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ABSTRACT

The United States Coast Guard Academy has integrated a successful senior-level ship design course sequence into an undergraduate engineering curriculum in order to achieve specifically desired academic and professional outcomes. The Naval Architecture and Marine Engineering (NAME) curriculum discussed is designed to allow for efficient use of class and lab time. Students at this level are considered to have gained the maturity and self-discipline necessary to complete independent design work. This paper presents an overview of the NAME curriculum given at the Academy with specific emphasis on the senior design project. Descriptions of the "capstone" design courses (Principles of Ship Design and Ship Design and System Integration) are given and details of their organization are included in the appendices. Additionally, the senior design project is described in detail including a brief discussion of its effectiveness in achieving a thoughtfully developed list of desired outcomes. (GLR)

ONE APPROACH TO SENIOR LEVEL DESIGN IN NAVAL ARCHITECTURE AND MARINE ENGINEERING

K. J. Colella

Report 09-92

June 1992

Center for Advanced Studies
United States Coast Guard Academy
New London CT, 06320

One Approach to Senior Level Design in Naval Architecture and Marine Engineering

LT Kurt J. Colella, Instructor, Department of Engineering, U. S. Coast Guard Academy

Paper to be presented at the ASEE Annual Conference 21-25 June 1992

ABSTRACT:

The ability to integrate a successful senior-level design course sequence into an undergraduate engineering curriculum is paramount in achieving the desired academic and professional outcomes of a demanding institution.

This paper presents an overview of the Naval Architecture and Marine Engineering curriculum at the U. S. Coast Guard Academy with specific emphasis on the senior design project. Descriptions of the "capstone" design courses are given and details of their organization are included in the appendices.

The senior design project is described in detail including a brief discussion of its effectiveness in achieving a thoughtfully developed list of desired outcomes.

BACKGROUND:

The U. S. Coast Guard Academy has three primary objectives, all of which involve the training and education of young men and women as they strive to develop into competent, professional, junior officers.

The first objective is to provide, by precept and example, an environment which encourages a high sense of honor, loyalty and obedience. Secondly, to provide a sound undergraduate education in a field of interest to the Coast Guard. Third, to provide training which enables graduates to assume their immediate duties as Junior Officers afloat.[1] The four year program at CGA culminates with the award of both a bachelor of science degree in one of seven academic majors and a commission as Ensign, U. S. Coast Guard.

An understanding of these objectives is significant in view of the makeup of CGA's curriculum. Of specific note are the engineering courses of study where it has historically been difficult for students to endure a demanding academic curriculum which lies in the midst of an equally demanding professional and military curriculum. One of the greatest burdens on the student in such an environment is the senior level design course. In the Naval Architecture and Marine Engineering major at the Coast Guard Academy, the senior design courses are much more than an academic exercise. Course objectives are carefully developed and frequently reviewed to ensure that precious lab and class time is used most effectively. Students at this level are considered to have gained the maturity and self-discipline necessary to complete independent design work.

The N. A. M. E. major is geared to the study of sound engineering fundamentals and their applications to surface ships. It is much like many undergraduate mechanical engineering curricula with the exception of two "capstone" design courses.

FALL SEMESTER	SPRING SEMESTER
FOURTH CLASS YEAR (FRESHMAN YEAR)	
English Comp. and Speech	Intro. To Engineering Design
Calculus I	Human Behavior
Chemistry I	Intro. To Lit.
Nautical Science I	Calculus II
Foundations of Comp. Science	Chemistry II
Physical Education	Physical Education
THIRD CLASS YEAR (SOPHOMORE YEAR)	
Statics/Strength of Materials	Matl. Science For Engineers
Multivariable Calculus	Dynamics
Physics I	History of the U. S.
Nautical Science II	Differential Equations
Social Science Elective	Physics II
Physical Education	Physical Education
SECOND CLASS YEAR (JUNIOR YEAR)	
Electrical Engineering I	Electromechanics
Fluid Mechanics	Principles of Naval Arch.
Thermodynamics	Shipboard Energy Systems
Probability and Statistics	Engineering Experimentation and Analysis
Nautical Science III	American Government
Physical Education	Physical Education
FIRST CLASS YEAR (SENIOR YEAR)	
Principles of Ship Design	Ship Design/System Integration
Ship Propulsion Design	Maritime Law Enforcement
Legal Systems	Nautical Science IV
Oceanography	Economics
Major Area Elective	Free Elective
Physical Education	Physical Education

Major Area Electives

Heat Transfer
Mechanical Vibrations
Mech. Auto Controls
Directed Studies in N.A.M.E.

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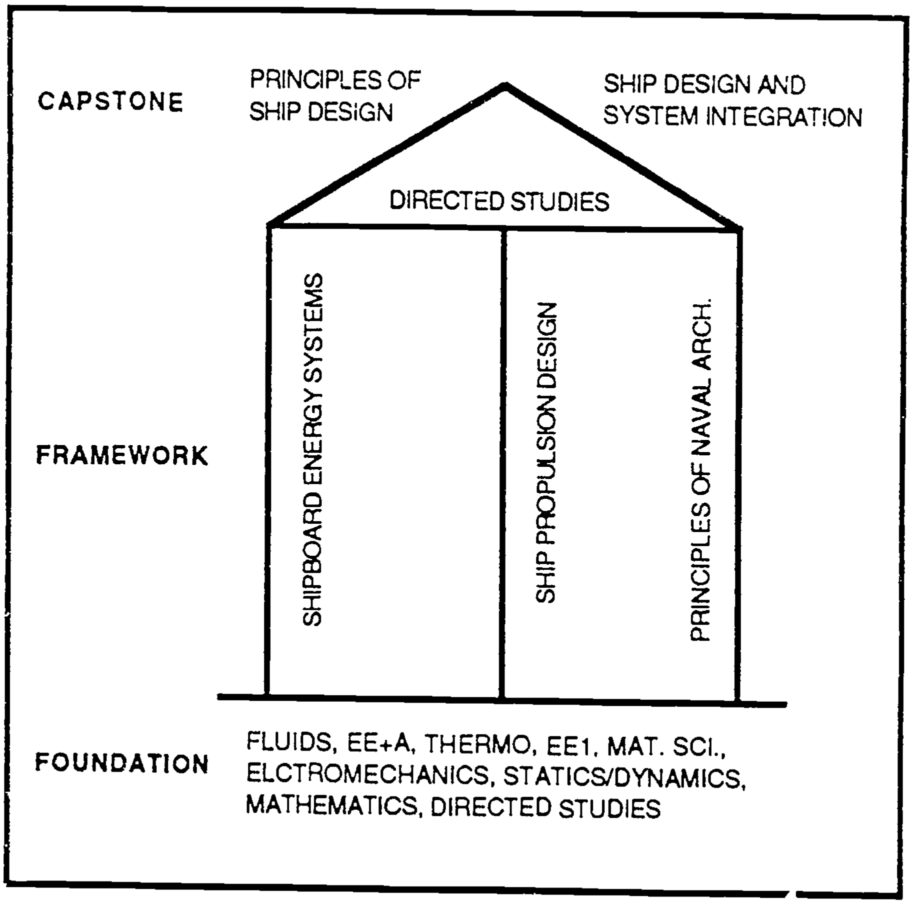
The overriding philosophy in the major is that design may only be accomplished after rigorous treatment of the fundamentals and adequate exposure to more specialized theory and practice. The illustration below reflects this philosophy.



