No. 218
June 1979

# THE PRACTICE OF NAVAL ARCHITECTURE:

## A Career Survey of Recent Graduates

Gordon Firestein

Department of Naval Architecture
and Marine Engineering
College of Engineering
The University of Michigan
Ann Arbor, Michigan 48109

## Preface

This report summarizes the responses to a mail survey I conducted in May 1978. About 250 questionnaires were sent to naval architects and marine engineers who were graduated with bachelor's degrees from the University of Michigan from 1970 to 1977 (a few of these also received master's degrees during that period). There were 23 responses.

Luckily, the survey was not intended to be statistically valid. The questions were designed to elicit verbal descriptions of experiences since graduation, and reflections on the academic program at Michigan, rather than quantifiable data. The responses, therefore, were in the form of personal letters. the longest of which was nine handwritten pages. The success of any questionnaire that requires this sort of effort to complete must be judged mostly on the basis of the quality of the responses rather than their quantity.

I would like to thank those 23 stalwart authors for their letters. The time and effort they invested are valuable contributions to the Department of Naval Architecture and Marine Engineering and to anyone who is fascinated by the profession.

I would also like to thank Prof. T. Francis Ogilvie, chairman of the department, for his support of this project and for his guidance.

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## Introduction

A couple years ago, faced with the prospect of getting a bachelor's degree in naval architecture, I asked myself a simple question which I have been trying to answer ever since. What do naval architects actually do for a living? I was appalled by how little I knew about the profession I would begin to practice very soon. And I was struck by the real need for written information on this subject at the country's most prolific source of graduate naval architects, The University of Michigan.

The initial question spawned many others in my mind, even before I could begin to seek answers to it. How well does the educational program at Michigan prepare me for my impending career? How can I make the most of my time at Michigan? Will I like working as a naval architect? What will my first job assignment be like, and how different will it be from the homework assignments with which I've been nurtured? Who can tell me these things?

I guessed at this last question first. It seemed to me, at the time, that the obvious sources of information are my predecessors, alumni of the department who have been working long enough to know the professional ropes but not too long to have forgotten the anxieties and curiosities of the student. And so was hatched the survey the results of which are summarized in this report.

In the intervening two years I have broadened this campaign for career information. I have talked to professors, employers, graduates of other schools, and my own classmates. I have visited design offices and shipyards. All of these letters, phone calls and interviews have led me to some general conclusions:

• There is, at least at the moment, a healthy range of options for maritime employment open to Michigan graduates, despite the reported gloom pervading the maritime industry:

• naval architects do a large variety of tasks, some of them never considered in the curriculum, and a few of them not related to naval architecture at all;

• the bachelor's degree is good background for work as a naval architect. The key word here is "background." The learning process really accelerates <u>after</u> graduation;

• summer work experience is essential to ease the transition from studenthood to professional practice;

• the computer is ubiquitous. The naval architect must be able to communicate fluently with this machine, for he is likely to consult it often, perhaps daily;

• bureaucratic inefficiency, commonly manifested by large volumes of tedious paperwork, may demand much more of the naval architects's time than most students care to imagine;

• the ability to write well is an invaluable asset on the job, and in fact the rate of promotion may depend heavily on it;

• the deep satisfaction gained from seeing one's design assume tangible form, and perform as intended, usually outweighs whatever disadvantages pertain to naval architecture as a career.

These general observations belie the vast variety of experience encountered by naval architects after they leave Ann Arbor. The respondents to the survey provided many contrasting details by describing their particular situations and feelings. The differences among them are perhaps as instructive as the generalities.

Most of the letters were received during the summer of 1978. Information contained in this report about specific careers, despite the use of the present tense, is only valid as of that date. Also, most references to naval architects can be interpreted as references to naval architects <u>and</u> marine engineers. The shorter designation is used for convenience, and only when the distinction is not germane.

The appendix contains a sample questionnaire and cover letter, and a list of contributors. I would like to reproduce all the responses in their entirety, but lack of space prohibits that here. The letters are available for inspection, however, in the department office.

The ten questions I posed generated responses that fall roughly into four categories:

1) what naval architects actually do during the first few years on the job;

2) the rewards and frustrations of work as a naval architect;

3) the merits and deficiencies of undergraduate education for a career in naval architecture; and

4) advice from experienced professionals to those who will soon follow in their tracks.

## What Do Naval Architects Do?

It's hard to answer this question briefly. Although naval architects are academically prepared for their work by a nearly uniform curriculum, what they do with their training varies so much it defies categorization.

Unlike medicine or law, naval architecture has few well-defined specialities. The profession is traditionally, and nominally, divided between naval architects per se (engineers who consider problems of hull form, resistance, seakeeping, etc.) and marine engineers (which includes experts on power generation, piping, auxiliary machinery, etc.). Yet it is much more common to find a marine engineer occasionally performing naval architecture (and vice versa) than it is to encounter a heart surgeon delivering babies.

A few respondents to the survey denied any specialization at all. The generalists described their jobs as a potpourri of ship's engineering, with assignments ranging from stability analyses to interior decoration of the accommodation spaces. In some of these cases, the variety of work is the most appealing aspect of the job.

Those who chose to identify themselves as specialists in one or more areas of naval architecture named fifteen separate categories of concentration. I received letters from three yacht designers, two dyed-in-the-wool marine engineers, two hydrodynamicists, two computer-aided ship designers, and one each of the following species of expertise:

- underwater engineering, marine instrumentation, and control engineering
- structures
- ship motions and computing
- offshore engineering

* stability
* shipbuilding and repair
* naval ship alterations

One might be led to believe that the generalists encounter a variety of ship engineering tasks, while the specialists handle problems confined within their realm of interests. In reality, it is impossible to pigeonhole naval architects so easily. The distinction between those who specialize and those who don't is blurred by the varied nature of the work almost all naval architects perform.

