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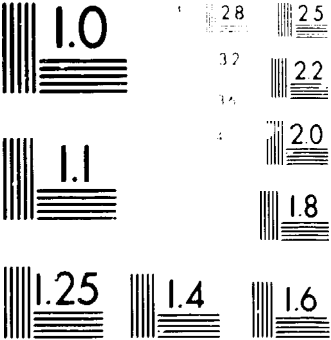

MICROCOPY RESOLUTION TEST CHART

13683

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and the Pacific Countries

Jakarta, Indonesia, 26-31 March 1984

TECHNIQUES AND SPECIFIC METHODS FOR THE DESIGN AND CONSTRUCTION OF SEA GOING SHIPS AT PT PAL INDONESIA*

prepared by

Suleman Wiriadidjaja**

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** Naval architect. PT. PAL Indonesia.

V.84-86454

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b. "Surya" Sailing Ship
c. 3,000 DWT Coaster
d. 5,000 TLC Floating Dock
e. 5,700 m^3 LPG Tankers
f. 800 HP Tug Boats

1.2 Naval Vessels

a. FPB 57 Speed Boats (see schedule, page 6)
b. FPB 28 Speed Boats (see schedule, page 7)
c. Jetfoils

2. Draw up and carry out Quality Control and Quality Assurance Programs for new ships in the following fields :

- Welding
- Assembling and erection
- Outfitting

For detailed explanation, see Performance Quality Control and Quality Assurance.

3. Maintenance of Naval and Commercial Vessels

4. Effect the management of the arms & electronics systems, already commenced with the FPB 57 and FPB 28

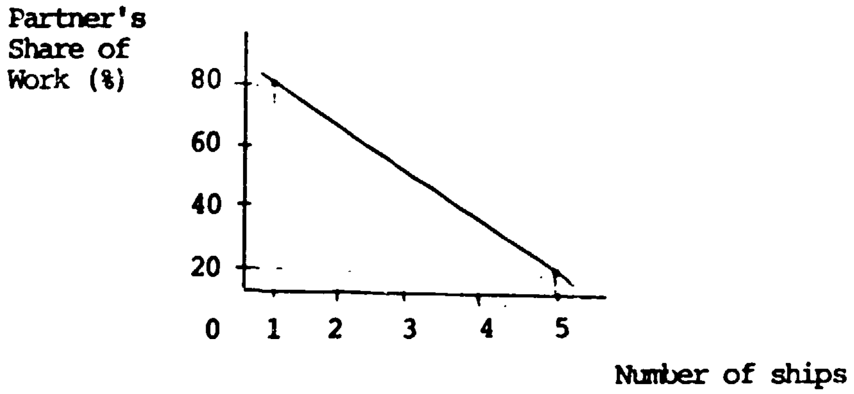
5. General Engineering.

B. In order to reach the objective that PT PAL become the Centre of Maritime Industry in the Eastern Part of Indonesia, the execution of those programs is supported as well as possible by :

1. Making a program for cooperation in the form of Technical Assistance with foreign enterprises using advanced industrial techniques, as follows :

   a. Fr. Luerssen Werft, West Germany, for the FPB 57 program
   b. Belgian Ship-Building Corporation, for the FPB 28 program
   c. Mitsui Engineering & Shipbuilding for the following programs :
      - 3,500 DWT Tankers
      - 3,000 DWT Coasters (Caraka Jaya)
      - Development of facilities for Commercial Shipbuilding (30,000 DWT capacity)
   d. Ministry of Research & Technology, Federal Republic of Germany, for the program to develop the "Surya" Sailing Ship (Maruta Jaya)
   e. Boeing Marine System for the program to build Jetfoils.

   The tranfer of technology is affected by means of Licence System and the Progressive Manufacturing System.
   Example : Division of work in the making of hulls, for instance :



2. Building the PAL Computer Centre, which will help the work in the stages of design, construction and production (inclusive of steel ordering, steel and NC tapes, data for planning and production control of steel workshops).

   In this connection, PAL is working together with :

   - SENER of Spain for design, construction and production drawings with the FORAN 1 + 2 systems, and
   - NOBISKRUG of West Germany for designs with the Possy program.

3. To add to the skill of workers on site, a beginning has already been made for setting up a Training Centre capable of educating and training 1,000 persons to become experts in the various work disciplines of a shipyards; later on, graduated trainees can also be used by other industrial enterprises.