Principles of Naval Architecture (PNA) is the fundamental "ship theory" course. It exposes the students to the basic fundamentals of marine hull geometry, nomenclature, hydrostatic properties and stability. It also covers the internal subdivision of surface ships as well as the fundamentals of vessel powering and resistance. This course is extremely time-intensive primarily due to a highly demanding, "hands-on" laboratory syllabus. Labs in this course such as ship's lines drawings, numerical integration of ship's form to obtain hydrostatics, intact and damage stability calculations, etc. are all done by hand with limited assistance from personal computers.

Shipboard Energy Systems (SES) and Ship Propulsion Design (SPD) are major course requirements which emphasize the principles learned in thermodynamics and introduce the concepts necessary for the design of several internal mechanical systems. These two courses are instrumental in providing the background necessary to complete a ship propulsion plant design complete with prime mover, propellor, shafting, reduction gear, piping, HVAC, electrical and auxiliary systems (course descriptions in appendix I).

Together, these three "framework" courses provide the subject area exposure which is necessary for the completion of the year-long design project to be carried out in the two capstone design courses (Principles of Ship Design and Ship Design and Systems Integration). This project is the culmination of the student's experience in the N.A.M.E. major and is the primary focus of this paper.

THE DESIGN PROJECT:

Desired Outcomes:

As with any major project, it is essential that continuous self-evaluation be carried out. It is advantageous to frequently review the "desired outcomes" of the project both from the instructor and the student perspective. The following is a list compiled from instructor notes and student critiques.

The desired outcomes of the ship design project in the N.A.M.E. major are as follows: (in no particular order)

1. To expose students to a set of owners requirements and apply sound engineering principles to meet those requirements.
2. To expose students to a "design team" environment and present *what* deliverables are required with lenient restrictions upon *when*. This concept forces the team to hone their own management skills and promote group communication on design issues. This also develops a sound group design "philosophy."
3. To break down the barriers of "you teach me" and open doors to encourage outside class research of new and innovative ideas. Develop a sense of resourcefulness.
4. To develop technical writing and speaking skills to a level of competent "briefers."
5. To develop a sense of utility, rather than reliability on the use of personal computers and applicable software.
6. To learn how to get the job done by managing and evaluating own progress. Develop a sense of pride in group work.
7. Develop a cadet interface with industry and CG professionals through guest lectures, class trips, society activities SNAME, etc..
8. Prepare cadets to compete at the graduate level in any N.A.M.E. or mechanical engineering curriculum.
9. To pass the EIT exam

Capstone Courses:

Fall Semester:

The senior level design course in the fall semester is called Principles of Ship Design (PSD). This course consists of three 50 minute lecture meetings and one 2 hr and 40 minute lab each week. It is in this course that a comprehensive Sponsor's Requirement Document (SRD: See appendix IV) is presented to the cadets which introduces the year long project. The SRD must be developed by the instructor before the start of classes. Also, a research topic list and preliminary list of references must accompany the SRD class handout. The classroom is immediately broken down into teams consisting of 3-5 cadets (at their discretion) who will act as team members for an entire year. The management of each team is left up to the cadets and the instructor takes on the title as "Project Manager".

The purpose of PSD is to introduce the ship design process and incorporate previous "framework" course information into an organized portfolio. PSD also introduces basic design techniques for determining vessel preliminary dimensions and form coefficients. A significant amount of time (10-12 lectures) is devoted to ship structures and vessel materials. Additionally, rules and regulations governing ship design, construction and performance are introduced early on in the semester. It is imperative that the "Project Manager" be fully aware of the content, or have previously taught the three "framework" courses (PNA, SES, and SPD).

Grading the course is based primarily upon design work of the group and is broken down as follows;

Notebook/Homework	10%
Exams (2)	25%
Research Presentation	10%
Design Submittals	55%

(entire course syllabus is included as Appendix II)

The notebook is an individual responsibility and is collected both at mid-term and at the end of the semester. This portion of the grade is also combined with a limited number of comprehensive homework assignments (4-5). Homework assignments are assigned in conjunction with material being presented in class. The notebook is examined for completeness, neatness, and organization and reflects classroom lecture notes as well as notes obtained from references which parallel notes presented in class.

Exams in the course represent 25% of the overall course grade. Exams are administered either in class or are of the take home variety. All exams are individual work of students. The students make a collective decision on when exams will be held so as to minimize conflict with design team schedules and planning. The "Project Manager" has the final say in when exams will be administered.

The research presentation represents 10% of the overall course grade and has a very specific purpose. The Project Manager must ensure that adequate information concerning the specific type of vessel being designed (in excess of the normal course lecture sequence) is presented to the entire class such that educated design decisions can be made on the specific type of ship at hand. The Project Manager develops a list of research topics (before the fall semester starts) and assigns one to each student at the beginning of the fall semester. The research topics are carefully chosen based on the task at hand. For example, if the SRD was developed for the design of an icebreaker, topics may include such items as:

Icebreaker Bow Configurations
Icebreaker Stability Requirements
Ice Cover at North and South Poles
Scientific Lab Storage Requirements Aboard Icebreakers
Icebreaker Hull Coatings
etc.

Students are also allowed to develop their own topics at the discretion of the Project Manager. Research of these topics is entirely an individual effort and is accompanied by a formal report/handout and oral presentation to be completed within one month of assignment. It is stressed to the cadets that the "quality" of their research sets the tone for the entire project for all design teams, and that the thoroughness of their work represents a collective data base from which all students draw information.