It is also tempting to lump naval architects according to the environment in which they work. There are at least six categories of employer:

* design office
* shipyard or construction firm
* shipowner
* U.S. Government (primarily Navy)
* self-employed
* research and testing facility (e.g. towing tanks).

The respondents to the survey are distributed among these types of employment, except for research and testing. Curiously, no response was received from naval architects employed by a research laboratory.*

Nevertheless, this type of classification scheme also breaks down. The day-to-day experience of a naval architect employed by a shipyard is not necessarily different from his or her classmate's experience in a design office. Naval architects may perform some of the same tasks no matter where they work. Conversely, two naval architects working for

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*One respondent, Herbert Stephens, had worked for several years at the David W. Taylor Naval Ship R & D Center. In fact, he went through Michigan in the co-op program between the University and DTNSRDC.

shipowners, for example, may spend their days working on completely different types of projects. Ships are profoundly complex organisms; what naval architects do is correspondingly multifaceted.

The respondents' descriptions of their activities illustrate the difficulty of generalizing. A few examples follow:

• Bob Walsh is a naval architect in the Washington, D.C. office of M. Rosenblatt & Son. "My responsibilities are generally as varied as my job title implies," he wrote.

> I have primarily been involved in design studies, performing whatever tasks are required — feasibility studies, stability calculations, weight estimates, computer modeling, report writing, oral reviews, etc. My work takes me into contact with a number of people outside my own company — both engineers and non-engineers — and I must assume a variety of roles — designer, salesman, researcher, author, speaker, diplomat — depending upon who I meet. I find, more than ever, that as a naval architect, I must be both a jack and a master of all trades.

• Herbert Stephens, whose title is Development Engineer — Marine, works for Phillips Petroleum Company in, of all places, Bartlesville, Oklahoma. Herb's job requires him to function as a shipowner's representative in all phases of planning, design, and construction of the company's ships.

> My contributions have been in feasibility studies for LNG and LPG projects, ship specification preparation for LNG carriers and crude oil tankers, design detail approval for recent newbuildings, review and commenting on proposed USCG and IMCO rules and inspection of new construction ....
>
> Because Phillips does not own a large fleet, I am often called upon to do non-marine work in other areas of our design division. This provides a good deal of variety of work and has helped to keep the job interesting. One of my non-marine contributions is a prediction routine for estimating the rate of thermal expansion of a buried pipeline ....

> On any day, I may find myself listening to ship builders' proposals for ships or floating plants, attending planning meetings, reviewing ship specifications, working to develop shipping simulation computer programs, performing feasibility studies, serving as a consultant within the company on marine-related or interfacing areas, or traveling to or from inspection sites, technical meetings or other work-related meetings. In my less than three years with Phillips I have been to San Francisco; Washington, D.C.; New York; Boston; St. John's, Newfoundland; Stavanger, Norway; Paris, France; and Tokyo and Sasebo, Japan. Most of this travel is for short periods and occurs on an irregular basis.

• Ed Glowacki holds two jobs, and considers himself a specialist in each occupation. During the day, he's a project engineer at CDI Marine, in Jacksonville, Florida, where he works on naval ship alteration projects and occasionally a large commercial vessel. "Most of my energy in this position," he wrote, "is spent wiggling through Navy paperwork." At night, he's a small craft designer and part-owner of Bold Yachts, Inc.

> We specialize in small craft design, i.e. planing and sail boats of all size and displacement to 150 feet. Builders of these craft are usually capable of producing a boat from relatively few drawings, compared with the information required by a large shipyard. Without a large drafting staff it is necessary to stay in a world where construction is largely guided by common sense and experience. Our contracts typically require only a dozen drawings or so.

Ed is dissatisfied with the Navy work, but, as he put it, "It pays the bills. Life as an independent designer is more in tune with my personal life style."

In the six years that had elapsed since Ed got his degree, he worked on three major projects for CDI Marine and a host of smaller ones:

1) he was responsible for installing a towed underwater monitoring system (TUMS) on the USS Monab, a U.S. Navy auxiliary vessel. He coordinated the required mechanical, electrical and structural efforts. He performed the stress analysis himself, and studied the effect of the installation on the vessel's trim and stability;

2) he planned, performed and wrote the report on the inclining experiment for the Santa Maria, a replica of Columbus' flagship;

3) he coordinated the shipcheck of the aircraft carrier USS Saratoga, and also coordinated the design of twenty alterations to improve its ability to refuel at sea and to accommodate the required weaponry.

Ed included a brief diary of a day at the office. He arrives every day around 7:45 a.m. This particular day, he worked on a design estimate for the installation of a chaff launcher on an LST until about 8:30 a.m. Then he spent an hour-and-a-half working on a stress analysis of a pump foundation, and provided the draftsman for the project with the foundation scantlings. Before lunch, he spent two hours reviewing the contract drawing of a tanker's shell plating to make sure it complied with ABS rules, adjusting the scantlings when necessary.

After lunch, at 12:30, he attended a meeting to establish the company's format for a report presentation to a client. Then, he worked for an hour on a stress analysis of the bottom of a tanker's chain locker and provided the draftsman with the scantlings. At 2:30 there was another meeting, this one to plan a forthcoming shipcheck, and to make sure that the participants understood their responsibilities. After the meeting he put in an hour on a trim and stability booklet for a research vessel that was being modified. He calculated weight and moment changes, and worked on stability sheets for submittal to the U.S. Coast Guard. At 4:30, he called it quits for the day.

