin had been doing, and I was thrown in to help them with the computation of the schedules. The schedules consisted of so many submarines of such and such characteristics trying to find and sink shipping and so many convoys protected by such and such numbers of escorts. I do not think that submarine barriers were a big deal then. I think ASW aircraft were a twinkle in the eye of Admiral Martell and a few other visionaries, but the hardcore of the analysis was an assumption that the decisions would be reached in the convoys.

**NOTE:** The interview paused at this point, and resumed at Quantico, Virginia with Wayne Hughes, Mike Garrambone, and Dr. Bob Sheldon, FS.

**MIKE GARRAMBONE:** It is the 9th of June and Bob Sheldon and I are sitting today at the Alfred M. Gray Marine Corps Research Center, United States Marine Corps Base, Quantico, Virginia with Wayne Hughes. Sir, let's continue the discussion of the Cyclops study. Please remind us how everything went and some of the activities that ensued thereafter.

**WAYNE HUGHES:** Picking up from last time, I was on my student experience tour from the Naval Postgraduate School having one year under my belt and before my second year. One of the interesting things about the Cyclops study that I didn't mention before was a decision whether or not to use a computer program to do the Markov chain calculations that I was describing, or to do them by hand. This was a very important decision for a young Lieutenant Commander Hughes and his accomplice, Ken Bolin, because we knew that if we went "by hand" we were going to be using mechanical machine calculators deep into the night. Well, the decision was made, wisely as it turned out, to go both ways. That is, we did them by hand and also attempted to write a computer program in Fortran code. We found a young woman to program the thing who said: "Oh, I'll have this ready in a couple of days and all debugged." When I left four weeks later, she was still debugging the program. Since the study was on a very short fuse, it was a good thing that we did it by hand. But we did burn the midnight oil many nights using hand calculators with only Frank Houck, Ken Bolin and myself to do the cranking.

**BOB SHELDON:** How many states or stages were you modeling in the Markov chain?

**WAYNE HUGHES:** There were probably ten. What was involved was a circumstance where a submarine would deploy. It would then have to survive to get to a convoy. Then it would go through a series of attacks on a stream of convoys depending upon how many torpedoes it had. Each time it would run the gauntlet and be subject to attack. And then it would have to safely get back to its base.

**MIKE GARRAMBONE:** Remind us how the title "Cyclops Study" was derived.

**WAYNE HUGHES:** "Cyclops" came from question number 1-I (One Eye)—it's a pun, folks. Secretary McNamara sent down a series of questions to the Services and question One Eye was assigned to the Navy to estimate what it would take to keep the sea lines open against a large submarine threat in the 1960's.

**BOB SHELDON:** Did that question come from McNamara himself or his staff?

**WAYNE HUGHES:** That I don't know, but McNamara signed it out. So his staff might have assembled the questions that were thought to be the important ones. This one was important because in a non-nuclear war there was a feeling that we would fail if we couldn't keep the sea lines of communications open to Europe.

**MIKE GARRAMBONE:** Did anyone research to see if that problem had been looked at before?

**WAYNE HUGHES:** Yes. There was a precedent. In fact the Markov chain model had been used in 1958 or 1959 in a US Navy study. Frank Houck had participated in that, so it wasn't as if he had invented the model out of whole cloth.

**MIKE GARRAMBONE:** Tell us about your first analyst tour.

**WAYNE HUGHES:** Yes, but before I do that, let me tell you one more thing about my second year at graduate school. We all had to write a thesis. When I was on my experience tour a problem arose involving nuclear submarines. The November class, which was the first class of Soviet nuclear submarines, were just coming from the shipyards and heading off to sea. At the time, there were about ten of them in a fleet of three hundred or so submarines that could go out and attack shipping. Up until that time, we had used a screen only in the forward part of the convoy. It was called a Bentline Screen to protect the front of the convoy be-

cause diesel submarines didn't have the speed to come in from the sides or from the rear. Nuclear submarines had the speed to come in from any direction, but if we protected three hundred and sixty degrees instead of just the forward hundred and twenty degrees we would have to triple the length of the perimeter that we were guarding. Using the same screening technique this would have diluted the screen to one-third of its effectiveness in terms of detection.

**MIKE GARRAMBONE:** Was this a big issue?

**WAYNE HUGHES:** Yes, if the submarine threat consisted of ten out of three hundred, then you ignored it. You just took your licks from SSNs and concentrated on the large number of diesels. But how long would this circumstance last? At some point you would have to start accepting a greater success by the diesel submarines in order to counter the nuclear submarines in the three hundred and sixty degree mode. I went back to NPS with this special problem in mind for my thesis. This analysis had to take into account a number of other things. I solved for when that break point occurred to shift to 360-degree protection and also how far out on the perimeter the screen should be placed. The farther out, the more you took away an outside shot from the submarine but the thinner the screen would become, which would allow the submarines to penetrate and attack from inside. Inside attack was the more serious threat because once they got in they were hard to chase out again. I enjoyed solving that problem then, and it's been something that I continued to work on, off and on for the rest of my days in uniform. I've always said that any successful thesis should be something that made you an expert in some little niche of professional knowledge.

**MIKE GARRAMBONE:** Was there a follow-on to this work?

**WAYNE HUGHES:** There was a student about ten years ago named Keith Kowalski who knew about this thesis and he said he wanted to update it. I was his thesis advisor, and using the same optimization of defense concept, he adapted it for a lot of things that happened since I did my thesis, like tactical towed sonars and the effect of guided missile submarines which could fire both torpedoes and missiles at the formation. Of course, since then the Soviet Union has collapsed. Neither the Hughes solution nor the Kowalski solution is relevant any-

more. We now have a new situation that sort of brings us back to the drawing board. Inshore diesel submarines with torpedoes are the threat de jour again, except that the water environment is much different and the number of attacking submarines is much smaller. The whole strategy of protection is different than it was. We were talking about convoy defense. Today we're talking about a much more comprehensive method which would include getting the submarines in port, getting them in barriers, and getting them by sanitizing a region through which our warships or shipping will pass.

**MIKE GARRAMBONE:** Was your mathematical formulation similar to Kowalski's formulation?

**WAYNE HUGHES:** His mathematical formulation was identical to mine and that brings up another point that I think has enduring value. Both of us could optimize the screening without knowing what our losses would be once the optimum screen was in place. You would have to do a campaign analysis that depends on what you thought the total number of submarines attacking was going to be in order to see whether you could stand the losses. What we had done was to derive the best thing to do, the optimal solution without knowing whether the optimal solution was going to be good enough. Now that kind of thing comes up again and again. The guy who doesn't know much about analysis can't understand that you can do the best you can and still not know whether the best you can do will win or lose.

**MIKE GARRAMBONE:** It sounds like you picked a thesis that was seaworthy and applicable, but not necessarily a theoretical thesis. This is something I've heard you speak about before, which is you like to see the application of knowledge.

**WAYNE HUGHES:** I also like to see real solutions to real problems presented at MORS. There is new theory that may help some day and new gadgets that people are promoting, but work which is demonstrably relevant to today's problems are the ones that get my juices flowing.

**MIKE GARRAMBONE:** For the optimization, did you use a linear or non-linear programming formulation?

**WAYNE HUGHES:** It was linear in part and non-linear in part. We made some assumptions, simplifying assumptions that is, for the calculation of the circumferential distance at

which you should put the screen. It was simplified to the extent that we assumed that at max range when the submarine torpedo would run out of fuel, we would call that the zero point. When the submarine was just outside the screen, outside the detection by the screen, then we did a calculation of what the probable number of hits would be if it fired a big load, and then we straight lined it in between. Then there was a discontinuity. If the submarine penetrated the screen, snuck in and didn't try to shoot from outside but took his chances and got inside the screen, then there was a step increase in his performance because at that point he was going to be able to fire a complete salvo, reload and fire another before we could find him and chase him away.

**MIKE GARRAMBONE:** Did you publish your thesis in some journal?

**WAYNE HUGHES:** Sadly, I don't remember it ever getting into the literature.

**MIKE GARRAMBONE:** Were you able to convince the Navy customer that this was a reasonable approach?

**WAYNE HUGHES:** Yes in the sense that we used it for campaign analysis purposes when it was applicable. Also, there was a specific use I'll come to in a moment, but for tactical use I did try to get the fleet interested by sending out a questionnaire saying: "How would you position your defenses if you were facing this threat of part nuclear and part diesel submarine?" The destroyer squadron commanders and their staffs who responded were sent the completed thesis to show them how one would determine where they should put their screen. Insofar as I know, I simply overwhelmed them with mathematics without any practical effect on ASW defenses whatsoever.