Finally, the group design submittals represent 55% of the course grade. There are 21 design submittals for each group in the PSD course. Each submittal is assigned a "degree of difficulty" from 1 to 8 based on the amount of outside research required, and significance of the submittal to the project as a whole. Deliverables for each submittal include: a title page which indicates the principal author(s) of the submittal and a paragraph which summarizes author participation accompanied by signatures of group members, a design summary write-up, supporting calculations, and graphical supporting data in the form of plots and drawings. Additionally, the write-up should include any conclusions, recommendations or compromises in accordance with the group's design philosophy. A list of the submittals required in the PSD course, along with weighting factors is given below:

1.	Designated Task Statement	1
2.	Similar Ships/Parent Hulls	2
3.	Principle Dimensions/ Coefficients of Form	2
4.	Rough Body Plan/Sectional Area Curve	4
5.	Final Lines	2
6.	Profile Sketch	2
7.	Creation of Offsets File/ Cross Curves of Stability	3
8.	Hydrostatics	2
9.	Floodable Length	1
10.	Horsepower Estimate	3
11.	General arrangements	[illegible]

12.	Propeller/Rudder Design and Selection	4
13.	First Weight Estimate/Center of Gravity Determination	8
14.	Tank Capacity Calculations	4
15.	Second Weight Estimate/Center of Gravity Determination	4
16.	Loading Condition Calculations and Summary	3
17.	Intact Stability	4
18.	Damaged Stability	8
19.	Longitudinal Strength	5
20.	Midship Section Design	4
21.	Model Ship Preparation	2

Each group must schedule personnel allocations for each submittal as well as due dates. The Project Manager checks for equality of workload and reasonableness of due dates. Frequent meetings are held during laboratory periods or at the design team's request to monitor progress. A "critical path" to semester's end must be identified early on and provided to the Project Manager. Each group's schedule will frequently change throughout the semester, but changes may only occur after consultation with the Project Manager. A list of design submittal specifications is handed out as part of the syllabus to the course (included in Appendix II). Submittal specifications are updated every year to reflect specific changes required by the type of vessel being designed. In revising these submittal specifications, the Project Manager must ensure that the educational content of the exercise does not become overshadowed by the specific requirements of the vessel being designed. Academic completeness must be maintained such that the desired outcomes of the course are effectively addressed.

Completion of the required work in the fall semester can only be accomplished by an organized and informed team effort. Cadets learn what it is like to depend on others for valuable pieces of design information which maintain continuity between submittals. They also learn the value of effective communication in the organization of off-hours design effort to avoid unnecessary gaps or duplication of effort. All lectures in the PSD syllabus are scheduled to occupy a 1/2 hour time block such that pace of the course can be more easily adjusted to keep in step with design progress. All laboratory time, with the exception of the first three meetings (which are spent on software familiarization), is used exclusively for design work and group meetings with the Project Manager.

Spring Semester:

The spring semester course, Ship Design and System Integration (SD+SI syllabus in Appendix III) is handled much the same way as the Principles of Ship Design course, however there are only two 50 minute class meetings per week, supplemented by two 2 hr and 40 minute lab meetings per week. There are fewer planned lectures in the spring such that lab work and design project time can be maximized. By the spring semester, most design groups have found a reasonable "standard operating procedure" by which their work is being accomplished. Below is a list of topics specifically covered by classroom lecture:

Model Testing
Power Plant Tradeoff/Analysis
HVAC Preliminary Design
Electrical Loading and Distribution
Vital Piping Systems
Damaged Stability/Symmetric and Asymmetric
Cost Analysis
Top Level requirements
Final Oral Presentation

As with PSD, the SD+SI course emphasizes design submittals as the major portion of the course grade. There are 20 submittals required in the spring semester, many of which are repeats or refinements of those already completed in the fall. Submittal specifications are significantly more detailed than those in PSD. Rather than include the entire collection of SD+SI submittal specifications, one is shown below.

Ship Design & System Integration
Design Project

Guidance for Model Test Report:
Weighting Factor: 4
Responsible Person(s): ______________________

I. Refs: a) The Fundamentals of Ship Model Testing, Dr. F.H. Todd, SNAME Transactions 1951, pp.850-887
b) On Ship Model Resistance Measurement Errors, J.R. Scott

II. General Procedure:

1. This submittal covers all aspects of the model building, instrumentation, testing and evaluation phases of SD/SI. Each phase of work should be broken down into the following components.
   a) Model Preparatory Work
   b) Instrumentation
   c) Testing Procedures
   d) Results
2. A detailed, yet concise description of all component parts for each phase should be generated. Special attention should be placed on sources of error and recommended areas for improvement in each phase of the program.

III. Specific Procedure:

1. Model Building Phase
   a) Provide the body plan used to digitize your vessel's lines into the automated model cutter along with any station plots provided by the HP 9816.
   b) Provide a model characteristics summary sheet detailing length, draft, depth, width, weight, location and size of cutout for force block connection plate, location and size of each weight

hole and the corresponding model weight in each, scale factor, etc. (Drawings and/or plots may be used to clarify)

c) Discuss the "closeness" of your scaled model to your full size ship.

2. Model Testing Instrumentation and Computer Use

a Provide a basic sketch of the model testing instrumentation and dynamometer.

b) Provide a copy of all calibration data and discuss the calibration procedure.

3. Model Testing

a Provide all computer output from all model test runs and a summary of the testing procedure followed.

4. Results of Testing

a Provide the following:

1) Plot of test EHP and predicted EHP vs. ship speed and Froude number

2. Model Resistance Summary Sheet

3. Ship Resistance Summary Sheet

4) Pronaska Plot

5) Basic sketch of max speed wave profile

b) Discuss in detail your EHP results, comparing and contrasting your predicted and test results. Centralize on the issue of validity and determine which curve or combination of curves should be used and why.

c) Provide a detailed error discussion and a list of recommendations for future testing.

IV. Deliverables:

1. Brief design history which links any previous submittals to this one.
2. All items outlined in the General and Specific Procedure portions of this guidance sheet.
3. Any additional calculations, plots, graphs, or pictures, which supplement your discussion.

A breakdown of the course grade in the SD+SI course is given below:

Notebook/homework	10%
Exams (2)	20%
Design Submittals	60%
Final Design Presentation	10%

The culmination of the project is marked by the Final Design Presentation and the Top Level Requirements submittal. The final design presentation represents 10% of the individual's course grade. Each design group is given a period of 40 minutes, with a 10 minute question and answer period at conclusion. All group members must participate. A panel of evaluators is made up of faculty/staff members, CGA's Engineering Department Head, the N.A.M.E. Section Chief, Coast Guard Headquarters design representatives, and other invited guests. It is not uncommon to have an audience of 60 people, 10 of which act as evaluators. Cadets are encouraged to use a variety of visual aids including video, vu-graph, demonstrations, computer generated text/images, etc..

The Top Level Requirements submittal is a conglomeration of all submittals from the start of the project in the fall semester to the end of the academic year. It is a refinement of all design submittal summaries, calculations and graphics, and includes an overall team evaluation of how well the SRD was satisfied. It is assigned a weighting factor of 8. It addresses problems that were encountered during the year and suggestions for enhancement of the design as well as the design process. A limit of two 3 inch triple ring binders is imposed on this submittal. A complete portfolio of full size ("E" size) prints accompanies this submittal. These prints include ship's lines, outboard profile, plan views of general arrangements, watertight subdivision, piping systems, electrical distribution, and a detailed power plant layout including designated auxiliary systems.