• Ann Rundle is a full-time yacht designer, currently employed by Kiwi Boats in Largo, Florida. At the time of her letter, she was working with another engineer there on the preliminary design of three-quarter, half, and eighth-ton racing sloops. During a typical day she works on wiring, plumbing and hardware specifications; she prepares detailed drawings of wood working, fittings, H-frames and the like; and she usually spends some time supervising the actual construction of the boats. Before she joined Kiwi Boats, Ann worked for Ted Irwin, for whom she did the complete design of the Irwin Citation 28. She also co-designed a 38-foot cruising boat and a 26-foot MORC racing sloop. And the Irwin Mini-ton benefited from the extensive rating work and rig design she performed for that vessel.

• Robert Levine is a marine engineer with the Atlantic Richfield Company in Los Angeles. A typical day there may consist of:

a) a computer analysis of vessel operating costs at various speeds,

b) vessel energy consumption audits,

c) vessel bunker fuel surveys to study fuel type and quality,

d) energy conservation programs.

Although Bob's current preoccupation is with fuel use and cost, he has also supervised tanker construction and approved structural plans. The field work aboard tankers, he wrote, has been the most satisfying part of his work.

• John Rosborough works in the Hull Division of the Naval Ship Engineering Center (NAVSEC) in Washington, D.C.. John is particularly interested in stability problems, and during a routine day at the office will probably use the computer to help him solve them. The first year with NAVSEC consisted of a training rotation in which he worked in twelve different branches within a Hull Division. He was exposed to such diverse topics as submarine structures, ship arrangements, and weapons systems. He spent a month in management (Naval Sea Systems Command) and about a half-year at a naval shipyard. Since deciding to concentrate on stability, John has worked on the contract design of well-ships (amphibious landing craft).

## Rewards and Frustrations

The previous section included brief examples of what young naval architects do. This section examines how they feel about doing it — the rewards and the disappointments of life at work.

Generally, the response was positive. Most (but not all) of the respondents are glad they are naval architects and would choose that career again if the clock were turned back and they were given another chance. The typically-varied workload is one of the benefits of the job. A common satisfaction is the pride of creation, of seeing a tangible result from hours of hard work with paper, pencil and calculator. The continual challenge to learn and to acquire new skills, the encouragement to constantly better oneself also appeals to those who answered the survey.

Numerous other aspects, some predictably attractive, others seemingly mundane, make these naval architects happy. For instance:

• Matt Devine, a naval architect at Boeing in Seattle, Washington, enjoys the novelty of earning enough money to pay the expenses and still have some left over for the savings account after years of poverty as a student (this comment balances the typical complaint, to be discussed later, that naval architects in general are poorly paid).

• Several others enjoy the opportunities to travel (the usual destination is Japan, Western Europe, Scandinavia or the Middle East).

• Ann Rundel mentioned that frequent opportunities to sail are a pleasant fringe benefit.

• Herbert Stephens cited the prestige of being the only practicing naval architect, and hence the resident expert on marine design problems, at a large company.

• Richard Metz, a computer specialist for Boeing Marine Systems, gets his professional kicks from seeing the output from a successful computer simulation.

In the day-to-day development of a career, it's probably the accumulation of victories in many small battles, rather than rare, major triumphs or the routine monthly paycheck, that forms the core of professional satisfaction. "The most satisfying facet of my work," Ed Glowacki wrote, "is the feeling of success that goes along with seeing my design actually built and operating. For example, I performed a stability analysis on a badly-rolling fishing boat. I recommended the installation of tank baffles and bilge keels. My recommendation was accepted, and roll was reduced to an acceptable level. Success."

Robert Green, a hull engineer at Bath Iron Works, affirmed that if he had it to do all over again, he would still choose naval architecture for his profession. "The rewards for those who try to put beauty in a utilitarian steel or wooden seagoing vessel never stop," he wrote. "A perfect ship or boat will never be built, but I'm sure each of us will try to design or build it."

The road to success, however one defines it for oneself, may contain the occasional pothole. L.L. Bembalkar, a naval architect with Brown & Root in Houston, Texas, put it this way:

> As in any profession, there are ups and downs in naval architecture. We seem to have a lot more expectations about our future profession, while the reality is not always satisfying. The problems are complex and not easy to solve. All major engineering projects are so big and complex, that many engineers and naval architects are needed to handle different pieces of one project. Naturally, recognition and appreciation are hard to come by, so this leads to frustration and a feeling of disappointment. This need not be so if the proper attitudes and expectations are developed while one is still in school. The future is very

challenging for naval architects and marine engineers, but we must base our expectations on reality and not on academic fantasies.

In reality, every balance sheet has a column for liabilities. It behooves anyone considering naval architecture for himself to recognize the potential disadvantages of that career. First, there is broad agreement that one does not fast become wealthy designing or analyzing ships.

"Regarding the naval architect in industry, the word is that one doesn't become a naval architect to become rich," Matt Devine wrote. "The jobs in general pay poorly compared to other disciplines of engineering, especially since so many naval architects are employed by less than industrial giants. For them the pay seems rotten."

Everett Lunsford, a marine investigator with the National Transportation Safety Board in Washington, D.C., feels very strongly about this issue. If he had a choice, he "would not choose naval architecture again because of the lack of financial opportunity. This is a profession where you must be willing to forego salary for your love of boats."

This is exactly what Ed Glowacki has done. "When I started college, there was no other possible career on my mind. Now I think: doctor? lawyer? car salesman? Knowing what I know now about pay scales I would probably be tempted to try 'doctor' just to try to achieve the freedom that money in the bank can give you. Actually, though, my aptitude really runs well with the boat design field and I am very proud of this profession so I guess I would still follow the same path."

Glowacki continued by raising another complaint about naval architecture. "Probably the largest drawback that this business has imposed on me is the geographical limitation associated with shipbuilding. If I wanted to go to Colorado or Montana or Arizona, for example, I probably couldn't find work there."

Another common dissatisfaction is the plague of tedious paperwork, and similar idiosyncrocies of bureaucratic management. Unfortunately, "red tape is not unique to the government," Richard Lutowski wrote. He works for NAVSEC.