**MIKE GARRAMBONE:** Thus far, we have talked about very tactical and technical jobs. You were going to tell us about your first analytical tour.

**WAYNE HUGHES:** After I graduated from NPS, I went back to the fleet and served a tour as the "exec" of a destroyer. The exec of a destroyer is like the deputy or number two man. In a Navy command, he is the inside guy. The commanding officer is the operational and outside guy. When that was over, I was assigned to OP-96 (Systems Analysis Division) of the Office of the Chief of Naval Operations; when it was first created. Bud Zumwalt was the first Director. His office was giving the Navy a brand new analytical capability. The year was

1966. And I'm a plank owner for this organization since I was part of the original team. There were some early people like Bob Hallex and Al Rhode who were there for many years after that and became almost institutions in their own right. The original composition was ten civilians and ten officers. The officers were not all analysts because we didn't have many officer analysts at the time. We found out early that good solid officers were valuable if they had the right kind of sea experience. They became practical operations analysts because they were quick learners while on the job. This was a decision made at the time that endures to this day. We try and have three kinds of people in about the same proportion. First, civilian analysts are the permanent core capability with the corporate memory. Second, officer analysts who are able to blend the technical knowledge of analysis with the fleet experience they bring. And third, officers who are principally operators but are head and shoulders kinds of guys who tend to be future leaders who come and learn the value and limitations of analysis on the job. I'll give you an example. Later (around 1973), when I came back as the Deputy Director in OP-96, a guy named Vern Clark, now the Chief of Naval Operations, was a Lieutenant and the Administrative Assistant to the Director. Vern, to this day, will say that experience changed his life. His experience working in OP-96 was one of the most significant tours he had in learning how decisions ought to be made and—not the same thing—how they are often made. Another young Lieutenant in OP-96 was Dennis Blair, just recently retired. He rose to become Commander of the Pacific theater. Dennis would also say that his experience in OP-96 was one of the most valuable tours he had.

**BOB SHELDON:** Is that the same Admiral Blair that was on the Joint Staff?

**WAYNE HUGHES:** As a flag officer, he was briefly Director of OP-96 and then went to the Joint Staff. He recently retired and is now at IDA.

**BOB SHELDON:** The Al Rhode you mentioned, is that the same Al Rhode that's a MORS Fellow?

**WAYNE HUGHES:** That's correct.

**MIKE GARRAMBONE:** In the description of the three types of folks that came together to do operational studies, were you looking at them as a team or as individuals?

**WAYNE HUGHES:** I'm going to mention a study in a minute which depended heavily on all three kinds of characteristics, but OP-96 also did a lot of fire fights, a quick turnaround, almost overnight kinds of analyses where the Director would form a team but it usually consisted of just two people who were a subject matter expert teamed with a technical expert. Very often you didn't do any analysis. You went out and gathered data. You knew what studies had been done in the past. You knew who was knowledgeable on the subject at the CNA or IDA or RAND and you went to these people and then put together a point paper for the CNO or the Vice-Chief or the old Director of Plans and Programs who we call N8 now. The point being that the analyst knowing what work had been done and the Naval officer being familiar with the issues and the operational side of the problem were often as important as the analysis they did.

**MIKE GARRAMBONE:** Do we still grow those kinds of teams today?

**WAYNE HUGHES:** The CNO thinks that we need to restore some of the rigor to our decision making process. And that's been a boon at the Naval Postgraduate School because we've seen a rise in the numbers coming into the Operations Analysis curriculum. I don't think there was ever a time when the analysis was as consistently well done and influential as it was in the McNamara years. Hitch and Enthoven and the other whiz kids at the time took a lot of heat because as many a wise officer has said: "You can't make decisions purely based on analysis." On the other hand, because the Secretary of Defense proclaimed, somewhat hypocritically, that all decisions would be based on analysis, everybody paid a lot of attention. And the good of it was that we really did create a talented group of people who did a lot of good work and were listened to. I personally think that Alain Enthoven, who was the Director of OSD Systems Analysis at the time, was delighted with the Services developing these high quality, high skilled studies and analyses because he knew that he didn't have the corporate knowledge in OSD. If the Services would take their best shot at doing a good analysis to prove their case, and it was done objectively (he generally could tell whether it was slanted or not), then he knew he was getting the best advice and could make better decisions. So we did grow analysts back then and their analysis had influence the likes of which I

don't think is ever going to be seen again. In addition, we sent some very talented officers who became leaders of the Navy to work in OSD Systems Analysis: Bob Monroe, Staser Holcomb, Jerry Miller, and Stan Turner were four of them.

**BOB SHELDON:** You mean that analysis won't have the same influence unless we get another McNamara as the Secretary?

**WAYNE HUGHES:** Yes, but I don't really think that's a good idea either. Secretary McNamara's worst decisions had to do with the Vietnam War. But insofar as the skillful use of analysis was concerned, he did pretty well. Pat Parker is another old hand who's a good friend and who was in OSD systems analysis in those days, later was an acting Assistant Secretary for Intelligence in OSD and a good friend of Admiral Zumwalt's. Pat always spoke generously of McNamara and said, "If you knew what you were talking about you could always get a reading from him and usually a decision."

There's an old debate in the analytical community over the extent to which an analyst should simply lay out the results and the limitations of the analysis, versus going beyond providing results and including conclusions and recommendations. You can call it either way, and I think it depends a great deal on who your customer is and the extent to which he understands what he can get out of the analysis. But if the customer doesn't understand analysis, he will probably either ignore it completely or put too much weight on it. I have in mind wise customers like Admiral Zumwalt and three later CNO's: Admiral Holloway, Admiral Hayward, and Admiral Carl Trost, who were experienced in analysis and knew how to use it. There were people in the fleet as well who had the same kind of skill, like Staser Holcomb and Ike Kidd. Another one was Fred G. Bennett whom I worked for very closely when he was Commander of ASWFORLANT and I was his deputy for analysis. The point being that a good customer who knows the capabilities and limitations of analysis asks the right questions, and wants an objective appraisal, even if it's not what he wanted to hear. That's the kind of guy that you like to work for.

**BOB SHELDON:** Where was your OP-96 office located?

**WAYNE HUGHES:** In the A-ring on the fourth deck of the Pentagon.

**MIKE GARRAMBONE:** How long was your tour there?

**WAYNE HUGHES:** The first time was for two years. In the latter part of that tour I was very much involved in the major fleet escort study that had on it another one of my favorite people, Charlie Woods. Charlie was my nominal boss for the ASW analysis part of that study. When it was done, it turned out to be one of the most influential studies ever done in the sense that for about twenty years after that it determined the number of escorts that would be associated with different kinds of forces like convoys, carrier battle groups, amphibious groups and so on.

**MIKE GARRAMBONE:** This had to be a classified study?

**WAYNE HUGHES:** Yes, this was a secret study. Probably no longer classified now. It doesn't need to be secret any longer.

**MIKE GARRAMBONE:** How was it working in the late Sixties in the Pentagon, working with McNamara's whiz kids?

**WAYNE HUGHES:** The CNO himself would frequently be the recipient of studies, if not him, then the Director of Program Planning. The Secretary of the Navy was Paul Nitze who understood analysis as well as anybody. Since he was very astute, he personally would take critical studies. Since we believed that these studies would be used to make decisions, we would give frequent progress reports. The terms of reference for the study would be carefully vetted ahead of time. Every two to three weeks we would come in and make a progress report. Those of us who were doing the work thought: "C'mon now, give us some time to do our job." But on the good side, the frequent briefings meant that by the time the study was complete, the surprises were all over with. Everybody knew what the nature of the surprises were going to be and they were prepared for them and they knew why the study was coming out the way it did, and so the study tended to be compelling.

**MIKE GARRAMBONE:** As a young O-5 at the time, what level people were you briefing?

**WAYNE HUGHES:** Vice Admirals and above. One of the wise pieces of advice from Charlie Woods was, "Wayne, don't be scared. You're going to know more about the subject than anybody else in the room. Just go in there and strut your stuff."