As with PSD, a notebook is collected for a grade and two exams are administered during the semester.

RESOURCES:

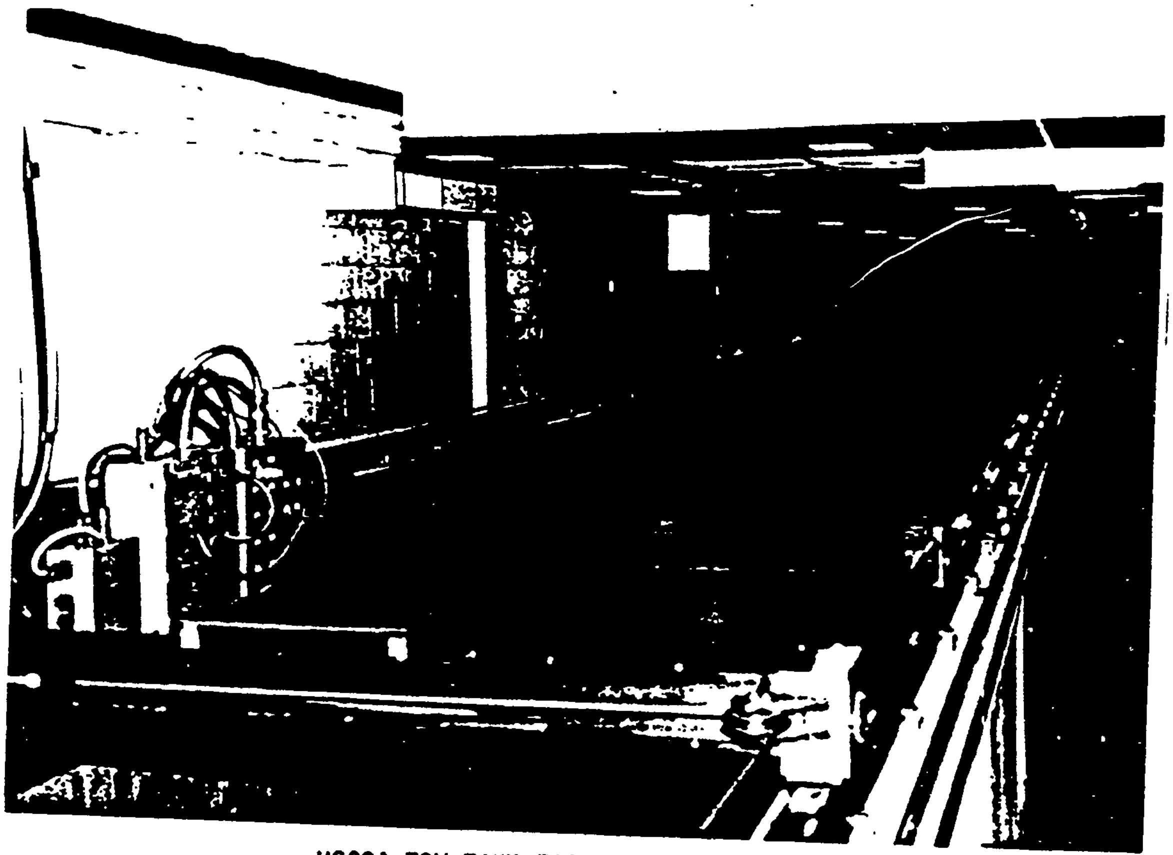
A comprehensive design project cannot be carried out without adequate resources being made available to the students in the form of personnel, hardware, software and written reference materials.

Hardware:

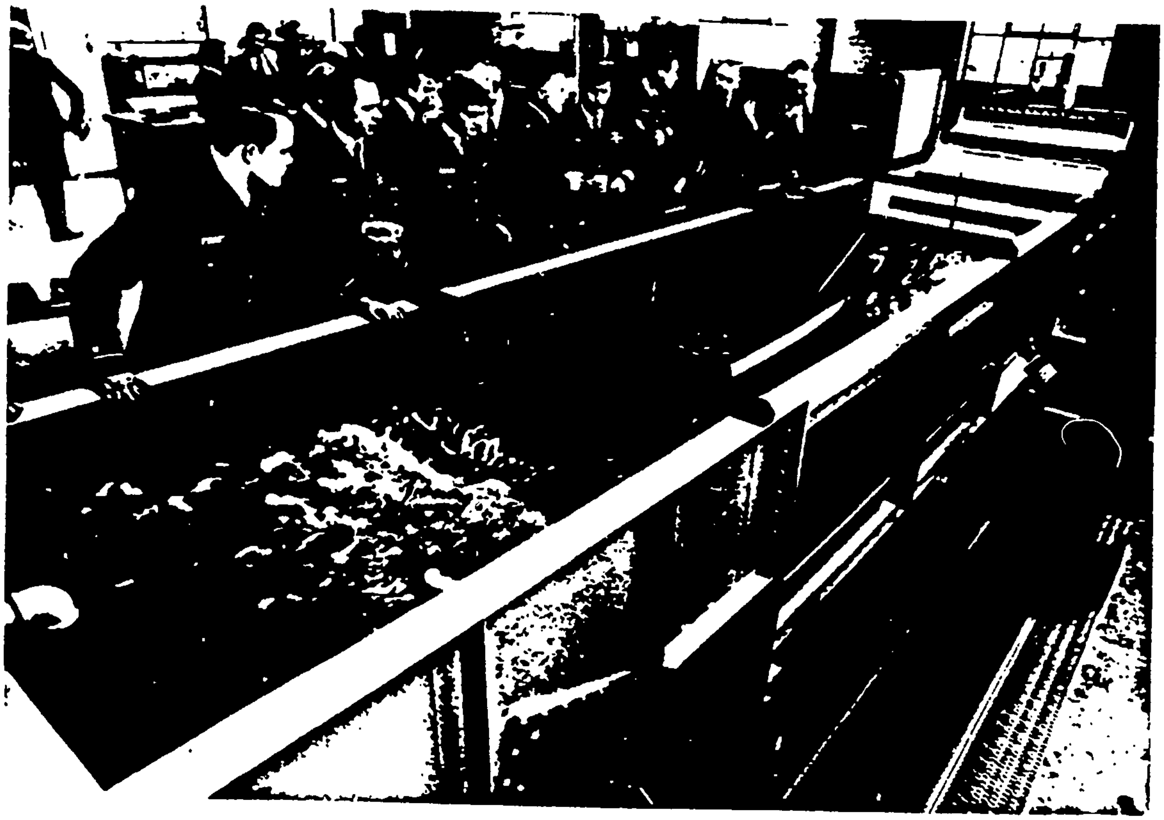
The Coast Guard Academy has a 130 ft long, 10 ft wide, 6 ft deep tow tank used for scaled model testing of vessel designs. The tank is equipped with a plunging wedge wave maker and a computer controlled data acquisition system. The setup has the capability to receive and process three channels of data (drag, pitch and heave) simultaneously. The primary purpose of the tank is to obtain horsepower predictions and a limited assessment of ship scaled motions. LABVIEW (National Instruments) data acquisition software is used in conjunction with a MAC II computer to acquire data signals and produce horsepower vs. speed curves as well as a Prohaska Plot.