> It occurs in any organization where there's a chain of command, including private industry. The best you can do is grin and bear it, and keep plugging away at your job. The worst you can do is try to change it — because you can't. It will merely absorb you and all your solutions, to the detriment of your technical work. Red tape is merely an unfortunate by-product of management, which itself is necessary for the functioning of any organization. Learn to live with it, and if possible, work around it.

Several respondents expressed dissatisfaction with the inexorable workload. "I never seem to be able to catch up," Jim Mackie wrote. He works for Marinette Marine in Wisconsin. "I often put in long hours of overtime, for which I am not paid since I'm salaried." Lenny Wanex, who works at NAVSEC, regrets that the workload keeps him from attending to any single project as much as he would like. "The large workload doesn't allow me to pursue ideas I have for improvement of the equipment. I can't afford to create additional work for myself since I know I won't be able to keep up with it."

There are a couple other problems one should anticipate encountering as a naval architect:

1) constant pressure to prove oneself as a competent engineer, especially to co-workers who do not hold university degrees. Ann Rundle wrote that "sometimes non-technical associates do tend to be a bit scornful" because of her university background. In her case, she wrote, the problem is aggravated by sexism. "I'm dissatisfied with being looked down on, or being doubted, by some men because I am a woman."

Ed Glowacki also noticed the pressure of having to live up to one's credentials.

> I have been embarrassed to various degrees because of my ignorance of welding practice, plate preparation, propeller shaft installation, etc. I found it necessary at times to plead ignorance and ask a draftsman from Newport News who spent time in the yard just how certain things are done. There's nothing wrong with asking an older man for advice, but frankly, as a junior engineer many experienced draftsmen have fun 'testing' your ability. It takes time to establish your credibility.

2) the pitfalls of professional unions. One alumnus made the following observation:

> One roadblock in big industry is the unionization of the 'professional staff.' That is, at most major corporations, engineers usually belong to a union of sorts. What usually happens is that the older engineers, who compose a majority of the union members, force the union to negotiate with the company for a contract that is quite favorable to the older engineers and SCREWS THE HELL out of the younger engineers. Result: in my company, many young engineers are leaving because vacations, benefits, and salary increases benefit the older, often obsolete engineer at the expense of the younger. The future looks worse with respect to unionization and engineering.

## Academic Preparation for a Practical Profession

Some of the preceding comments raise questions concerning the academic preparation students receive for their probably nonacademic careers. How adequate is our education? By how much do our academic impressions of naval architecture diverge from the realities of the job?

The survey included three questions intended to shed light on these questions, and some of the answers are indeed illuminating. The first of these questions, "What was your first assignment on your first job?" elicited responses that were remarkable not so much in themselves, but rather in contrast to the replies concerning current job activities. The point here is that initial assignments do not seem to be wholly different from assignments once handled as homework. Within a year or two, however, the young naval architect usually has progressed to projects involving substantial responsibility requiring expertise extrapolated from one's academic background, an expertise developed mostly on the job. This suggests that employers can judge fairly well what a naval architect can handle when freshly released from Ann Arbor; his or her progress after the first few months, however, is largely a function of self-motivation and ability to learn on one's own.

This is illustrated particularly well by Eric Sponberg's reply:

> I first started doing a lot of work at Exxon with the computer. I analyzed mooring systems of VLCC's and damaged stability for all sizes of ships. These were given to me because a) they were drudgery, but had to be done, and b) I was one of the few people in the office who understood the computer. Soon, I became responsible for all computer operations including budgeting computer time and costs, and data upkeep and update.

Later on, Eric found himself responsible for all naval architectural matters involved in the construction of a liquefied petroleum gas carrier. As if that were not enough to worry about, he also served as troubleshooter, handling special projects as they would develop with the existing fleet of tankers. For example, he supervised the at-sea testing of a tanker on a voyage between Cape Town and the Persian Gulf.

Ann Rundle's experience is also illustrative of this point. Her first assignment was to design deck fittings for a yacht. It wasn't long before she was designing an entire yacht herself.

Stuart Aferiat started out by plowing through Exxon's ship data file, updating it where necessary. By way of contrast, he's now project engineer in tanker research and development.

Before graduation, Steve Milne had worked at J.J. Henry Co. in Moorestown, N.J., making drawings, cataloging the weights of various off-the-shelf items available from vendors, and helping prepare Ship Hull Characteristics Program input. He then worked for two summers at Sun Shipbuilding in Chester, PA, where he returned for a year and a half after graduation. There he prepared trim and stability booklets, a loading manual, a damaged stability report, and tank tables, performed many inclining experiments, went on one sea trial, made some drawings, and did quite a lot of computer work. Steve has been working at El Paso Marine in Houston, TX, for two years now. He has done complete ultrasonic surveys of liquefied natural gas carriers (LNGC's). He has even done basic research on LNGC's and instrumented them to test his theories. Steve has acquired a high degree of responsibility as one of three naval architects responsible for nine vessels.

Other alumni cited the following examples of assignments handed them on Day One as a practicing engineer:

- prepare an inclining test report,
- prepare a computer analysis of lifeline stanchions,
- perform trim and stability calculations,

• help install machinery in supply tugs,

• design a generator foundation,

• design a water run-off trough for the flight deck of an aircraft carrier.

Associated with the question of "What did you do first?" is the consideration of "How well prepared were you to do it?" As I mentioned at the beginning of this report, one question quickly begat another, and soon there was a large family of curiosities burgeoning from the same root concern. This is a good example.

The subject of career preparation, in this case undergraduate education, can be approached from many different angles. I chose to ask two questions intended to provide a sort of stereoscopic perspective of the topic. The first angle is the positive one: "What part of your undergraduate education best prepared you for a career in naval architecture?"