4. Developing PT PAL's production facilities for :

   - Commercial vessels up to 30,000 DWT
   - Naval vessels, and
   - Ship repairs and maintenance.

C. Work Already Done By the Commercial Shipping Division

1. Two 3,500 DWT Tankers are in the course of construction

2. The following work program for 1984 - 1988 inclusive has been drawn up :

   - One 900 DWT "Surya" Sailing Ship
   - One 5,000 TLC Floating Dock
   - Two 3,500 DWT (5,700 m^3) LPG Carriers
   - Four 3,500 DWT Coasters
   - Six 800 HP Tug Boats
   - Three 30,000 DWT Tankers.

3. Preparation have begun for constructing facilities for the building of ships of up to 30,000 DWT; construction will be commenced in 1984 and is planned to be finished in 1987 (see page 8).

BUILDING PROGRAM OF COMMERCIAL SHIPS 1983 - 1988

NO.	BUILDING BERTH	1983	1984	1985	1986	1987	1988
1.	GRAVING DOCK 20,000 TLC			TANKER 3,500 DWT			
2.	GRAVING DOCK 20,000 TLC			TANKER 3,500 DWT			
3.	SLIPWAY 1,000 TLC			SOLAR SHIP 900 DWT			
4.	GRAVING DOCK				FLOATING DOCK 6,000 TLC		
5.	GRAVING DOCK				LPG CARRIER 3,500 DWT		
6.	GRAVING DOCK					COASTER 3,000 DWT	
7.	SLIPWAY 1,000 TLC				TUG BOAT 800 HP		
8.	- ; -				TUG BOAT 800 HP		
9.	- ; -				TUG BOAT 800 HP		
10.	- ; -				TUG BOAT 800 HP		
11.	- ; -				TUG BOAT 800 HP		
	- ; -				TUG BOAT 800 HP		
12.	GRAVING DOCK 20,000 TLC					LPG CARRIER 3,500 DWT	
13.	- ; -					COASTER 3,000 DWT	
14.	- ; -					COASTER 3,000 DWT	
15.	- ; -						COASTER 3,000 DWT
16.	GRAVING DOCK 30,000 TLC						
							PO; TANKER 30,000 TLC