**MIKE GARRAMBONE:** So as an analyst, you did more than just deliver coffee to the Admirals?

**WAYNE HUGHES:** I felt like I was right in the middle of it.

**BOB SHELDON:** Were the briefings ever published as studies or papers?

**WAYNE HUGHES:** These were really working papers. They contained the analytical approach, the critical assumptions, and the results of the analysis to date. An interesting and critical part of the ASW analysis, which was what I was mainly concerned with, was the detection ranges of the new sonar candidates. And for that, there was a lot of debate over whether we were going to make active detections in the convergent zone and whether there would be “bottom bounce” detections the way we had been getting detections using passive sonar in submarines. Interestingly enough, our answer turned out to be wrong—too optimistic. But the technical community predicted that under the right water conditions, we would get detections as much as twenty-five miles out. And that was with active sonar. Essentially we never saw that performance. But it was those kinds of technical predictions that were critical and we wanted to be sure everybody was aware of the detection values that went into the campaign level part of the study.

The technical (detection) input affected the tactics of protection for each kind of formation, which in turn influenced the macro-campaign analysis that was going to determine the right number of forces to buy. The right number of forces depended on an analytic scheme introduced to us by Charlie Dibona who was then in the Office of Program Appraisal under Paul Nitze, the SECNAV. It said the right number of forces to buy is as many escorting forces up to the point where the cost of buying one more escort was more than the value of the forces being saved by the protection. Said in another way, at some point you reach a point of diminishing returns. A better solution than buying more protection is to buy more of the protected forces. A related theoretical problem was whether that means you should actually buy more protected forces before the war based on what you expect to lose during the war. This is a shorthand way of addressing some really complicated issues. But the short answer was no because you don’t expect to come out of the war with the same number of forces that you have going into it. What you can do is make a more informed judgment about losses when you buy the efficient number of forces according to Dibona criterion.

**MIKE GARRAMBONE:** How did you feel about your NPS background? Did you feel that you had a pretty solid technical background for working in the Pentagon?

**WAYNE HUGHES:** I thought then and think to this day that even though there were lots of gaps in what I learned that it didn’t matter very much. The important thing was that I had been steeped with enough of the tools and the mindset of doing objective analysis. From that base, whatever I additionally needed I could either work out myself or find help. There was a very funny situation that arose. We were looking at what we thought was a really poor analysis being done for Admiral Martell, OP-95, the ASW branch of OP-NAV. There was a fellow in OSD who really wanted what the analysis purported to support. He said that his understanding came together while at a stoplight driving into work one morning. He said he’d figured out the analysis proved, when you looked at it carefully, that the effectiveness was invariant as a function of the number of ASW forces you had. In other words, if you had doubled the number of forces, you would double the effectiveness. Well, if that was the case, this was going to absolutely make the case for this new ASW system. Admiral Zumwalt asked me if this could possibly be true. And I said: “Well, it sounds very weird, sir. Let me think about it.” I struggled till midnight or one in the morning over the claim and finally realized that this particular analyst in OSD had used the wrong function. He should have been using an exponential function but he was using the logarithmic function. Therefore what he argued was definitely not true.

**MIKE GARRAMBONE:** Point settled?

**WAYNE HUGHES:** Yes, that was the end of that.

**BOB SHELDON:** What are the kinds of things that you read in those days?

**WAYNE HUGHES:** I probably did as little background reading then as ever in my life. The typical day was from 7:00 in the morning till 7:00 or 8:00 at night, with one break to play squash during the day. So the answer, for that particular time, is probably I was so busy reading job-related memoranda, quick turn around studies, and one-pagers, that I didn’t really stay up with either technical or world events.

There is something important to say here about when you get to be a high-level decision maker. If you haven’t got your battery “fully

charged" when you go into the job, you will find you just don't have time to catch up. What you do is to pick staff members who understand this and give you the essential things about intelligence, about the latest trends in world events, and the things that are likely going to affect the future of analysis if that is going to be your world. I mean things like complexity theory and chaos theory and the issues of how to construct useful simulations instead of overly detailed simulations, those kinds of things to be made aware of. Or take the questions of modern fratricide, or how to build an understanding of the command and control process, or how to win wars by having better detection capabilities. All of those are things that you as a decision maker will get second-hand input as opposed to first-hand knowledge. So just surround yourself with people who have more time than you do to stay abreast, then you'll be the best informed of anybody because you are the only one who takes time to be the synthesizer of all this.

**MIKE GARRAMBONE:** It sounds like you're making a case for students to study a lot of things when they're in school and the environment is right for them to learn. All the preparation is for the jobs you envision they will have when they take on problems in the future.

**WAYNE HUGHES:** Actually I applied that theory when I was a student. I remember that statistics baffled me. I had two elective slots, and I very carefully chose the professors that I trusted who were statisticians. One of them was Jack Borsting; the other was Max Woods. I took advanced statistics from them, risking all in terms of grades because I knew that if I didn't get a better understanding at NPS, I'd never get it later. As a result, I know what I don't know. And I mean to tell you, there are a lot of tricks to the trade in the world of statistics. And a lot of things that you can screw up if you're not careful, including spurious cause and effect relationships that don't exist.

**MIKE GARRAMBONE:** Did you continue your analytic discussions when you went to the courts to play squash?

**WAYNE HUGHES:** A good friend of mine, Mike Melich, used to love to play squash with me when I was the Deputy. I knew it was because he figured while we were dressing he'd have some time to lobby me. I enjoyed playing squash with him anyway.

**MIKE GARRAMBONE:** Tell us about the fleet side of your life.

**WAYNE HUGHES:** I think that in the Sixties the emphasis on analysis shifted away from the fleet and back towards decision making in Washington. Ever since then, there has been a widespread feeling that if there weren't dollars involved in the decision then it wasn't important for analysts to be engaged. But it's good to remember that the roots of analysis in World War II came when scientists went to war and they went out to help make better operational decisions. There's a good reason why fleet analysis is in many ways more important than Washington analysis. In Washington there can't help but be limitations on the quality of analysis when you're dealing with paper airplanes and paper ships and conjectures about the way systems are going to work. These circumstances will inevitably affect your decision whether to buy items when you're performing systems analysis and cost effectiveness analysis.

Now contrast this with the fleet side of things where everybody's working on the same team. When analysts went to sea they were motivated because they knew they would go down with the ship just like everybody else. This state of affairs kind of focuses your attention on doing the best you can.

**MIKE GARRAMBONE:** What was your fleet duty like?

**WAYNE HUGHES:** I should point out I first went back and had my Command tour. From there I went to First Fleet staff. The relevance of that was not so much that I was in an Ops Analyst billet, but that I worked for Isaac C. Kidd, Jr. Ike Kidd was one of the Navy's greats and he also understood how to use analysis better than the average guy. He went out of his way to make sure that he was tuned in to what fleet analysts were doing. He also had a civilian fleet analyst on his staff. I was nominally an analyst, but I was really a staff guy who understood enough analysis to put an objective and quantitative slant on things now and then. I think the civilian analyst really should be protected from staff work and keep close to Commander who should have him working on analysis problems almost exclusively. The civilian analyst on the staff works that way, while the military analyst does staff work, but with the objectivity of an analyst. I do think the roles should be different. That is especially true if the military analyst views himself as being groomed for Command, which means that he isn't just solving analytical prob-

lems, but he's very much in the middle of the operational aspects of the problem as well. The "doing" of the operation is as demanding as the planning of it and the analysis of it when it's over.

Anyway, the Ike Kidd tour was really interesting. I arrived almost the same time Kidd took command of First Fleet in San Diego and left within a few weeks of when he left. From there I went to SACLANT. I was totally into analysis at SACLANT and we did two memorable studies while I was there. I had a very good relationship with my boss, who was a civilian. Ralph Nahra was consumed with a lot of things other than analysis, for example, the politics of SACLANT Centre, which was in La Spezia, Italy. But Ralph knew and trusted me enough to give me a lot of freedom to maneuver in doing these two studies. One was associated with supporting SACLANT in what were called force proposals. Every two years, SACLANT would come in to the NATO Military Committee and Defence Planning Committee (the civilian leadership), and say what our requirements were in order to carry out our job of protecting ships at sea. This was kind of a marketing thing where you knew that your forces were inadequate to do the job with a high assurance of success. Trying to describe what would give you the highest assurance of success was technically a difficult challenge because you're talking about maybe a five or ten percent increase in forces and you had to figure out how to demonstrate that that would make something more like a fifty percent increase in reducing losses or something else like that.