The answers cited many different classes, ranging from basic naval architecture to Psychology 101. Several people thought the curriculum was as tight as it could be, that every course helped prepare them for their careers.

A couple categories were mentioned more often than others. The technical writing courses rated high on the list, probably because technical writing is so often demanded on the job, is so difficult to master, and is allocated so little time for practice in a curriculum packed with analytical engineering courses. John Rosborough, Stuart Aferiat, and Richard Metz listed humanities courses as some of the best parts of their educations. Michael Allman explains why:

> I have written a great number of reports, and cannot stress enough how important it is to be able to write good concise technical reports. It has taken a good deal of effort on my part

> to write well, and it helped me to advance in the company to be able to do so. The best technical work can look bad if it is not presented in the proper manner. Every engineer should have the ability to write well if he is to succeed.

Matt Devine expressed complete agreement:

> I might put a damper on someone's day by saying the following, but here goes...in my industry, i.e. a major aerospace giant, an engineer HAS to be able to write (fortunately, he doesn't have to type well, thank God). It seems that all of us employed by Boeing are forever writing about the technical material we've been wrestling with. Many of my fellow engineers are sadly lacking in that department.

The senior design series, NA 470 and 475, earned special mention from several alumni as being particularly good preparation for their work. And, in at least one case, the class was more than just an academic exercise. Steve Brecheisen's design miraculously came to life after graduation. "Talk about irony," he wrote. "My NA 475 design project was some far-out aluminum, 40-knot, gas turbine powered, water-jet driven, 100-foot passenger vessel. Even I found it difficult to take it seriously. Within a year after my graduation, I was project engineer for the construction of just such a vessel. I was ready." The senior design series can be valuable even for those who are not so prescient with their choice of a project. "Obtaining an overall view of the ship as a whole has probably helped most in preparing me for a career," Herb Stephens wrote.

> There is very little a naval architect does or knows that is not covered by various other disciplines of engineering, but the overview obtained as a student of naval architecture makes it easier to keep each aspect in perspective and realize how each item in a ship affects the other items in the ship as a whole. Beyond that, an understanding of the interactions between ship and sea which are unique to naval architecture is essential. This is more than just understanding the motions, it also includes hull stresses, effects on machinery,

> cargo, and human habitability. Without this background, the naval architect's job could as easily be done by mechanical, civil and structural engineers.

There's more to an education than just classes, of course. The attitudes one acquires in school may be just as important as the technical skills. Ed Glowacki emphasized the value of an engineering "frame of mind." "Developing an 'engineering head' is the most valuable thing to me," Ed wrote.

> Everything I studied in Engineering School seemed to require that quality, and therefore helped develop it; the ability to be coldly analytical and honest, to read the bottom line and then decide what action is required. This problem solving philosophy is sometimes a subtle thing to recognize as it develops in you, but it is obvious when someone skilled, such as our chief engineer here, begins sorting out a muddy problem. I believe the 'engineering approach' is a powerful tool and essential to our work.

Ed's comments suggest a curious omission from the responses to this question. It seems surprising to me that no one mentioned his association with one of his teachers as the most valuable part of his education. The faculty is probably the greatest resource the Department of Naval Architecture and Marine Engineering has to offer. A tremendous store of knowledge resides nowhere else but in the minds of our professors. More important than knowledge, however, may be the accumulated years of experience our teachers possess, and their practiced professional approach to complex problems.

This brings me to the question that was intended to explore attitudes about the curriculum from a more critical point of view. The preceding paragraphs dealt with the most useful parts of the undergraduate education; this question deals with its shortcomings.

The responses to this question far surpassed, in volume, the replies to any of the other questions I posed. If every suggestion were adopted, the undergraduate program would probably take six years to complete. Nevertheless, the criticism by alumni is a measure of the gap between what one is eventually expected to know on the job and what one learns as a student. Everything is subject to improvement, and the letters I received expressed strong opinions on how the Department of Naval Architecture and Marine Engineering could improve its program.

First, many letters clamored for some sort of formal work experience arrangement, whereby the department would organize internships in shipyards or design offices during the summer. Those writers who recognized the difficulties of establishing such a program urged students to acquire shipyard experience on their own. I could fill several pages of this report with quotations from the letters exhorting the department to help provide work experience. For example, here's one from Robert Green:

> Get them out of those goddamn dinghies and into a ship or a shipyard; in short, learn your trade as an engineer, take a welder to lunch. If education stops in late April and starts again in September you aren't getting a full education; incorporate (similar to Webb Institute, but with longer than two months on the job) a work program between Junior and Senior years when the student really needs to see what he can do with what he knows. Practical naval architecture takes years to acquire and without a little sea time or experience around practical ship operations, something that can be accomplished during summer vacations, a recent University of Michigan graduate is an even 'rawer' recruit than he might think of himself.

John Rosborough echoed these sentiments. "The curriculum, as far as courses go, is fine," he wrote. "My only recommendation is that the students — through the college or department — should try to gain summer jobs or start a work-study program with local (or not-so-local) engineering/naval architecture firms. Experience will get you everywhere and is the one thing firms look for!"

The second most common disappointment expressed in the responses to the survey concerns the teaching of structures courses.

"Generally, the naval architect's background in structures is very poor compared to civil and even mechanical engineers," Kimber von Blohn wrote. To remedy the situation, he suggested that naval architecture students take structures courses through the civil engineering department. "Only one course in direct application need be taught by the naval architecture department," he wrote.

Robert Walsh expressed a different point of view about the same problem. Poor background in structures is partly a result of the way the subject is taught, and partly the result of the students' attitude toward the subject. "When I graduated from Michigan," he wrote,

> I, like many of my classmates, had somewhat of a disdain for ship structures, believing their design to be beneath the dignity of any self-respecting Naval Architect. This belief was founded, I think, more on our ignorance of structures than our ability as hydrodynamicists. I learned a great deal at Newport News, where I first worked as a structural engineer, and developed a real affection for structural design. I firmly believe that the best ship design is worthless if it can't be built, and it couldn't be built without a well-conceived structural design. It behooves all naval architects to remember that the development of a transverse web frame is as important to a ship as the model test.