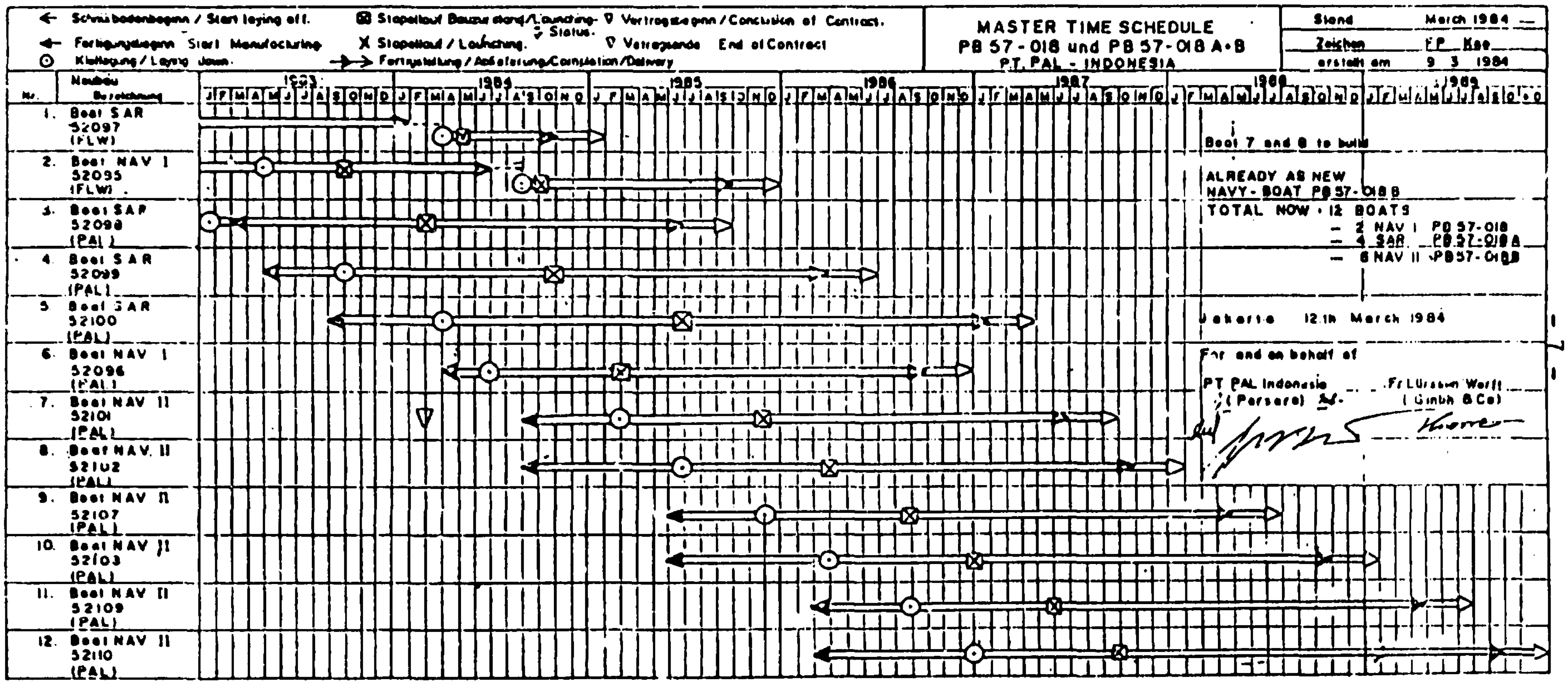
Notes : ML = Mould Loft

F = Fabrication

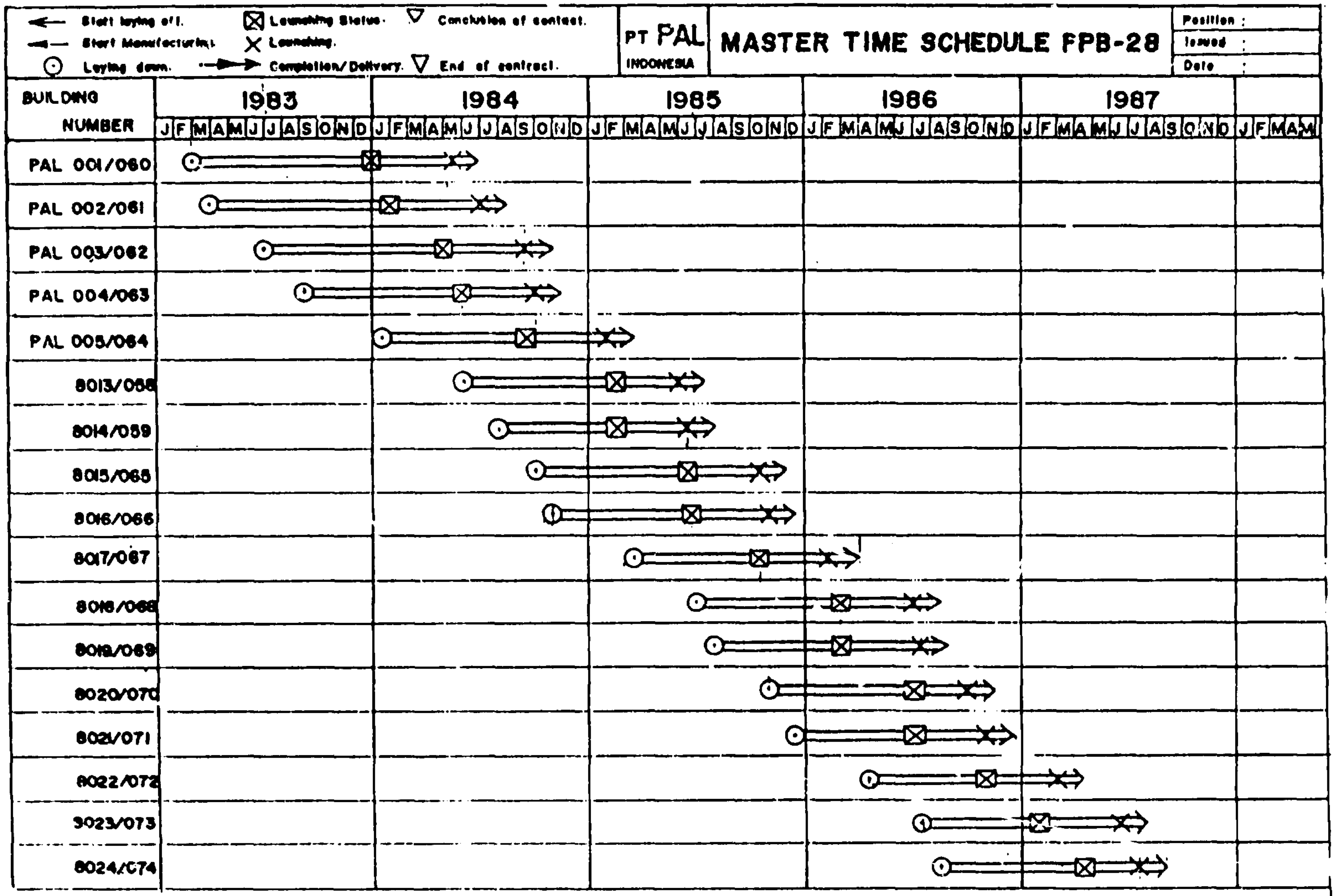
KL = Keel Laying

L = Launching

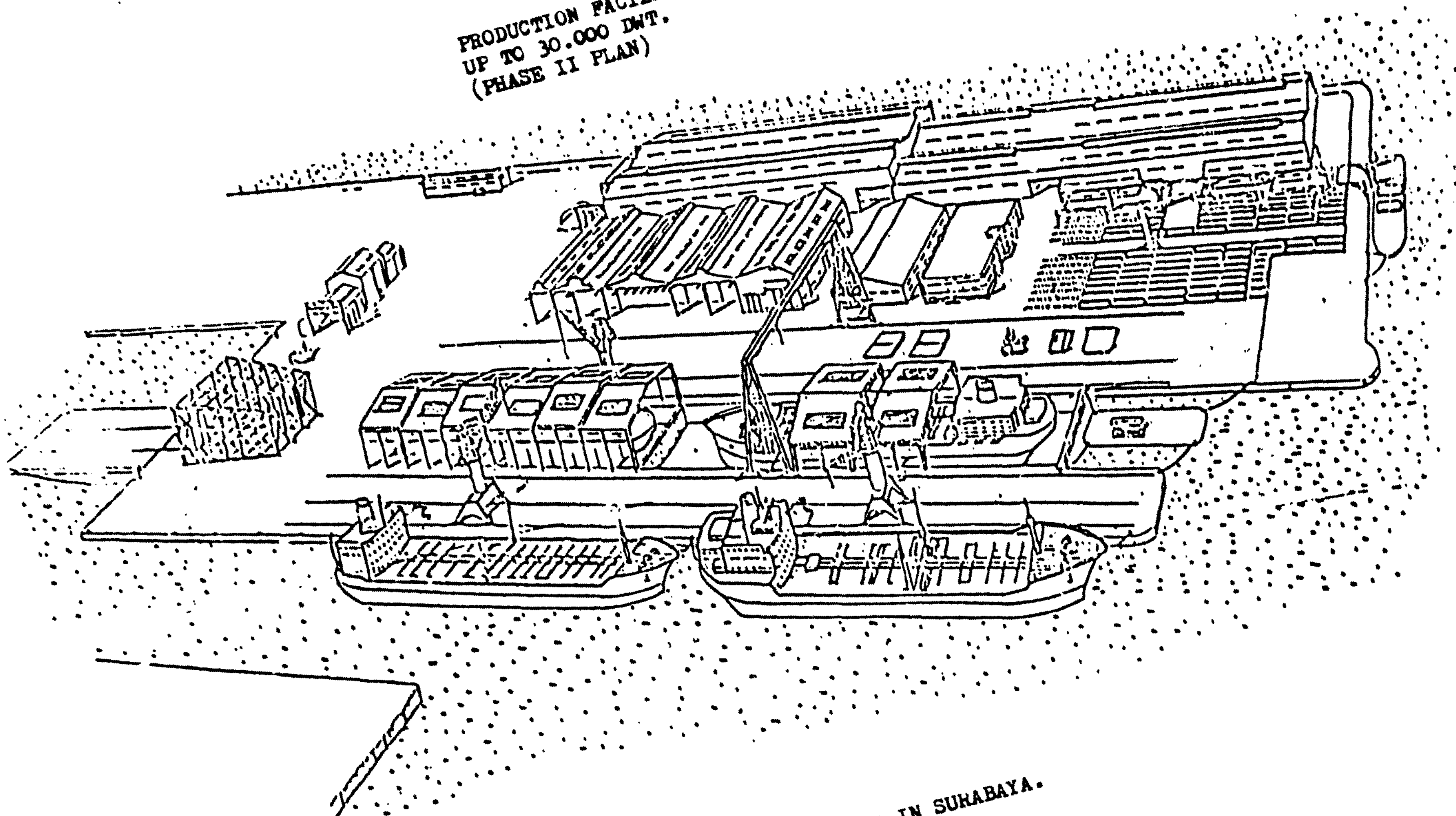
D = Delivery



Schnürbodenbeginn / Start laying off.
Fertigungsbeginn Start Manufacturing
Kiellegung / Laying down.
Stapellauf Bauzustand / Launching-Status.
X Stapellauf / Launching.
Fertigstellung / Ablieferung / Completion / Delivery
Vertragsbeginn / Conclusion of Contract.
Vertragsende End of Contract
MASTER TIME SCHEDULE
PB 57-018 und PB 57-018 A+B
P.T. PAL - INDONESIA
Stand March 1984
Zeichen FP Kae
erstellt am 9 3 1984
Nr.
Neubau Bezeichnung
1983
1984
1985
1986
1987
1988
1989
1. Boat SAR 52097 (FLW)
2. Boat NAV I 52095 (FLW)
3. Boat SAR 52098 (PAL)
4. Boat SAR 52099 (PAL)
5. Boat SAR 52100 (PAL)
6. Boat NAV I 52096 (PAL)
7. Boat NAV II 52101 (PAL)
8. Boat NAV II 52102 (PAL)
9. Boat NAV II 52107 (PAL)
10. Boat NAV II 52103 (PAL)
11. Boat NAV II 52109 (PAL)
12. Boat NAV II 52110 (PAL)
Boat 7 and 8 to build
ALREADY AS NEW NAVY-BOAT PB 57-018 B
TOTAL NOW: 12 BOATS
– 2 NAV I PB 57-018
– 4 SAR PB 57-018 A
– 6 NAV II PB 57-018 B
Jakarta 12th March 1984
For and on behalf of
PT PAL Indonesia (Persero)
Fr. Lürssen Werft (GmbH & Co)


Start laying off.
Start Manufacturing.
Laying down.
Launching Status.
Launching.
Completion/Delivery.