**BOB SHELDON:** Were you competing with resources from the Pacific, since this was during the Vietnam era?

**WAYNE HUGHES:** That was kind of a sideshow. The Vietnam War was drawing down because we are now around 1972. The thing you wanted was to get the NATO nations to pony up more money for Navy forces. This was very difficult to do in Europe because the NATO nations in Europe were Army oriented. Most of the members of the Military Committee were Generals. When I testified before them, they were asking me very hard questions about whether we really needed more ships, naval aircraft and ASW protection, because in their eyes, they needed more ground forces. In some ways they were right, but we could have used more forces everywhere to face off against the Soviet force, because we were pretty vulnerable

at the time. Be that as it may, our analysis had appearances of a marketing device. I don't mean to say we corrupted the analysis, but I do mean to say that the nature of the problem was to demonstrate why a small increment of additional forces would have a large payoff. We used a campaign model which was already developed when it arrived. If I remember correctly, Jerry Bracken of IDA developed it. We just adapted it. It was very much a campaign level analysis tool.

The second analysis I was part of was quite different in nature. It was called a defense of shipping study. The NATO navies were concerned that we truly did not have enough protection and that our losses at sea would be astronomical. It soon became apparent that they had a limited understanding that the strategy of the American ASW forces was to be offensive. We counted on the indirect protection of submarine barriers and long range ASW aircraft. Most NATO folks were still thinking in terms of World War II convoy escort.

In a sense some of our work could be seen as an education effort, but it also involved doing analysis that was objective. In those days, there was very little data in NATO. I've got to say that since then—the early 1970's—NATO developed an analysis capability that was very, very good. In the Eighties, it was quite robust. My approach, having done ASW analysis in the Pentagon, was to crib from US studies, and without ever saying so, we used effectiveness data that could be gleaned from our own studies. There was also a need to get everybody on board. And the way we did that was to call a meeting just outside London at CINC EASTLANT. The purpose was to involve at least one representative from each of the nations and at least two representatives from each of the Commands. We at SACLANT, who led the study, outlined the nature of the problem. We had twenty questions and we farmed those out to little teams. Bear in mind; if you're a member of a NATO Command, you don't actually expect to do any work, you just sort of get along with each other. So here we were and we were actually going to work. This was like going back into their own national institutions and having to sit down and think things through and achieve results. We worked for about two weeks. And each of the teams came back feeling good about their answers. We on the Steering Committee also felt pretty good about their answers. The answers were all kinds of "going

in” things that were needed in the study to assemble the operational elements for the protection of shipping; the manner in which the sailings would occur, the assembly of convoys, the size of the convoys, the configuration of the convoys, the role of ASW in these operations, the danger from mines, the air threat to the ports where the goods would be unloaded—a whole raft of questions like that. The hidden agenda was to get the participants on board, give them a vested interest in the success of the study. And then promise that as the analysis unfolded, that we would share the results and the progress of the study, the interim results, the way it was going and so on.

We used a very large campaign model that had been developed at SACLANT Centre in La Spezia, Italy. I made about three or four trips to La Spezia to try out different things. We did something unusual that I’m to this day very proud of. We used the model with World War II inputs to see if the model could be validated against World War II data; that is, could we “predict” losses that were similar to the losses experienced in the Atlantic? A Scandinavian analyst, Töre Kristensen, did the work. We found it worked pretty well if you used World War II detection range, shipping flow rates, and densities of German U-Boats and made some assumptions about wolf packs. We got results that were comparable to merchant ship losses in the North Atlantic in World War II.

**MIKE GARRAMBONE:** What prompted you to go that route?

**WAYNE HUGHES:** Model validation through history was always something I thought we needed to do more of. I think we need to do more of it now. But let me return to our study approach and a second thing that was memorable. Until the study, everybody assumed that the peacetime cargo flows would be the same as wartime flows. Now, if the volume of shipping in wartime is comparable to what it is in peacetime, then the numbers of things you have got to protect at sea is absolutely overwhelming. There were twelve or thirteen thousand merchant vessels in NATO’s peacetime trade! You cannot possibly cover that volume of traffic, and there’s no point in convoying because there will be so much shipping that you’ll have about one-half of an escort per convoy. All the US hoped to do was escort vital military shipping between US and European ports.

I thought to myself, “Well, maybe, you aren’t gonna be sending all those BMW’s to the US and Chryslers to Europe in wartime, so let’s see what we can find out about what might be wartime levels compared with peacetime levels.” We made a full-bore effort to see if anybody had ever done this and the answer was no. So we simply first displayed the results if you used a hundred percent peacetime shipping and then we reduced the volume down to eighty, sixty, and forty percent. Forty percent of peacetime would be the presumed minimum flow of shipping. That analysis demonstrated that the biggest volume and longest lines of communication were, as you might guess, for petroleum. And that if you could reduce the volume of oil being transferred at sea—because consumption in Europe was curtailed to sixty percent instead of a hundred percent of peacetime and if you did things like rationing in the US, all of a sudden you lost interest in the Middle East. That is, you didn’t need Middle East oil. When you got the oil from Nigeria and Venezuela and Alaska and Libya, you could shorten your lines. If your oil consumption is eighty percent of peacetime, then all of a sudden the convoy escort requirement is down at forty percent. There is that much of a non-linearity between consumption and the length of the sea lines that you have to protect.

**BOB SHELDON:** What compensation might have come from things going to Europe for the war?

**WAYNE HUGHES:** We never looked at how much the military operations were going to increase demand at the front. We rationalized that by saying: “Well, the people who are driving cars back in France are gonna be consuming less, so the tanks in Germany can consume as much as they need to fight the war.” In that sense our study was kind of hokey. But let me tell you that there was a study done later—I believe it was by SACLANT, because the interest stayed on in SACLANT—about ten or fifteen years later which was done not by guess or parametrically, but by actually looking at likely consumption. I felt vindicated because sixty percent of peacetime was what they worked out as the probable level of actual wartime consumption.

**BOB SHELDON:** Where was your SACLANT office?

**WAYNE HUGHES:** It was in Norfolk right next to CINCLANT, in the CINCLANTFLT compound near the Norfolk Naval Base.

**BOB SHELDON:** Did you go to Europe to work with your Naval counterparts?

**WAYNE HUGHES:** Maybe four times to Brussels and London and to La Spezia three or four times. SACLANT Centre's people were formally attached to SACLANT. The people in London were in a different component of NATO. CINCCAN was the London component of NATO. There was a little Command at Lisbon called COMIBERLANT.

**BOB SHELDON:** Did any of your NATO counterparts have analytic degrees or analytic backgrounds?

**WAYNE HUGHES:** Most of the analysts at SACLANT Centre were civilians who did analytical or scientific research. SACLANT Centre did more oceanographic work than analytical work. In SACLANT proper, there was a very small analysis staff in 1972. In my time it was just one Brit, one young American computer whiz, the Director, and me. Sometimes analysis was a one-man show. Later it grew into a fairly sizable operation. And I think very effective.

The Brit team, whom I got to know very well later, were all operators as opposed to analysts, but they had been doing a big data gathering effort. They were, you might say, self-taught. They had rigorous and objective minds, but definitely self-taught. Now that I think about it, all were operators as opposed to analysts.

We had a couple of very capable Germans getting PhD's at the Postgraduate School that came to SACLANT. I went back to Jack Borsting at NPS and asked him if he had any students from the NATO nations that could do short tours in Norfolk. Both of them were really talented and did very useful analytical work, real computational work during those six weeks with me. Since then, the Germans have built their own analysis and educational establishments, so we don't see many at NPS any more.

After two years, I was ordered to ASWFORLANT staff. The Commander was VADM Fred G. Bennett. He had had a lot of Pentagon experience. In fact, he had been Director of Navy Program Planning and really knew how to use analysis. I was then a fresh-caught Navy Captain and was his Assistant Chief of Staff for Analysis. We did several at-sea exercises that were carefully planned, carefully executed, and carefully reconstructed and analyzed. This was a lot of fun with a great sense of accomplishment.

**MIKE GARRAMBONE:** What was the time frame for those events?

**WAYNE HUGHES:** It was 1973. And just to show you that this was no accident, ASWFORLANT was subsumed as part of Commander Second Fleet Staff and Commander Second Fleet didn't know about, nor care about, analysis. He was a great people person, but analysis was not his bag, and so for the last three or four months I was there, I was frustrated because I felt like he didn't need any analysts because he didn't know how to use them.

**BOB SHELDON:** Where was ASWFORLANT? Was that also in Norfolk?

**WAYNE HUGHES:** Yes. I moved my office literally one block down the street.

**MIKE GARRAMBONE:** You talked about two things that were of interest to the peacetime Navy. The first was the execution of exercises, which is more or less practice for the military to prepare for war. But then you also mentioned the data gathering that takes place during those exercises. How do you see data and data collection matching up? Did you have a collection mechanism for getting data or did you have to create one when you went to exercises?