Several letter-writers suggested that students should be encouraged to follow realistic design procedures in some of their coursework. Von Blohn, for instance, urged instructors to require students to use the AISC Steel Construction Manual in structures courses. James Mackie wished he had been more familiar with ABS and USCG rules before he started to work. And Stuart Aferiat suggested assigning more homework problems in which some of the required information is not available, where the solution depends partly on guesswork. These are the types of problems, he said, an engineer can expect to encounter on the job.

Herb Stephens gave an example of just such a problem:

> One of the major differences between school and practice is in the problems to be solved. Normally, in a classroom environment the problems are fairly well-defined, the necessary information to solve the problem is available, the answer is unique, and guesswork plays a minimum role. In real life, the problem is not quite so well-defined, information is lacking, the answer is not unique, and experienced guesswork plays a very major role. For example, a problem might be posed as follows:
>
> What freight rate will I need to charge to transport 2.5M cubic feet per calendar day of LNG from Bonny, Nigeria, to Savannah, Georgia, in a fleet of LNG tankers? This will involve selecting the size and powering, estimating the service speed, cargo boiloff, fuel requirements, port charges, crew costs, stores, insurance, maintenance, overhead, investment, and numerous other details. It will be up to you to decide what details to consider, how to make your estimates, and how much effort to put into the solution. Remember, this fleet of ships has not yet been built or designed, so a certain amount of error tolerance is built into the problem. Going into too much detail is wasted effort, while not enough can lead to erroneous conclusions.

Paul Gow and Jay Miner, both of whom work for Nickum and Spaulding Associates in Seattle, Washington, collaborated on a letter in which they listed topics that would be useful to students. This list, which includes subjects they wished they had studied while still in school, is reproduced here verbatun:

"How do shipyards operate?

- Mold loft procedures from plans to plates.
- Fabrication techniques. What kind of mistakes does the designer make because the yard cannot build it that way? How are compound curves formed in plate? What is union melt?

• How are sandblasting and painting performed?

• Welding. What do welding symbols mean? What are some of the mistakes that designers make in welded structures? How do welders cheat on welds? How does this weaken the structure?

• How do you set foundations, align bearings for high tolerance work?

• What are the procedures for drydocking large ships?

• Why is quality control such a problem and what can be done about it?

• What are the standard steel shapes used in shipbuilding?

"What is the procedure in a design office?

• Difference between contract plans and working drawings. How much detail is required?

• How do design offices bid on jobs? What is a plan schedule? How does the plan approval process work?

• How does the role of the designer draftsman differ in a design office from that of naval architect?

• What is the interrelationship between fabrication cost and the way a steel structure is designed?

• Why is gross tonnage important in design and what concessions are made in arrangements because of it?

• What are the implications of product liability and the effect of the legal profession in general on the marine industry?"

To make space in the curriculum for these subjects, some existing courses would have to be eliminated. A popular candidate for extinction, if alumni could have their way, is the electrical engineering requirement.

Perhaps the subject could be made more palatable if it were taught as part of the marine engineering curriculum. "It would be infinitely more valuable," Ed Glowacki wrote, "to expand the portion of marine engineering dealing with electrical loads, cable sizing, lighting requirements, generator sets, etc. Perhaps the course would then be of value to the marine engineering specialists, but it's a waste of time for the boat designers."

Robert Levine, one of the marine engineers who replied to the survey, concurred with Ed's advice. He also suggested amending the marine engineering curriculum to include the study of:

1) deck machinery,
2) machinery lubrication
3) boiler water treatment,
4) combustion,
5) materials specification.

Richard Lutowski, a naval architect in the Advanced Technology Branch of NAVSEC, urged modification of the courses on ship design. "One thing I know now that I did not know when I graduated is, believe it or not, the process involved in designing a ship," he wrote. "The department's curriculum does not teach it. Even the final design course does not really teach it. And most naval architects never learn it, even on the job!"

Lutowski distinguished between the subsystem design (propellers, hull forms, structures, etc.) that most naval architects do, and the conceptual design (treating the ship as a single integrated system) that very, very few naval architects ever get involved in. Designing a whole ship, he said, is best approached by first considering the requirements for volume and weight, then estimating how much space and buoyancy are available to satisfy the requirements, and iterating until the available space and buoyancy match the required volume and weight. "It sounds so simple," he wrote. "You probably knew it all along. But has anyone ever explicitly taught it to you? Has anyone ever taught you what it means when applied to ships?"

Other suggestions from alumni include:

• "Much much more use by the students of the towing tank. The NA 320 (ship propulsion) labs were too short as far as allowing the student to get any experience in tank testing," Ann Rundle wrote. "I found them to be rather a letdown. The University of Michigan is one of the few universities in the world with testing facilities, yet the students, as a whole, don't benefit from the tank."

• "Although this may seem foreign to you (as it did to me in school), more effort should be spent using naval ships as examples," John Rosborough suggested. "They have much more rigorous limitations, specifications, and design criteria than commercial ships. This is not to say that the Navy is any more advanced or 'state-of-the-art' than commercial designers. Usually the Navy is very conservative or pessimistic — a good approach these days."

• "Offshore oil exploration, production, etc., is an important developing field," Kimber von Blohn wrote. "Related naval architecture courses should be offered, such as wave loading analysis, motion analysis, and oceanography — winds and waves."

• "There is no class at all on fractures," Eric Sponberg observed. "Structures fail sometimes, but why? What is the difference between a brittle fracture and a fatigue fracture? What do the failed pieces of material look like? How should the design be changed, and how is the repair going to be made? Actually, this last area of fractures is the most important."