Conclusion of contract.
End of contract.
PT PAL INDONESIA
MASTER TIME SCHEDULE FPB-28
Position :
Issued :
Date :
BUILDING NUMBER
1983
1984
1985
1986
1987
J F M A M J J A S O N D
PAL 001/060
PAL 002/061
PAL 003/062
PAL 004/063
PAL 005/064
8013/058
8014/059
8015/065
8016/066
8017/067
8018/068
8019/069
8020/070
8021/071
8022/072
3023/073
8024/074

PRODUCTION FACILITY FOR MERCHANT SHIP
UP TO 30.000 DWT.
(PHASE II PLAN)



PT. PAL INDONESIA IN SURABAYA.

II. COMPUTER AIDED DESIGN AND COMPUTER AIDED MANUFACTURING

Computers are now being utilized extensively in the design of ships, with the result that designs are generated more quickly at lower cost. However, design costs are invariably less than 10 % of the total shipbuilding budget, while more than 90 % is devoted to construction cost. Therefore, even large reductions in design cost are relatively insignificant in terms of economic impact, by comparison with relatively minor improvements in construction techniques. For this basic reason, the major thrust in the shipbuilding industry today is to find ways to used computers effectively to reduce construction cost.

To date, the introduction into the shipyard of numerically controlled flame cutters has made the largest impact on construction costs. Most large yards in the world and some small yards are now using numerically controlled cutters to cut shell plates, frames, brackets, and other parts that can be cut from steel plate. Because generating the neccessary punched paper or mylar tapes containing instructions for the flame cutter is an unreasonably tedious task, all of these yards are using one of the many integrated production software systems developed specifically for that purpose. These systems are different in detail but all of them, in one fashion or another, allow shipyard production personnel efficiently and quickly to generate punched tapes for controlling flame cutter which cut out the pieces of the ship.

One of the world's leading ship design and production systems is FORAN. Developed initially as a design system in Spain by SENER, FORAN emphasizes efficient and rapid design. Its major goal is complete integration of design and production. It has a lines generation module for creating new hull forms from form parameters.

The FORAN system can be used on mini-computers as well as mainframe machines. This means that FORAN should now be within the financial reach of the small and medium sized shipyards, and that the technical department of the large yard can also be provided with its own computer power. Two Indonesian shipyards, PT PAL Indonesia and PT ADHIGUNA shipyard, are now using the FORAN system for design and production.