**WAYNE HUGHES:** If there is an analysis being done from a cold start without any data, you're in deep trouble. There had better be a body of data that already has been collected on things such as detection ranges and sweep rates. Your analysis had better be adding an increment to the knowledge base, which is often the purpose for doing the analysis in the first place.

**BOB SHELDON:** Did you ever run into the case where you finally had to tell your boss what you thought was important and what he should really be interested in?

**WAYNE HUGHES:** At ASWFORLANT, the boss was so good—this is Fred Bennett mind you—that there was never any question. We always had a good idea what our data collection effort was going to be, how we were going to do it, and what we were supposed to get out of it. We also had some pretty specific problems that we were addressing at the time. One thing I do remember is going to sea with a tactical commander who was executing one of these analytical efforts and he was so rigid in his outlook that he said: "No departures from the analytical plan." The issue was the following. We were the flagship and we were on a

little LPH (Landing Platform Helicopter—it's a small helicopter carrier for amphibious operations), but we were pretending to be the new Sea Control Ship, which was one of the CNO's, Admiral Zumwalt's, pet projects. The commander in charge of the experiment didn't much believe in analysis and he didn't much believe in the Sea Control Ship. We had this carefully designed tactical formation. We formed up and ran it through a string of submarines. The idea was to force as many interactions as we could with these submarines to see whether the Sea Control Ship and its escorts could detect all or most of the submarines that were threatening us. On the occasion I'm describing, a submarine was coming right down the throat. It was dead ahead. It had been detected. We had an experimental towed array sonar ship ahead of us, which held solid contact on the "enemy" submarine. In fact, the ship was detecting just about every submarine and it was very apparent that towed arrays were going to be the wave of the future for surface ASW. But right then, it was also apparent that if we didn't dodge the submarine, then it was going to come right down on us and fire a torpedo at us. So I went into CIC and said, "Aren't you gonna take evasive action?" And they said: "No, we're gonna steady steam, same course, same speed." So I went up and urged the Admiral to take an evasive course. But he said: "We can't change the plan." And I said: "But it's my plan, sir." {Laughter} He said, "No, I'm not gonna change, it might cause the helicopters more trouble in taking off and landing." So, I did a little mental calculation and I figured the submarine was going to show up around 1:00 in the morning, so at 12:30 I went up and looked for the green flare. A green flare was what the submarine fired to pretend it was making a torpedo attack. Lo and behold, at 12:45, here comes the green flare out of the water. Well, in the larger scheme of things, this didn't matter a wit because the exercise reconstruction demonstrated that that particular submarine had been detected and would have been attacked and probably sunk. But the thought remains that it was very frustrating to have an admiral in command who took an exercise plan so literally that he wasn't going to avoid a certain attack.

**MIKE GARRAMBONE:** Tell us about some of your other experiences.

**WAYNE HUGHES:** In my three tours in the fleet, we emphasized the importance of fleet

analysis. I have the feeling that we've lost the art. I'm not the only one who thinks that our ability to do fleet analysis has decayed. There is a SUBDEVRON TWELVE fiftieth anniversary book—it's a big fat book in fact—which covered the memories of the people who had been in the Submarine Development Group during the Sixties, Seventies, and Eighties. A series of at sea experiments called Big Daddy and Little Daddy were done at the Submarine Development Group. Admiral Bob Fountain who had been one of the SUBDEVRON Commanders was quite caustic in criticizing the loss of analytical capability and loss of rigor in analysis since those days. I think ASW analysis was the best in the world then. I've been told that AAW (Anti-Air Warfare) analysis was also strong, but I wasn't involved. Some of us think we do need to try to revitalize our ability to do careful exercise analysis in the fleet.

**MIKE GARRAMBONE:** How do you think this might be done?

**WAYNE HUGHES:** I think that may be happening now in that Admiral Ron Route at the Naval Warfare Development Center Newport has been given a charter under Commander of Fleet Forces Command to conduct a series of experiments under a sea trial program. He will conduct sea trials, experiments, and exercises at sea in a structured way. So I'm hopeful that maybe we'll rebuild this more rigorous analytical capability at sea. At the Postgraduate School there is also a re-emphasis on the fleet side of OA.

After ASWFORLANT and Second Fleet staffs, I was invited back to be the Deputy in OP-96, a second tour in the Pentagon. That was a wonderful tour with two really fine bosses. One was Rear Admiral Harry Train who went on to be CINCLANT and CINCLANTFLT and one of the most capable leaders I've ever worked for. The second was Rear Admiral Staser Holcomb, very capable and a dear friend. Admiral Train was not an analyst and he grew up in the policy science world. He wanted me as his deputy as somebody who did understand analysis. The net effect was that he kind of left me alone. If it was an analytical problem, I was in charge and if it was an issue that had components of analysis and policy then he was in charge. When Staser Holcomb came in as the director of OP-96, he had an analytic background himself, so we split up the workload somewhat differently. I would take, I'm guessing here, but for illustration, the ASW side, and

he would take the air side. But he would take ASW in instances say when there were hot button issues that the CNO personally was interested in. In any event, both of them were wonderful leaders and I'd like to mention again that Vernon Clark was the Administrative Assistant under both of them. Bill Hancock was my personal assistant. He went on to be a Vice Admiral and a superb leader. Grant Sharp was there and went on to be a Rear Admiral and was the Navy liaison on General Schwartzkopf's staff during Desert Storm. Guy Zeller worked alongside Grant Sharp. Will Rogers was another personal assistant to me. All four of them had studied OR in Monterey and all four viewed themselves primarily as operators and not primarily as analysts. They are truly my kind of guys who believe you use analysis wherever you are and in whatever you're doing, not just when you're in a "P-coded" billet on a staff.

Those were heady days, not because Admiral Zumwalt, who had been the founding director of OP-96, was now the Chief of Naval Operations. He very much knew the capabilities and limitations of analysis. He was replaced by Admiral Jim Holloway. I don't know where Holloway learned to use OP-96 effectively, but I know that he did. And in many ways we were as close to him as we were to Admiral Zumwalt before him.

One of the things the deputy was associated with was liaison with CNA. I went over there every two weeks and they would brief whatever the study of interest was at the time. The CNO wanted us to vet all of his Congressional testimony to make sure that it was consistent. One other funny thing bears telling. It was only about two years since we did the SACLANT Defense Shipping Study. It took quite awhile to wind its way through the NATO review process. But in due course, it got to the Secretary of Defense's office after I'd arrived in OP-96. The Secretary of Defense sent it to the Secretary of the Navy. The Secretary of the Navy said, "Well, this is something the CNO should have." And the CNO said, "This is an analysis so obviously it should go to OP-96." So I ended up reviewing my own study. **{Laughter}** Even after two years had passed, I decided it was still a pretty good study.

We did both the long, deep studies such as those for the CNO and the Defense of Shipping Study, and short fuse analysis that were quick

turnaround kinds of things that you had just a long weekend to answer.

**MIKE GARRAMBONE:** Did any of those studies have a really big impact at the time?

**WAYNE HUGHES:** Admiral Zumwalt wanted to wring out the real value of high speed. Another friend, Tom Meeks, was made the Project Officer to examine the value of speed. I'd have to say that what Zumwalt really had in mind was a surface effects ship or hydrofoil. Without nuclear power, a surface effects ship burned too much fuel and one of the conclusions of the study was exactly that. But Admiral Rickover didn't think much of the light weight nuclear reactor needed for the SES (Surface Effect Ship) so it never went anywhere. But overall, the study itself did not conclude that high speed, and I mean a difference between, say, thirty-five and sixty knots, contained high value. A high-speed surface ship was sort of halfway between the advantages of a ship over an aircraft, which was carrying a lot of stuff but not very fast, and the value of an aircraft over a ship which was that the aircraft would always beat the ship, even if it was only a helicopter, in delivering less stuff but at a much higher speed. We're still struggling with that. It's an issue that re-emerges even today. Is there a case for sixty-knot ship or even a fifty-knot ship? I think the answer's going to be "you take all the speed you can get when it doesn't cost you much." And therefore you should be working on new hull forms to see if you can get an increased speed without a large change in of cost, payload, and fuel consumption. But certainly at the time of the study Meeks did, you couldn't make a case for high speed except to escape.