The use of the tow tank is valid only if an "adequate" geosim of the proposed design can be fabricated. A "home made" numerically controlled device affectionately known as "Robbie the Robot" is used to assist the design teams in this process. "Robbie" consists of a flat table which is allowed to move longitudinally with the use of a stepper motor and threaded rod. Above the flat table is a two-axis stepper motor/threaded rod setup with a router bit on a vertical shaft. This allows vertical and transverse movement of the bit relative to the block of foam which is to be cut. The directional control is governed by an HP Basic program which directs the router bit to cut out designated stations on the model. Fairing between stations is carried out by the students. After completion of the station cuts and fairing process, multiple coats of fiberglass and resin are applied to the models.

For smaller models, or testing which requires more extensive instrumentation, CGA's circulating water channel may be used. The channel consists of a large (10,000 gallon



USCGA TOW TANK FACILITY



USCGA CIRCULATING WATER CHANNEL
(PHOTOS COURTESY OF CGA N.A.M.E. SECTION FILES)

rectangular shaped tunnel with a stationary test section (8 ft long, 4 ft wide, 3 ft deep). This setup is especially handy for flow visualization and the installation of a variety of different "stinger" arrangements.

Two full-time lab technicians assist in the maintenance and operation of these items as well as provide students with instruction and assistance in the model building process.

Student design work is conducted in the CADD laboratory which consists of 12 networked Mac II computers (approximately 1 machine for every two students), two "B" size HP plotters, one "E" size HP plotter, one HP colorjet printer, a laserwriter and several dot-matrix printers. Also, there is a PC clone for running peripheral software and an HP digitizing setup for model cutting.

Software:

The Navy standard Ship Hull Characteristics Program (SHCP) which evaluates vessel hydrostatics, stability, and strength is available on all MAC II computer workstations. The program was adapted using MPW FORTRAN by LCDR Bruce Mustain of CGA's N.A.M.E. staff. The use of this program for design purposes is only introduced after extensive work "by hand" in the Principles of Naval Architecture course.

Vessel lines are generated using MACSURF which is a "user friendly", interactive 3-D surface modeling program. Additionally, MACSURF allows on screen splining of curves and continuous screen updates of all three orthographic projections as well as isometric views of the vessel. Vessel station offsets are taken from MACSURF and hydrostatics verified with SHCP. Other standard CADD, plotting, and word processing software is available for use in generating design submittals. There are also several "presentation" software packages to be used in Project Manager meetings and final presentations.

PC-based software (for use on only one machine) is available for horsepower estimating, propellor/engine selection and ship motions analysis.

Written Materials:

The N.A.M.E. section has collected a tremendous amount of material, to supplement CGA's main library, for use in the senior design project. In fact, adjacent to the CADD lab is an entire room dedicated to books and technical reports (approximately 5000) relating to the design of offshore structures and marine vehicles. Students are required to "dig out" references cited in design submittal specifications as well as research topics for fall semester presentations.

Textbooks for the year long course are chosen at the option of the students in their junior year in the major. A list of the "highly encouraged" ones is given below.

Principles of Naval Architecture (Vols I,II,III)
Lewis, SNAME, 1988
Ship Design and Construction
Taggart, 1980
Marine Engineering
Harrington, 1971
Basic Ship Theory (Vols I,II)
Rawson and Tupper, 1983
Modern Ship Design
Gillmer, 1977

Once again, these books are optional (due to their expense) and made available to the students in the CADD lab reference library. Most students buy them for convenience as well as their own professional libraries.

PROFESSIONAL ACTIVITY:

In addition to written materials, it is also common to invite guest speakers from the design community into the classroom or lab to supplement course work with discussion and handouts. This forum is also used for career counseling by Coast Guard junior and senior officers in "the field." Additionally, professional society activity (SNAME) is highly encouraged. CGA maintains active student section participation in local SNAME and ASNE functions as well as the SNAME Annual Meeting and International Maritime Exposition.

STUDENT EVALUATIONS:

Students are asked to complete free-form course evaluations at mid term and at the end of the semester in each of the capstone courses. Evaluations typically cite the autonomous work environment as a new and rewarding experience (keeping in mind that CGA is a military academy). Also, students typically praise their own advancements in their ability to think independently and to manage their own time in such a "worthwhile" project.

Students who interact well and have a strong work ethic tend to rise to the top and actually dictate policy within their own design teams regardless of their GPA. The quieter, less aggressive students are usually perfectly willing to accept the role as "supervisees." Nevertheless, each design team learns that diversity of makeup is a double-edged sword, and compromises must be made in order to garner group progress.

INSTRUCTOR DEMANDS:

The course instructor for the design sequence must possess the energy and vitality to carry out the required work necessary to educate, manage, counsel, and evaluate the performance of the students. For this design sequence, it is preferable to have two instructors (class size is about 20-25), especially in the laboratory environment, even if one is just a trainee or helper.

The instructor must be willing to maintain constant communication with each of the design groups including calls at home, and weekend trips to the lab to assist students with academic, design, or equipment problems. Additionally he/she must be willing to evaluate design team submittals promptly and thoroughly to ensure continuity in the process. The instructor must act as consultant and advisor from both an academic and professional standpoint. This requires being "in touch" with the outside design community and involvement in professional activity both in the Coast Guard and the civilian sector.

Finally, the instructor must understand fully the demands which are being placed upon the students and carry out frequent "gut checks", with outsider input, to assess the project's effectiveness in achieving the desired outcomes.

ASSESSMENT:

The faculty and staff of the N.A.M.E. section at CGA feel strongly that the design sequence in the major is an effective vehicle by which students are able to achieve the aforementioned desired outcomes. It is enjoyable and satisfying to watch students as they work toward, and eventually achieve, the completion of such an arduous task.

REFERENCES:

[1]U. S. Coast Guard Academy 1991-92 Catalogue of Courses

I would like to acknowledge the work of those instructors who have taught this design sequence before me. I especially acknowledge the work of LCDR Bruce Mustain who has done extensive work with software, hardware and design specifications in both the PSD and SD+SI courses.

APPENDIX I

Course Descriptions:

Principles of Naval Architecture:

An introduction to the fundamental principles of Naval Architecture. Basic ship geometry and nomenclature, hydrostatics and hydrodynamics of floating bodies, vessel stability and subdivision, and an investigation into resistance of marine vehicles.