The FORAN system is composed of two phases connected through a Data Base:

1. Design Phase, which defines the hull forms and carries out the calculation of :
   - Naval Architecture
   - Basic Design
   - Definitive Design

2. Production Phase, which covers the following fabrication stages:
   - Steel classification drawings
   - Steel ordering
   - Construction design
   - Steel (workshop documents) and NC tapes
   - Data for planning and production control of steel workshop.

Each phase consists of several modules, each one of which is composed of a set of computer programs. Each modules carries out a specific function using its own data and those of preceding modules, stored in the Data Base. The outputs supply new information to the Data Base.

It is important to remark that FORAN formulation is not an interpolation among a set of different hull forms previously classified and stored on computer, but a surface defined by a proper analytical equation.

1. FORAN System Design Phase

The Design Phase consists of several modules. They are :

1) Module F.1 - Calculation of Horse Power, Propeller, Stern Frame and Rudder

The object of module F.1 :
- to obtain an estimation of trial and service speeds
- to design the optimum propeller for the given conditions
- to define the geometry of the stern frame and rudder.

The calculation of EHP is optionally made according to Lap's or Holtrop's method. The speed estimations for different trim conditions can also be performed for a given propeller.

The following outputs are obtained graphically and numerically :
- BHP curves in trial and service conditions
- Stern frame, rudder and propeller.

2) Module F.3 - Identification and Generation of Forms

The object of module F.3 (F.3/F and F.3/G) is the calculation of the mathematical parameters which define the ship form. Module F.3/F carries out the fitting and the analytical fairing of pre-existing forms defined by a table of offsets. Module F.3/G generates intensively faired forms directly from the basic design data.

The output of these modules is :
- Forms (graphical results for module F.3/G and graphical & numerical results for module F.3/F)
- Hydrostatic calculation (numerical and graphical output)
- Curves of sectional areas and half-breadths
- Bonjean curves (numerical and graphical output)
- Drawing of design section, diagonals, buttocks and waterline endings.

3) Module F.4 - Definition of Decks, Bulwarks and Double Bottom

The objective of this module is the definition of the frame spacing and the obtension of the line drawing and the schematic general arrangement. This module allows the designer to analyze both line drawings and the geometry of the hull, decks, double bottom etc.

4) Module F.5 - Transverse Stability, Freeboard and Capacities

The calculations made by this module are :

- Individual capasities (graphical and numerical output)
- Total capacities by grouping the different contents
- Transverse stability for even keel or trimmed condition
- Regulatory freeboard
- Maximum allowable heeling moments and volumetric heeling moment of compartments
- Sounding and ullage tables.

5) Module F.6 - Loading Conditions, Longitudinal Strength

The objectives of this module are :

- Calculation of lightship weight distribution and abscissa of its centre of gravity (acc. to Lloyd Register Rules)
- Study of the loading conditions : displacement, trims, static and dynamic stability, including damage conditions (graphical and numerical output)
- Determination of bending moments and shearing forces of each loading condition in still water or on a given wave defined as input (graphical and numerical output)
- Grain calculations (Solas '74)
- Floodable lengths acc. to Shirokauer method (graphical and numerical output).

6) Module F.7 - Table of Offsets

This F.7 module gives the numerical definition of the hull surface by means of a table of offsets by construction frame or design sections. The table of offsets includes complete information for all the construction frames, deck knuckles, limit of flat of side and that of bottom, stem and stern profiles, bulwark etc. This table of offsets can be directly used in the mould loft.

7) Module F.8 - Body Plan and Stem & Stern Frame Drawing

The object of this module is to obtain the Body Plan and Stem & Stern Frame details. This module produces a graphical representation through the automatic drafting machine, of the output of module F.7.

8) Module F.30 - General Fairing

This fairing program is based on a conventional computer-aided mould loft technique. It is applicable to general types of ships as with any other conventional fairing computer program.

The tasks of the F.30 module are :

- To define the hull surface to the degree of precision required for production. This involves incorporation into the original hull definition of stem and stern details together with any special requirement from a constructional point of view.
- To smooth the mesh of curves describing the hull surface
- To interpolate additional mesh lines on the faired surface.

2. FORAN System Production Phase

1) Module F.9

This module creates and supplies to the file of Standards of the Data Base such necessary information as :

- Plate & profiles, construction standard, fabrication method of profiles and pieces
- Standard Notches & Holes.