**MIKE GARRAMBONE:** Please tell us what your first MORS event was like and how you got involved in the Society.

**WAYNE HUGHES:** Rather than trust my memory here, I've dredged up the file of my first MORS. It was the 28th, at Fort Lee, in November 1971. I was a commander on SACLANT staff at the time, and Fort Lee was an easy drive up from Norfolk. I had been serving on a little committee established by Bob Miller, who was then the MORS sponsor at the Office of Naval Research. On the committee were also Erv Kapos, Captain Frank Andrews, and perhaps another analyst or two. I became known as someone interested in Operations Analysis in the fleet. It might have been Erv Kapos who asked me to take the Naval Warfare

Working Group, but I don't know who to thank for sure. At the 28th, Ken Bohlin (whom I worked with on the Cyclops Study) had Undersea Warfare, Dick Lester had Land Warfare, and Jack Walker had Ethics and Standards (at which Jack Borsting, then NPS Chairman, Colonel Neil Downey from USMA, Clay Thomas, and Bob Stevens of Cornell Labs, Buffalo attended).

I'm still proud of my lineup of classy speakers in the Naval Warfare Working Group. They included Bernie Koopman, Sid Shear from CNA, John Kettelle of Ketron, Ernie Holmboe of ORI, Inc. on High Speed Ships, Mike Sovereign of NPS, Lieutenant Commander Dave Clark, later Captain, of OP-96, Commander Rich Handford of COMASWFORLANT staff on SSNs in an escort role, and not least Captain Staser Holcomb on the tests at sea of the then-new CV concept. Staser's presence was especially remarkable because he was at the time the executive officer of the carrier SARATOGA.

**BOB SHELDON:** I want to ask about your transition to NPS. Did you choose to go back because it was a great place to live or for the academics?

**WAYNE HUGHES:** I ought to first step back and describe my tour in the Under Secretary of the Navy's office. It was part and parcel of that decision. From Deputy Director of OP-96 I went to a big Training Command in Pensacola, Florida. I was there for two years when I got interviewed for Executive Assistant to the Under Secretary of the Navy, Jim Woolsey. This was the same Jim Woolsey who was later the Director of Central Intelligence. Young and energetic with an analytical background, he wanted an Executive Assistant (EA) who understood analysis. Personally, I think he had his mind made up before I even went back for the interview. Another analyst interviewed to be the Secretary of the Navy's Executive Assistant was Skid Masterson. Skid and I had worked on the Major Fleet Escort Study together. Skid had had a tour in OPA and was remarkable in his own right. In any event, I became Jim Woolsey's EA for two years. I must tell you one other great story with all kinds of lessons associated with it. While Woolsey was the Under Secretary there was a big hurrah in the Congress over whether the next carrier should be nuclear powered or conventionally powered. The House Armed Service Committee had one view and the Senate had another and since they couldn't resolve the issue, they

decided to do what they always do under such circumstances, which was to commission a study. The time allotted for the study was six months. The study came down to the Secretary of Defense and he passed it to Secretary of the Navy Graham Claytor who told Woolsey: "I want you to honcho this personally and carefully." Claytor passed the study to Tom Hayward, the CNO, who was hard over for a CVN (Carrier Vessel Nuclear). Secretary Claytor was strongly in favor of a conventionally powered carrier although he knew that the Navy should have a big voice in the final decision. Both Claytor and Woolsey knew the Navy leadership favored a CVN and they certainly didn't want to be blindsided by some kind of biased, pre-ordained result. So the agreement was that it would go to OP-96. OP-96 at that time was directed by Rear Admiral Carl Trost, later Chief of Naval Operations. A brilliant man, he became the virtual study director, and spent a lot of time with the team that actually did the work at the Center of Naval Analyses. A key participant in the study was Bruce Powers. I've talked to Bruce and he essentially confirms what I'm about to tell you about the way the study was done. Which was, let me tell you, an act of genius. The study was done in a rush, in about three months, which means that they really had to move on it quickly, yet take a comprehensive look at the many issues involved. And they proceeded in the following way, and I'm talking about a lot of analysis with realistic scenarios and analytical "attacks" by Soviet submarines and aircraft. And also the carrier's role in non-Soviet situations like a war in Korea.

When the study was done, there were not two but three finalists. There was a CVN of ninety thousand tons, a NIMITZ class in effect. There was an equally large conventionally powered carrier, the characteristics of which only differed in the propulsion plant. And there was a small carrier of about thirty-five thousand tons. But the aircraft flying off the small carrier would be a STOVL, a short take-off, vertical landing aircraft.

The study report came into my office, the outer office of Jim Woolsey, copy number one. And I immediately took it in without looking at it and gave it to the Under Secretary. Within half an hour a known proponent of the little carrier and STOVL aircraft came running into my office, it was Rear Admiral Doug Mow, waving the study, saying: "Look Wayne, this

study proves that the STOVL aircraft flying off the little carrier is the only way to go." Well, if Doug Mow says that, then it must be true, but how can that possibly be the outcome of a study when it is well-known that Admiral Hayward favors a CVN? So while I'm pondering that, somebody else came running into my office waving this study saying: "Look Wayne, the study proves that a CVN is the only way to go." WOW! Thirty minutes later another guy came in waving the study saying: "Look Wayne, the non-nuclear powered CV is the clear winner. The study proves it." Well, not long after that I got my hands on the study myself, borrowed back from the Under Secretary. And I said: "Oh, now I see." The study had seven different scenarios. At least two scenarios favored each of the candidates. Not only was this the politically astute answer to a Congressional inquiry—otherwise you cannot make everyone happy—but it was also literally true. If there was a clear-cut winner, we would've known this twenty years earlier because this has been a controversial subject outside the Navy since the 1960's. It's literally true that the preferred carrier design depends upon what war you think you're going to fight, and you can find a number of situations that would favor any particular answer.

Yet I also thought that the study, when probed more deeply, made a compelling case for the CVN. To make a long story short, the reason is because the cost of the carrier itself is not the driving cost of the system. The system is the cost of the carrier and the aircraft on it. So you can have a twenty-five percent premium on the cost of the nuclear power carrier, which is substantially more expensive than the conventionally powered carrier. But if you put the aircraft on it, the aircraft costs as much or more than the carrier. The carrier is probably going to last for fifty years and has two generations of aircraft flying off it in those fifty years. So you doggone well want to include the operating cost of both the carrier and the aircraft. The operating cost of a CV and a CVN is just about a wash, since the carriers are by assumption the same, except for the propulsion plant. The operating cost of an aircraft is annually something like ten percent of the procurement cost of an aircraft. With a ship it's more like four percent of the cost of construction. Sometime around the twentieth year you're going to want to buy a new generation aircraft to fly off of it. The new generation aircraft is going to cost at least

as much as the first generation aircraft and probably more. In other words, I'm painting a picture where the operating cost of the ship and the aircraft and the procurement of the aircraft that are going to fly off the aircraft carrier clearly dominate the ship procurement cost. So the premium that you pay, twenty-five percent extra for the cost of the nuclear powered carrier to begin with, even though it's very big bucks, is dominated by the cost of the aircraft and the operating costs. The conclusion is that the premium that you have to pay for a nuclear power plant is small potatoes compared to overall cost, yet there are many situations in which the CVN has an advantage over the CV in an operating environment. Especially when it's not subject to attack. Be that as it may, the sea-based air platform study I thought was one of the great studies of all time by telling the Congress: "Look, the decision really depends upon how you think the carrier's going to be employed and what the next war is going to look like." That's a judgment call, and the judgment ought to be that of the Chief of Naval Operations. The Secretary of the Navy and the Secretary of Defense (who also favored a CV over a CVN) bowed to Admiral Hayward and the result was the next year a CVN was authorized and appropriated for. To answer the question that started this story, after two years in Jim Woolsey's office, I said: "I think it's time for me to make a transition." And he supported me.

**NOTE.** The interview was paused at this point and resumes with Wayne Hughes, Dr. Bob Sheldon, and a list of questions about teaching, book writing, and views on analysis.

**BOB SHELDON:** It is the 11th of June and we have resumed our interview with Wayne Hughes at the Alfred M. Gray Marine Corps Research Center, United States Marine Corps Base, Quantico, Virginia. Wayne, please tell us how you got the job at NPS?

**WAYNE HUGHES:** After two years with Jim Woolsey, the Under Secretary, I decided it was time to make a career shift and was thinking of retiring. I had an offer then to go to Newport to the Naval War College or to the Naval Postgraduate School in Monterey. In fact, the Superintendent Tyler Dedman, Jack Borsting, the Provost, and Mike Sovereign, who was the Chairman of the Department, all wandered into my office and said, "Wayne, you really ought to come to Monterey. That's the best place for you." So I went home and I asked my wife Joan what she wanted to do, because I

said that we'd made twenty-two moves in a thirty-year career and she had never been given a choice so now she got to choose. Happily, she decided that Monterey was the best place.