Shipboard Energy Systems:

Principles of steam turbine, gas turbine, and diesel engine prime movers and their operating characteristics. Principles of thermodynamic power cycles, including variations from the simple cycles. Basic heat transfer with emphasis on heat exchanger analysis. Principles of HVAC.

Ship Propulsion Design:

Application of sound judgment to engineering decisions in the design of optimal mechanical systems that meet specific operating specifications. Principles, characteristics and selection processes for the fixed and controllable pitch screw propeller. Principles of matching propeller characteristics to prime mover characteristics. Power transmission systems. Vibration considerations within the marine propulsion plant. Completion of a preliminary design of a marine propulsion system.

(COURSE DESCRIPTIONS ARE EXCERPTS FROM THE U. S. COAST GUARD ACADEMY'S 1991-1992 CATALOGUE OF COURSES)

APPENDIX II

UNITED STATES COAST GUARD ACADEMY
Department of Engineering

Principles of Ship Design
Fall 1991

This is the second course in a three course ship design sequence. The first course (PNA) introduced the basic principles of naval architecture. This course will lay the foundation required to enable the student to complete a 2 semester independent ship design. Some of the basic principles learned in PNA will be reviewed but the bulk of the course will be dedicated to the information necessary to complete the ship design process. A considerable amount of time will be devoted to ship structures including longitudinal strength and midship section design. Other areas include; general arrangements, design lanes, model testing, ABS Rules, and various other topics included in lab submittals.

Instructor: LT Kurt J. Colella room M125 (ext 8535)

Textbooks:
1) Ship Design and Construction
2) Basic Ship theory
3) Principles of Naval Architecture
4) Marine Engineering

References:
a) ABS Rules
b) Modern Ship Design
c) Jane's Fighting Ships
d) Various Handouts
e) N.A.M.E. Library

Grading: Grading will be based on performance in several different areas which include:

1)	Notebook/Homework	10%
2)	Exams (2)	25%
3)	Design Submittals	55%
4)	Research Presentation	10%

The grade for design submittals will be assigned primarily on individual effort put forth by team members in each submittal (80%). A group submittal average will be determined from the entire set of lab assignments for each group. This group average will make up the remaining 20% of each group member's laboratory grade.

There will be no final exam in this class.

Educational Objectives:

The student should be able to recall and comprehend information presented in the following subject areas:

1) Basic design principles
2) Determination of preliminary dimensions
    a) Math models
    b) Similar ships
3) Hydrostatic curves of form
4) Intact and damaged stability
5) Floodable length
6) EHP determination/NAVCAD
7) General Arrangements
8) Ship structures
    a) Beam analysis
    b) longitudinal strength
    c) midship section design
    d) interaction of superstructure and hull
    e) ABS rules
9) Simple vessel motion
10) Model Testing

Software used in this course will include:

Microsoft WORD
Microsoft EXCEL
MACSURF
AUTOCAD
CRICKET GRAPH
Ship Hull Characteristics Program (SHCP)
NAVCAD
MOSES (PC-BASED)

Policies:

1) I will be available for extra instruction when not involved in teaching another class. Feel free to drop by at any time but give me a call first if you want to make sure that I'm around.

2) The housekeeping in the lab is your responsibility. I will allow you to drink sodas in the lab only if you do not drink them while sitting at a computer keyboard and if you place all cans in an appropriate recyclable receptacle in the back of the classroom.

3) A keyholder for the lab will be assigned to a member of the class. The key will be signed out in the barracks through that person or the CCDO. The after hours uniform in the lab is also your responsibility. If you want to wear any uniform other than the uniform of the day, you must submit a

memo to the Asst. Commandant of Cadets via me requesting approval.

Policies for Design Group Submittals:

1) All submittals will be submitted in report form and contain an adequate explanation, in text form of the contents of the submittal and the members of the group who participated in that submittal.

2) Submittals can be resubmitted for re-evaluation for a limited amount of additional credit. NOTE: Many submittals may be required to be re-submitted in order to continue with the design.

3) Submittals are required to be turned in prior to, or on, the deadline dates established by the design team with approval of the instructor.

4) LAB TIME IS PRECIOUS, don't waste it!. Do not wait until the night before to try and accomplish four or five days worth of work.

DATE	DAY	TOPIC	REFERENCES
21-Aug	W	PSD INTRO. CLASS/LAB ORGANIZATION	
23-Aug	F	SHIP DESIGN INTRODUCTION	SDC 1-13
26-Aug	M	DESIGN REQUIREMENTS, CONTROLS, RESOURCES	SDC 45-46,SDC 13-24,BST CHAP 15
28-Aug	W	DESIGN REQUIREMENTS, CONTROLS, RESOURCES	
30-Aug	F	DESIGN LANES, FIGURES OF MERIT, SELECTION OF DESIGN VARIABLES	BST CHAP 14,SDC 24-40
4-Sep	W	DESIGN LANES, FIGURES OF MERIT, SELECTION OF DESIGN VARIABLES	
6-Sep	F	DESIGN MODELING	G 257-269
9-Sep	M	INFLUENCE OF FORM ON VESSEL DESIGN	HANDOUT
11-Sep	W	INFLUENCE OF FORM/LENGTH ON VESSEL DESIGN	BST 460-465,514-515
13-Sep	F	MISSION IMPACT ON VESSEL DESIGN	SDC 51-102 (SKIM)
16-Sep	M	INFLUENCE OF DRAFT, DEPTH, FREEBOARD ON VESSEL DESIGN	
18-Sep	W	SHIP'S LINES INTRODUCTION	PNAI 1-16
20-Sep	F	RELATION OF HULL FORM TO RESISTANCE	PNAII 66-78
23-Sep	M	SHIP'S LINES BOW	PNAII 79-88
25-Sep	W	SHIP'S LINES STERN	
27-Sep	F	PRINCIPLES OF PLANING CRAFT	
30-Sep	M	GENERAL ARRANGEMENTS- CONCEPTUAL/PRELIMINARY DESIGN	PNAII 99-105
2-Oct	W	GENERAL ARRANGEMENTS- PRELIMINARY DESIGN METHODS	SDC 105-134
4-Oct	F	GENERAL ARRANGEMENTS- MACHINERY SPACES	SDC 134-172
7-Oct	M	REVIEW OF STRENGTH OF MATERIALS	
9-Oct	W	EXAM #1	
11-Oct	F	FORCES AND STRESSES ON SHIPS	G 205-216
16-Oct	W	STILL WATER LONGITUDINAL STRENGTH	PNAI 208-212, BST 174-177
18-Oct	F	WEIGHT AND BUOYANCY CURVES	
21-Oct	M	SHEAR AND BENDING MOMENT DIAGRAMS FOR SHIPS	
23-Oct	W	LONGITUIDINAL STRENGTH WAVE CONDIITONS	PNAI 212-221, BST 177-182
25-Oct	F	HULL LONGITUDINAL STRESS AND MIDSHIP SECTION MODULUS	BST 185-191,PNAI 233-242
28-Oct	M	HULL LONGITUDINAL STRESS AND MIDSHIP SECTION MODULUS	
30-Oct	W	DEFLECTION OF SHIPS	PNA1 233-237, SDC 257-258
1-Nov	F	SHEAR STRESS/SHEAR FLOW	
4-Nov	M	SHEAR STRESS/SHEAR FLOW	PNAI 242-246,SDC 247-249, BST 190-191,199
6-Nov	W	SUPERSTRUCTURE/DECKHOUSE EFFECTS ON LONGITUDINAL STRENGTH	
8-Nov	F	STRUCTURAL ANALYSIS	BST 223-224, SDC 249-252,319-322,PNAI 266-271
13-Nov	W	MIDSHIP DESIGN	
15-Nov	F	MIDSHIP DESIGN	
18-Nov	M	MIDSHIP DESIGN	
20-Nov	W	HULL MATERIALS	
22-Nov	F	ABS/SOCIETY RULES	HANDOUT
25-Nov	M	VIBRATION OF SHIPS	SDC 207-212,230-238,259-267
27-Nov	W	EXAM #2	SDC 29, BST 349-360
2-Dec	M	MODEL PREP	
4-Dec	W	MODEL PREP	
6-Dec	F	MODEL PREP	
9-Dec	M	TEST #3	
11-Dec	W	LAST DAY - CRITIQUES	