## Advice to the Uninitiated

The letter accompanying the questionnaire urged the respondents to offer any pertinent advice that was not otherwise prompted by the questions. Some of these valuable bits of wisdom are presented below:

• "Don't take classes too seriously," Bill Lasher wrote. "Work hard, but keep things in perspective."

• Consider an advanced degree carefully. "I know several cases," Matt Devine wrote, "where naval architectural design offices wouldn't even offer a graduate naval architect a job because they couldn't possibly afford to pay a reasonable salary. They needed somebody who would come cheap." Robert Green seemed to concur, but for a different reason: "Too many grad students are overtrained for their practical lives as competent naval architects."

• Either combine the bachelor's in naval architecture with a BSE in mechanical engineering, or get a master's degree in a field other than naval architecture. "You need more than basic naval architecture," Steve Milne advised, "and unless you are lucky or unambitious, you are likely to want to change fields for more opportunity and flexibility." "I would urge all students to take a broad range of classes," John Rosborough wrote. "Don't specialize unless you have a particular job you know you will be doing after graduation."

• "The practicing engineer often has to perform a balancing act and he is responsible for his work," Herb Stephens wrote.

> I am not trying to scare anyone, but I don't think that with all the other things school has to cover that 'theory of practice' can be taken care of also. This is something that comes with experience. Your future employers realize this and will help you to gain it. Just be aware that college is only the beginning of your education as naval architects.

Robert Walsh offered similar advice:

I would recommend to a student, soon to graduate in Naval Architecture, to pursue the job opportunity that has the greatest potential for his continuing to learn. Your education does not end at graduation, but merely begins. Based upon my own experience, I would suggest that every naval architect spend some time working for a shipyard. There is a broad spectrum of experience to be gained and you can greatly broaden your educational base if you're willing to learn.

Without meaning to sound overly negative, I would suggest that a new graduate realize that no job will always seem perfect. You will have days when work is slack, when you don't feel 100%, when you're mad at your neighbor's dog for keeping you awake all night, or when for any of a thousand reasons, you can hardly drag yourself to your desk and you think that the end of the day will never come. This, too, shall pass.

I'm convinced that Naval Architecture is an exciting and stimulating profession. If you face each challenge that your work presents and try to solve it to the best of your ability — applying all you know and have learned and seeking out advice and guidance when you need it — then you will continue to grow and develop as an engineer, gaining the respect of your peers and yourself.

Paul Gow and Jay Miner compiled the following long list of suggestions, which is reproduced here from their letter:

- Get as much summer work in as you can, in both a shipyard and a design office.

- Do your best to understand your basic engineering courses. If you do not learn it in college, you will find it very difficult to make up the inadequacies later. Your education is costing you a lot of money. Make the most of it.

- By all means, take the E.I.T. exam as soon as possible; professional engineers earn better salaries, even if they work for a company instead of themselves. Having a P.E. license is becoming more important all the time.

- Do not ignore your technical writing courses and communication-related studies. Engineers who agonize over a draft of a report will never get very far and, rest assured, you will write plenty.

• Learn how to read drawings and become familiar with terms and symbols.

• Learn to organize. Sloppy students make sloppy engineers. You will never be a project manager if you cannot manage your own work effectively.

• Grades do matter to most employers. It is only logical that they want to hire the people who know their engineering. If your grades are not the best, try to make yourself more attractive to an employer by getting more practical experience. One summer in a shipyard is worth two summers anywhere else.

• Get aboard ships whenever you can.

• Do not be afraid to ask questions. An employer does not expect you to know everything, but he does expect you to seek help if you need it.

• Do not expect to get the best job assignments with the least seniority.

• If you are determined to work in a certain geographical area, move there and take a temporary job doing anything until you find what you want in the field. Maintain your contacts with the faculty, they are a good source for job information, as are former classmates.

• Just because you expect to specialize in one area does not mean you will never be doing anything else. Learn about all areas of naval architecture.

• Take some basic economics and business courses. Cost considerations play a dominant role in all aspects of industry. The more an engineer understands about the cost implications of his design, the better off he is.

• Read Marine Engineering/Log and other trade publications.

• Learn to draw. This primarily takes practice and must be done outside the normal curriculum. You will not in general spend much of your career on a drawing board, but you may spend the first few years there. Too many graduate naval architects cannot draw and therefore have difficulty expressing their own ideas.

• Try to get your first job after graduation in a shipyard. A yard that specializes in small commercial craft and has a high production rate will give you the most experience in the least amount of time. In the matter of a few years, you can gain experience in detail drafting (both hull and mechanical), structural and mechanical design, hydrostatics, preparation of purchase specifications, dealings with ABS and USCG, project management and owner liaison. Probably the most valuable experience to be gained during this time is a good working relationship with the yard production people. Some yards encourage engineers to work closely with production, but unfortunately many do not. In any case, a working relationship with yard foremen and leadmen does not come easily. You have to get in the bilges with them and demonstrate that you understand their business before they will respect what you have to offer. In the end, it will pay off and you will get their suggestions on solutions to problems and they will listen to your reasons for designing the way you do. The knowledge gained through this will be extremely valuable at such time as you choose to move on to bigger and better things.

## Conclusion

Students are expected to master many subjects during their undergraduate years. Very rarely, however, are they encouraged to study the process by which their careers are developed and their futures designed. This survey was an attempt to provide naval architecture students with some information on the experience of their predecessors, in the hope that this will be useful in planning the initial route from Ann Arbor.

The future is always uncertain, of course, and careers are often determined by opportunities that suddenly appear and disappear equally fast unless alertly seized. To be alert to these opportunities, one must be prepared and as knowledgeable as possible.