**BOB SHELDON:** How did you like being a professor?

**WAYNE HUGHES:** I never really succeeded in simply being an Operations Research professor. Most of my teaching has been pretty much military operations related. I taught Navy Operations Analysis, as an introductory course and also a capstone course in campaign analysis. I taught another capstone course in Joint C3 Operations, and a course in applied EW (electronic warfare), not in the OR Department, but elsewhere on campus. I did a lot of unusual and off the beaten path kinds of things.

I was in a Chair called Applied Systems Analysis for the first couple of years. And then I was the first Chairman in the newly created Chair of Tactical Analysis. This second position was created because we were trying to be more responsive to the Chief of Naval Operations. One of the Chief's goals was to revitalize the tactical competency of the Navy. The CNO was Admiral Tom Hayward. He sent a Rear Admiral to NPS named "Boot" Hill who asked what the school could do to enhance tactics. We said, "Well, we could create a tactical analysis curriculum—an entire curriculum devoted to the subject. Or, we could adjust a few courses in the OA curriculum if you send us a good, smart Navy captain tactician. We know where we could put them into the core curriculum for Ops Analysis. They will add emphasis on the fleet side and a better balance against the Washington decision making side, the systems analysis side." That seemed like a good thing to do regardless of the initiatives of the CNO. I thought this was something that was overdue anyway. When the Navy couldn't find anyone to sit in our new Chair of Tactical Analysis on short notice, I shifted from the Applied Systems Analysis Chair to the Tactical Analysis Chair. So I was the second holder of the Applied Systems Analysis Chair after Pat Parker, and the first holder of the Chair at Tactical Analysis.

**BOB SHELDON:** What year was that?

**WAYNE HUGHES:** I went out in 1979. I shifted to the Chair of Tactical Analysis in 1982. As soon as the Navy found somebody who was right for the position, I retired and became one of the civilian faculty in 1983.

**BOB SHELDON:** What did you put into your courses, and how did you incorporate your operational experiences?

**WAYNE HUGHES:** My value, my uniqueness at NPS, came from having had more operations experience. I had thought a lot about the tactics of combat, and especially about anti-submarine warfare. I became pretty proficient in warfare analysis. It was about this time I started thinking about writing a book on fleet tactics. I should also tell you that in my very first class I taught Pat Tracey who was then a Lieutenant Commander and is now a Vice Admiral. Pat took the tactics course, and shortly after that she asked me to be her thesis advisor. She was a self-starter and a hard working and perceptive student. A wise lady is the best way to describe her even then.

**BOB SHELDON:** What was her thesis topic?

**WAYNE HUGHES:** It was a cute thing. She had used a hand held programmable calculator, an old TI 59 hand held computer. She built a program in it that would compute the probability of hit of a spread of missiles. You could fire one, two, three or four harpoons at an enemy target using an error probability associated with the location, target location, and the distribution of the missiles from where you thought you were aiming them. She just worked out the math for the swept path probabilities against an area of uncertainty for the target and the algorithm would calculate the probability of one or more hits.

**BOB SHELDON:** Any other notable students?

**WAYNE HUGHES:** I'm proud to claim the Vice Chief, Admiral Mike Mullin as my thesis student. He did a thesis on AEGIS cruiser tactics. He wanted to write something practical that he knew something about, and did. I think he understood the power and limitations of Operations Analysis better than most graduates, which is saying a lot.

**BOB SHELDON:** Since you're at a graduate school, were you ever under any pressure academically that you should get a Ph.D. or Doctoral degree?

**WAYNE HUGHES:** When I decided I wanted to stay in education, I said, "I'll need a Ph.D." Mike Sovereign formed a little committee with himself as a member and Al Washburn was on it and a few other notables at the school. They came back in a day or two and said: "Wayne, we don't think you ought to take the

time to get a Ph.D. To be a tenured professor, then all during the tenure process (that's six years) you'll have to behave like everybody else. The reason we like you is because you're different and unique. And we'd rather you kept on doing what you're doing." I said: "That's okay by me. Anytime the Navy says I'm not pulling my weight I'll be more than happy to leave."

**BOB SHELDON:** When did you start writing your numerous books and articles?

**WAYNE HUGHES:** The order of the books was first *Military Modeling* and then *Fleet Tactics*. If I remember correctly, Charlie Woods was the President of the Military Operations Research Society. He called me up and said: "The Board feels like we need some book on VV&A, verification, validation, and accreditation," although I think then it was just called V & V in those pre-accreditation days. So I thought about it. Charlie was my mentor in the Pentagon, my first Pentagon boss, an old hand at analysis. He taught me a lot about how to be an action officer in the Pentagon. We were good friends. I called him back and said: "Charlie, what you do about validation and verification depends upon what kind of models you're talking about." They tend to be different depending upon whether they have to do with systems analysis and procurement, fleet operations analysis, force level analysis, training models, logistic models and even strategic deterrent models. This applies to the non-Navy or non-military type models (e.g., the State Department) as well. So I said: "I don't think there's any point in writing anything on VV&A until we covered the nature of military models and what they're good for." So he said: "Okay." I said, "I want to organize a committee and I want the committee to be prepared to write the individual chapters. The first thing I'll do is write an overview for the book which will serve as the glue and the common bond that guides each of the individual authors. The overview will have no name attributed to it. That'll be a collective effort but I'll write the draft and then everybody else can weigh in and we'll work out the common things and the individual things that mark these different kinds of military models." So I sweated out the draft for a while. There is a connection with *Fleet Tactics*, because I'm thinking about writing *Fleet Tactics* and, in fact, I'll come back and talk more about that, because they overlapped in principle.

**BOB SHELDON:** So things were off to a good start?

**WAYNE HUGHES:** Yes and no. When I had a decent draft written that I was very proud of, I sent it out to everybody on the committee and to Walt Hollis and Clay Thomas and other people whom I respected and who ought to read it anyway. They tore it up pretty badly. That slowed me down about six months, and as I rewrote it, I rethought a lot of things that I thought I had right and decided I didn't. Meanwhile I met with the committee members insofar as possible, people like Bob Hallex for the Navy, Jim Martin for Strategic Operations, and Colonel John Friel for the Air Force side. Steve Drezner and Bob Hillestead did logistics, Bernie Rostker drafted the chapter on human resources. It was hard to get them all together but I would meet them on and off, and they would read my latest overview and vent on me about it. We just proceeded and pretty soon we had it all assembled and then the MORS office took over and was the publisher of choice. By this time I was back on the MORS Board and enjoying myself. We did, in the end, say some useful things about verification, validation and accreditation. The book helped serve as a foundation for intelligent comments on what you can and can't expect to do with verification and validation. V&V is hard to do, as you well know, and everybody who's been in our business knows this.

As I said, I was in mid-passage thinking about this and was teaching all this time. We were getting into tactics in the classroom and I'd been looking for a book that contained anything on modern tactics. I found one by an Italian named Fiaravanzo, a retired admiral. It had been translated into English and published by the Naval Institute Press in the 1950s. But there was nothing, literally nothing that I could find by an American since 1941. So I called my friend Hugh Nott at the Naval War College and said: "Have I overlooked something?" He said: "I don't think so, but I'll check." He called back a few days later and said: "I don't think there's been a book by an American author in fifty years." Rear Admiral SS Robison published a book that stopped in 1931 but was republished in 1941. I said, "Well, why don't we write one?" And he said: "Good idea, but I've got two books of fiction to finish first." And I said: "That's good because I have this book on *Military Modeling* to finish." We outlined *Fleet Tactics* and sent it to the Naval Institute Press. The

Naval Institute Press came back with a signed contract.

**BOB SHELDON:** How did *Fleet Tactics* go?

**WAYNE HUGHES:** The date for which we were supposed to deliver a manuscript we failed to meet, but that was for two reasons. One was we were doing this stuff on the side. The other is that as we were starting to get serious and putting pen to paper, Hugh had several strokes and died. I had been counting on Hugh to do a lot of writing on modern tactics and I found myself confronted with the fact that I had nothing after the battleship era. There were lots of books on what tactics were, how they worked, how ships fought under oar, under sail, and under steam, but starting about 1950 there came this big vacuum. Even for World War II there wasn't any theoretical basis. Everything we had could describe the way we fought as history, but there wasn't any underlying, unifying scheme to think about modern tactics. I had been counting on Hugh Nott doing that because he was the Director of Naval Warfare Studies at the War College and it was his job to be current. Without Hugh, I was now stuck with doing it myself. But I am proud of the fact that I did a lot of original thinking.