APPENDIX III

UNITED STATES COAST GUARD ACADEMY
Department of Engineering

SHIP DESIGN AND SYSTEM INTEGRATION
SPRING 1992

This is the final course in a three course ship design sequence. The first course (PNA) introduced the basic principles of naval architecture. The second course, PSD introduced the actual ship design process and devoted a large amount of time to ship structures including longitudinal strength and midship section design. Other areas in PSD included; general arrangements,design lanes, model testing, ABS Rules, and various other topics included in lab submittals. In SD+SI we will continue to work with the design process and introduce several new topics to refine our actual vessel designs.

Instructor: LT Kurt J. Colella room M125 (ext 8535)

Textbooks:
1) Ship Design and Construction
2) Basic Ship theory
3) Principles of Naval Architecture
4) Marine Engineering

References:
a) ABS Rules
b) Modern Ship Design
c) Jane's Fighting Ships
d) Various Handouts
e) N.A.M.E. Library

Grading: Grading will be based on performance in several different areas which include:

1)	Notebook/Homework	10%
2)	Exams (2)	20%
3)	Design Submittals	60%
4)	Final Design Presentation	10%

The grade for design submittals will be assigned primarily on individual effort put forth by team members in each submittal (80%). A group submittal average will be determined from the entire set of lab assignments for each group. This group average will make up the remaining 20% of each group member's laboratory grade.

There will be no final exam in this class.

Submittals:

ALL PSD SUBMITTALS MUST BE COMPLETE PRIOR TO WORKING ON THIS LIST OF SUBMITTALS

1. Model Testing*
2. Power Plant Tradeoff*
3. Reduction Gear Design
4. Shafting Design
5. HVAC Requirements*
6. Electric Plant Requirements*
7. Power Plant Details
8. Stern Configuration
9. t and w Calculation
10. Propellor
11. Tankage (final)
12. General Arrangements (final)
13. Piping Design*
14. Final Weight Estimate
15. Hydrostatics (final)
16. Cross Curves (final)
17. Intact Stability (final)
18. Damaged Stability (final)*
19. Cost Analysis*
20. Top Level Requirements
21. Final Presentation*

A detailed description of the requirements for each of these submittals is contained in the SD+SI submittal specification handout.

* Denotes class lectures devoted to these topics

Policies:

As in PSD, the cleanliness and security of the lab is up to you. Any problems will result in changes being made in the way we do business.

Policies for Design Group Submittals:

1) All submittals will be submitted in report form and contain an adequate explanation, in text form, of the contents of the submittal and the members of the group who participated in that submittal.

2) I plan to "ride herd" much closer this semester on the due dates for submittals! If you would like me to lay out a schedule for you, I will be glad to do so.

SIGNIFICANT DATES/TIME FRAMES

TOPIC	DATES
MODEL TESTING	13-24 JANUARY
POWER PLANT TRADEOFF	27 JAN-14 FEB
HVAC REQUIREMENTS	18 FEB-6 MAR
COST ANALYSIS	16-27 MARCH
ELECTRICAL PLANT	30 MAR-3 APR
PIPING	5-17 APRIL
DAMAGED STABILITY	20-24 APRIL
PRESENTATIONS	22-29 APRIL

AFTER 24 APRIL, ALL WORK WILL BE SOLELY DEVOTED TO THE DESIGN PRESENTATION. NO MORE WORK WILL BE DONE ON THE PROJECT ITSELF

APPENDIX IV

SPONSOR'S REQUIREMENT DOCUMENT
MEDIUM ENDURANCE CUTTER REPLACEMENT PROGRAM

FALL 91 - SPRING 92

PRINCIPLES OF SHIP DESIGN
SHIP DESIGN AND SYSTEM INTEGRATION

I. INTRODUCTION

A) Purpose This document is the Sponsor's Requirement Document for a new medium Endurance Cutter (MEC). Its purpose is to provide possible contract .. with the required operational capabilities for the MEC to meet mission needs.

.B Organization: The Sponsor's Requirement Document (SRD) consists of three related sections which are:

(1) Introduction: This section describes the SRD. Its purpose is to describe the arrangement, use and maintenance of the document.

(2) Mission Requirements: This section describes the capabilities the cutter must possess to satisfy mission needs. Information herein provides ship designers with guidance for hull, propulsion, and combat system studies.

(3) Improvements: This section directs specific improvements deemed necessary on a variety of systems aboard present MEC's in service. Where a replacement is not yet determined, the requirement will be described in general terms.

(C) Usage: The SRD describes the requirements which the Sponsor has determined that the new MEC must possess in order to satisfy mission needs (i.e. to be a feasible option). The program manager, LT Colella must be informed whenever these requirements cannot be met.

II. MISSION REQUIREMENTS:

(A) Concept of Operations: The new MEC will be assigned missions in Enforcement of Laws and Treaties (ELT), Search and Rescue (SAR), Marine Environmental Protection (MEP), and Military preparedness (MP). Unresolved at this time is the extent to which the Coast Guard will retain or modernize armament capability.

(1) Specific Employment: It is anticipated that this vessel will remain in commission for 30 years. Some 75% of the MEC's peacetime employment will consist of ELT missions, serving as a surveillance and boarding platform. SAR, MEP, and MP are ancillary missions. MP missions are in effect and an extension of the peacetime employment, including coastal surveillance, combat SAR, special operations and Non-Combat Operations (NCO). No significant changes in combat capability are required, however the 3" 50 must be replaced by a U.S. Navy provided weapon.