What were the salient results of the survey? The respondents generally agreed that their educations prepared them adequately for their early careers; but they also agreed they could have been even better prepared. They suggested specific improvements to the curriculum and urged a general change of attitude amongst faculty and students on the importance of practical subjects and first-hand experience.

They described their activities on the job. The first assignments are usually at a level similar to that encountered as a student. The naval architect rapidly progresses, however, to problems involving greater responsibility and requiring new knowledge (often self-taught) for their solution. Each naval architect eventually handles a wide range of projects, despite his or her self-designation as a specialist.

They are generally happy with their work, the rewards stemming from the fresh challenges of the varied workload and the pride of creation when a design is built and performs well. They described the frustrations of low pay, bureaucratic hassles and paperwork, and the pressure to prove one's competence. They offered a variety of advice to students, the most emphatic of which is to get summer work in a shipyard.

## Appendix

### List of Contributors

Stuart Aferiat (BSE '77)
Tanker Department
Exxon International Co.
220 Park Avenue
Florham Park, NJ 07932

Michael Allman (BSE '76)
801 N. Pitt Street, Apt. 616
Alexandria, VA 22314

L.L. Bembalkar, (BSE '70)
Brown & Root, Inc.
Post Office Box 3
Houston, TX 77001

Steven Brecheisen, (BSE '73)
1130 Blackbird Road
Petoskey, MI 49770

Matthew Devine, (MSE '74)
10415 SE 174th St.
Renton, WA 98055

Edmund Glowacki, (BSE '72)
1962 Shelton Road
Jacksonville, FL 32211

Paul Gow, (BSE '70)
Nickum & Spaulding Associates, Inc.
811 First Avenue
Seattle, WA 98104

Robert Green, (BSE '75)
14 Somerset Place
Bath, ME 04530

William Lasher, (MSE '77)
217 Indiana Drive
Erie, PA 16505

Robert A. Levine, (BSE '74)
Transporation Division
Atlantic Richfield Co.
5900 Cherry Ave.
Long Beach, CA 90805

Everett Lunsford, Jr., (MSE "73)
644 Massachusets Ave., N.E., No.200
Washington, D.C.  20002

Richard Lutowski, (BSE '70)
4821 Indian Lane
College Park, MD  20740

James B. Mackie, (MSE'76)
3208 14th Street
Menominee, MI  49858

Richard Metz, (MSE '77)
10413 SE 174th St. #4460
Renton, WA  98055

Steven Milne, (BSE '75)
12251 E. West Village Drive
Houston, TX  77039

Jay Miner, (BSE '75)
Nickum & Spaulding Associates, Inc.
811 First Avenue
Seattle, WA  98104

John Rosborough, (BSE '76)
2000 Huntington Ave #808
Alexandria, VA  22303

Ann Rundle, (BSE '77)
1015 Locust St. NE
St. Petersburg, FL  33701

Eric Sponberg, (BSE '71)
c/o Cruising World Magazine
P.O. Box 452
Newport, RI 02840

Herbert G. Stephens, (MSE '73)
Engineering and Services
Phillips Petroleum Company
Bartlesville, OK  74004

Kimber Von Blohn, (BSE '71)
Earl & Wright, Consulting Engineers
1 Market Plaza
San Francisco, CA  94105

Robert Walsh, (BSE '73)
M. Rosenblatt & Son, Inc.
2341 Jefferson Davis Highway
Arlington, VA  22202

Lenny Wanex, (BSE "74)
2400 Queens Chapel Road #312
Hyattsville, MD  20782

THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF NAVAL ARCHITECTURE AND MARINE ENGINEERING
NA&ME BUILDING, NORTH CAMPUS
ANN ARBOR, MICHIGAN 48109
(313) 764-6470

3 May 1978

Mr. Kimber H. Von Blohn
Naval Architect
Earl & Wright Consult. Engrs.
657 Howard St.
San Francisco, CA 94105

Dear Mr. Von Blohn:

You have some very valuable knowledge about naval architecture that is not taught to naval architecture students: you know what it's like starting out in the profession. To those of us faced with initial decisions about our careers, that kind of knowledge could be more important than learning about Froude's law or the buckling strength of plating.

I'm writing to you and your classmates to ask your advice and guidance. My classmates and I will be keenly interested in your comments, which I hope to publish in a booklet to be distributed to students next Fall.

The list of questions on the next page indicates some of the areas of our curiosity about life beyond the classroom. It may be too much to expect answers to all of them, but a few moments of your time could influence years of ours. Any insight you can offer will be immensely appreciated, Mr. Von Blohn, for we can't get it from any other source.

Please be as specific and candid as possible. If you would prefer that certain sensitive comments not be attributed, your request for anonymity will be honored.

1. What area of naval architecture are you specializing in, and how did you decide on that?
2. What do you know now about the practice of naval architecture that you wished you had known while still in college?
3. Describe your contribution to some of the principal projects you have worked on. What is your current job title, and with whom are you affiliated?
4. Describe a "typical" day or two at work.
5. What have you found most satisfying about your work?
6. What have you found least satisfying about your work?
7. What was your first assignment on your first job?
8. What part of your undergraduate education best prepared you for work as a naval architect?
9. What changes in the curriculum here might better prepare a student for a career in naval architecture?
10. If you were a college freshman again, why would you (or why wouldn't you, as the case may be) choose to go into naval architecture?

We appreciate the amount of effort required to compose responses to these questions. Please consider them as guidelines-- if you have any comments or advice that do not fall into the categories suggested by these questions, please don't hesitate to include them.

My classmates and I can't thank you enough for your help. We could only repay you indirectly by doing the same for the students who may ask us these questions in a few years.

Sincerely,

Gordon Firestein

Gordon Firestein, '79
Survey Editor

P.S. If you like, we'll send you a free copy of the booklet when it's published in September. Perhaps you'd be interested to know some of your classmates' experiences since graduating.

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