**BOB SHELDON:** How did you lay out the book?

**WAYNE HUGHES:** Well, I first mapped out what I thought were the "essential dynamics," that is to say the dynamic processes of naval combat. I have a nice little speech, too long for this discussion, that lays out the things that are involved in naval combat. They are a lot easier described for naval combat than for land combat, because naval combat is so much cleaner and easier to understand in principle. That doesn't mean naval combat isn't sufficiently challenging. Knowing that there are twelve variables involved in naval combat of which you only control six requires some sorting out both analytically and operationally. If you have to understand the twelve vital variables and apply them (either to do a study or to fight and win the battle) you realize they are sufficiently challenging for anybody. One more thing and then I'll quit on the *Fleet Tactics* book. I kind of pooh-poohed the principles of war and said: "Look, after you go to a great effort to establish the great principles, then you kind of say—well, so what?" Many of the principles are self-evident, like the principle of concentration of force. It is something that two six-year olds discover on the playground early in life. Some

of the principles are internally self-contradictory or in tension with each other. The mutual tension shows up in the principles of the offense conflicting with the principle of security—they are not mutually exclusive but certainly being bold and cautious at the same time is something I highlight. Besides if you want to understand how to fight then you ought to be able to describe the way the battle goes in a dynamic fashion, which means developing a combat model. That's what my operations analysis experience brought to my thinking about the book. At the outset, I said in the book that it's a blend of operational background, from a guy who had two sea commands and thought an awful lot about battle, even though he never fought one. Operations Analysis was critical in looking at the subject rigorously, and a historical perspective was needed to put trends and constants in context. All three (operations, operations analysis, and history) are not everything, but they fit my personality and background to write the book. I think we signed the contract in 1983. The book was finally published in 1986.

**BOB SHELDON:** There have been revisions or updates to both of those books. What motivated those?

**WAYNE HUGHES:** The first book was introduced with the cornerstones of naval combat by describing the first battle of the Nile, that is, Nelson's great victory in 1798. Then I went through the whole length of the book and described what I thought was the evolution of naval tactics, how to understand tactics, and the dynamics of a battle. I ended the first edition with an imaginary battle in 1998 between a Soviet fleet and an American fleet and I called it the Second Battle of the Nile. That was very effective, but in 1990–1991 the Soviet Union collapsed. We had now passed the year 1998 and happily this battle never happened nor could it ever happen. I figured I needed a new conclusion. In addition, the theme of the second edition of *Fleet Tactics* was much more closely aligned with coastal combat and inshore operations. So I created a totally new second battle in the Aegean in which the Greeks and the Turks and the Americans were all involved in a confrontation that leads to a hot war. This was the way I modernized the incident to illustrate inshore tactics. It was a major reason that I decided that I needed to update the book. The Soviet Union had collapsed and our tactical emphasis had changed from blue water to

green coastal water. I'd gone overseas and worked on a project for three months in London. While I was there I dreamed up the scenario and vetted it with the intelligence officers there. Of course there is a long history of friction that has existed between Greece and Turkey. That led to an imaginary battle to illustrate littoral combat in the missile age.

**BOB SHELDON:** You incorporate a lot of historical examples or analogies into your writings. Do you have a favorite period in history you like to study?

**WAYNE HUGHES:** I think my very favorite is the night battles in the Solomons. For the first six months we kept losing and didn't know why. But through sheer grit we managed to hang on to Guadalcanal. The Japanese were losing a lot of aircraft and some ships and we were losing a lot of ships and some aircraft. The IJN (Imperial Japanese Navy) finally realized that they couldn't sustain Guadalcanal and withdrew. Then there was a pause and Commander Arleigh Burke came out, later CNO Admiral Arleigh Burke. He was in destroyers and he worked for a fellow named Tip Merrill who had the cruisers. They had time to think about what they'd been doing wrong and they worked out a new set of tactics. This captured my imagination in 1951 when I was a midshipman. Arleigh Burke, according to EB Potter, had attributed his tactical plan to having read the Battle of Zama in which Scipio Africanus defeated Hannibal. It turns out that the story was somewhat exaggerated, but it sure got this young midshipman's juices flowing. I've been a fan of Arleigh Burke ever since and I do think that he was our greatest wartime surface tactician and the greatest CNO since World War II.

**BOB SHELDON:** You maintain a lot of contacts with foreign students that come to NPS, as well as students across the other Services. What is your opinion about the quality of their Operations Research, their studies at NPS and follow-on Operations Research work?

**WAYNE HUGHES:** The old rule of quality in, quality out applies. Some of the foreign nations were sending us people who might've been here more as political appointees and were not all that good. But in the last ten years it seems to me that the students have been very capable. The Singaporeans have been very impressive. I don't get them as thesis students very often because they usually want to do something that is less tactically oriented and more in electronics, systems engineering, C2, or

logistics. But I know a lot of them and I admire a lot of them. In 1987 I was in Singapore for six months to help get their Operations Analysis program going by working with some of their new recent graduates in Singapore proper. I have the highest regard for their analytical skills and thinking.

The students I've worked with the most have been a series of Greek and Turkish students and that's kind of funny because of rivalry between the Mediterranean students. Starting with the Greeks, they had been reading *Fleet Tactics* and they were interested in the models that I developed. They extended the salvo equations for thesis work in a variety of ways. A series of three or four Greeks sort of handed me off from one student to the next. When the Turks found out about that, they couldn't stand the thought of the Greeks stealing a march on them. So I started to get a series of very good Turkish students too. We all did a lot of good thinking and expanding, developing, and extending the models. We all got a better understanding of the combat models this way.

**BOB SHELDON:** Do you have a leaning towards any of the academic areas of OR?

**WAYNE HUGHES:** Well, here's another dichotomy. I've generally said that the value of optimization has been oversold. But on the other hand my own thesis was an optimization solution. So it isn't as if I think this technique does not have value.

**BOB SHELDON:** Of the people who preceded you in the OR field, like the OEG folks, are there any of the early founders of military OR that you had close personal contacts with?

**WAYNE HUGHES:** No question about it, my very favorite, because I read *Search and Screening* long before I ever expected to meet the author, BO Koopman, Bernie Koopman. I invited him to be in my first MORS working group. He accepted, came, read a nifty little paper and we kind of hit it off right there. So when he was revising his *Search and Screening* not long before he died, he asked me if I'd read the manuscript. I said: "I don't know what I can do with the math." He said: "I don't want you to read it for the math. I want you to read it for its relevance." We did update the operational context for modern ASW (in the 1970's) since it had shifted in many ways. Towed arrays were important for screening and choke point search. The importance of aircraft, not only searching but also attacking submerged submarines, ex-

ceeded what was possible when he wrote the first edition in 1946. Of all the people I think Bernie Koopman is my favorite and most admired. Second to him would be Dan Wagner of Wagner Associates. Dan had latched onto me when I was at ASWFORLANT. He was a premier marketer, but he assembled the highest quality of mathematical analysts ever known and delivered quality work without fail. Dan Wagner's "children" are all over our community right now. Anything that has to do with better search techniques, there's a strong possibility that people like Larry Stone, Tony Richardson, and Bernie McCabe had a hand in. Dan Wagner was not himself as intellectually or analytically powerful as Koopman, but he may have had an equally great effect because he carefully selected the people he hired. He demanded high quality work. When they went off on their own, they were Wagner-trained men.

**BOB SHELDON:** A closing question. You touch a lot of students personally and impact them and guide them in their careers. Could you give similar guidance to some of the young analysts who don't have a chance to encounter you in the classroom at NPS?

**WAYNE HUGHES:** The single most important thing to remember is to be customer related in your work. You get prone to become overly charmed with your own model building. There's a lot of money in model building, but that really isn't analysis. The models ought to be developed with a particular purpose in mind. I have great skepticism about what in *Military Modeling* I called all-purpose models, which "always fail." If you keep in mind that there is a specific customer and a specific problem, it's okay to develop some theory on the side, like Koopman did. It was a conscious decision by Philip Morse to turn Koopman loose to synthesize a lot of practical things that now are the foundation of search, screening, and detection theory. To achieve great value in our practice, you have to work out a relationship with the customer—somebody you can help. If a tactical commander won't let you help him, there's not much you can do and you might as well help somebody else. But if you establish a bond and he trusts you and you trust that he will respect your work as honest and objective, then that's about as good as it gets. The only thing I can think of that's better is being married or having command of a ship.