(2) Mission Description:

(a) Enforcement of Laws and Treaties (ELT): The vessel must be capable of the Enforcement of Laws and Treaties through its deterrent presence on patrol or in conjunction with other missions; its ability to intercept suspect vessels, its ability to conduct boardings and make seizures, or its ability to escort or tow seized vessels to appropriate custody areas.

(i) Enforcement of fisheries regulations at sea through the use of its deterrent presence and boarding parties.

(ii) Deter smuggling operations. Deterrence of smuggling operations requires adequate time on station in OPAREA, thorough onboard inspection of suspect vessels for contraband, and a rate of seizure necessary to make smuggling economically unattractive.

The MEC must support WPBs when deployed away from home ports as operational squadrons.

(b) Search and Rescue (SAR): Provide the capability to search for, locate, rescue and recover vessels or personnel in distress. Rescue requires the ability to tow, dewater and extinguish fires aboard vessels in particular, vessels too large for, or located beyond, the range of patrol boats.

(c) Defense Operations: Provide the capability to meet MDZ requirements and to quickly adapt to wartime tasking. The following tasks are included: coastal surveillance and interdiction, convoy escort. intelligence gathering, serving as a C3 resource, and conducting other operations as required by the Navy.

(d) Marine Environmental Protection (MEP) and Port Safety and Security: Act as On Scene Coordinator for pollution incidents, deliver and deploy pollution equipment, conduct pollution cleanup operations and monitor water quality.

(e) Commercial Vessel and Marine Safety: Conduct various inspections (oil rig, deep water port, etc) and support diving operations.

(f) Miscellaneous Mission Area: The vessel must provide the capability to assist in the support of recreational boating safety and be capable of providing a platform for cadet, OCS and reserve training .

(3) Primary Mission Equipment:

(a) The main battery must be capable of defending the vessel against low level threats. In accordance with accepted practices of international law, it should be a deck gun capable of demonstrating, with warning shots, clear directions to heave to.

(b) The boat davit system will serve to transport boarding and inspection teams. The allowance is for two boats; each must be capable of transporting a boarding party or rescue and salvage team. Each MEC will have a 6.0m Avon RHI and a single point davit system. The other small boat can be an MSB, another RHI or any other suitable platform. The single point davit system on board must be able to provide cargo lift capacity to the main deck.

(c.) The towing system must be capable of meeting SAR requirements as have been historically assigned to 210' MEC's. No changes in towing system are required.

(B) Operating Profile: Mission employment demands a minimum of 18 knot flank speed (with 80% installed power) and 21 days endurance in fuel, water, and provisions at most economical speed with 10% reserve fuel on board. A limiting draft of 14'6" is imposed for operation in most all present MEC homeports. A helicopter, the HH-65 Dolphin will normally be deployed while the vessel is on patrol. Sufficient JP-5 tankage for 45 flight hours by the helo during a 21 day patrol is required. A separate storage facility for an entire Helicopter Support Kit, starting rectifier, fuel testing equipment, and engine washdown system must be available.

(C   Range of Capabilities Desired:

(1)   Habitability: There must be berthing and human facilities to accommodate the following minimums: crew: CPO-8, EM-65, Officers- 12; visiting personnel: EM-4, Officer's-3, Civilian-2. It is assumed that up to 30% of all crewmembers (including visitors) may be women, and separate facilities are required. All attempts shall be made to place habitability as a high priority.(i.e.lounges, recreational facilities, etc.).

(2)   Applicable common guidance is as follows:

(a)   High maintainability and reliability

(b)   The class is to be standardized

(c)   Commonality with other class cutters is sought where possible

(d)   State of the art design is sought

(e)   Modular maintenance is desired

(f)   Clustering of multiple vessels in homeports is a necessity (i.e. shoreside Maintenance Augmentation Teams (MAT) will be assigned for preventative maintenance

(g)   The ability to accommodate an expansion of combat capability is desired

(h)   Vessel must have two complete repair locker inventories (manning and equipment) in accordance with present 210' MEC requirements

(i)   Spaces must be available for separate supply areas for Engineering Spares, Electronic Spares, and utility materials (i.e. valves, piping, freon, etc.)

(j)   Space must be available to accommodate at least a 5" and an 8" towing hawser with ready accessibility to the towing area.

(k)   The vessel must have at least 700 square feet of utility deck space excluding the focsle, boat decks and helo landing area

(l)   The vessel must have accommodations (i.e. lock up) for at least 10 prisoners

(m)   The vessel must have a completely segregated ballast system with the capability to maintain at least 60% of all fuel weight on board at all times

(n)   A fixed firefighting system must be installed in the main propulsion area and JP-5 storage area.

(o)   The vessel must have the latest available.equipment on board for rapid response to water pollution incidents (i.e. booms, etc.), keeping in mind that MEC's typically act as On Scene Commanders (OSC's) during such evolutions.

(3)   Stability: An active roll stabilization system must be installed. Vessel roll stabilization is required to assure no more than 10 degrees roll in sea state 4 at 12 knots. All applicable stability criteria must be met or exceeded.

III.   IMPROVEMENTS: The following items refer to the present capacities of a "B" Class 210 WMEC. The new MEC should increase the following capacities/capabilities to be consistent with endurance and mission requirements:

A.)   Increase generator capacity. Insure ship's service and emergency generator capacities are adequate to support shipboard functions.

B.   Retain Refueling at Sea (RAS) capability

C.   Increase dirty oil stowage (at least 1500 gallons)

D.   Improve watermaking capability and storage to support a crew of ninety, 21 days endurance, helicopter and MSD demands

(E.)   JP-5 tankage: Increase as necessary to allow 45 flight hours and provide stripping capability. This will require at least 5000 gallons of JP-5.

F.   Mess deck must have the capacity to seat at least half of the crew.

G.) Install as state-of-the art as practical: navigation/positioning systems, electronic.communications systems, crypto gear, speed log. Install a collision avoidance system on the bridge.

H. Insure that antenna configuration is examined to reduce interference.

IV. SHORTCOMINGS OF EXISTING SYSTEMS:

The Coast Guard currently has fifteen (15) 210 foot WMEC's. A renovation program for this vessel is underway and will extend the service life of the hull form by fifteen years. This means that these vessels will need to be replaced commencing in the year 2000. The major problems will become critical with respect to the current fleet is that as the existing 210 WMECs approach the end of their useful service .life, increased maintenance requirements and growing supply support problems will result in decreased reliability and effectiveness or a loss of mission capability of the platform. The information contained herein is a synopsis of the requirements for the cutter which will replace these aging vessels.