2) Modules F.10, F.11, F.12, F.13, F.21, F.22, F.23

These modules are used to define and to obtain information about :

- Drafting, steel ordering, mould loft, preparation of work and assignment of materials, fabrication of profiles and plate.

3) F.14 - Definition of Structure Section

This module is used to assist the part making of Module F.44. Here the designer can divide the ship up in various kinds of sections, such as longitudinal, transverse and horizontal, just as he wishes. This is done by utilizing the data from the earlier modules.

4) F.44 - Part Definition

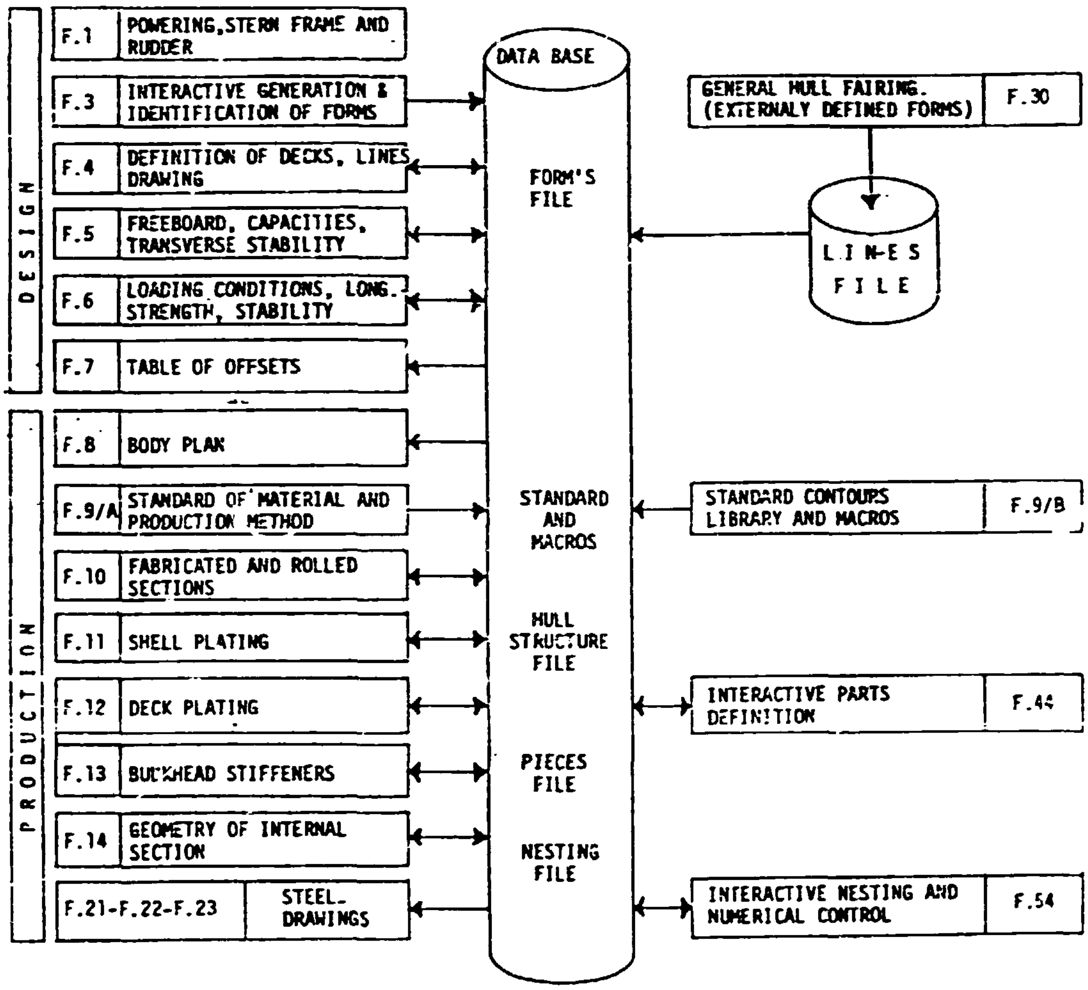
The aim to be reached with this module is to make and store the internal plans of parts of the ship construction. The final product will take the form of the geometry of the internal parts together with their characteristics and identifications that are stored in the Data Base. Use of modules F.44 must be affected with a graphical screen and the parts that are stored will be callable for nesting purposes.

5) F.54 - Nesting

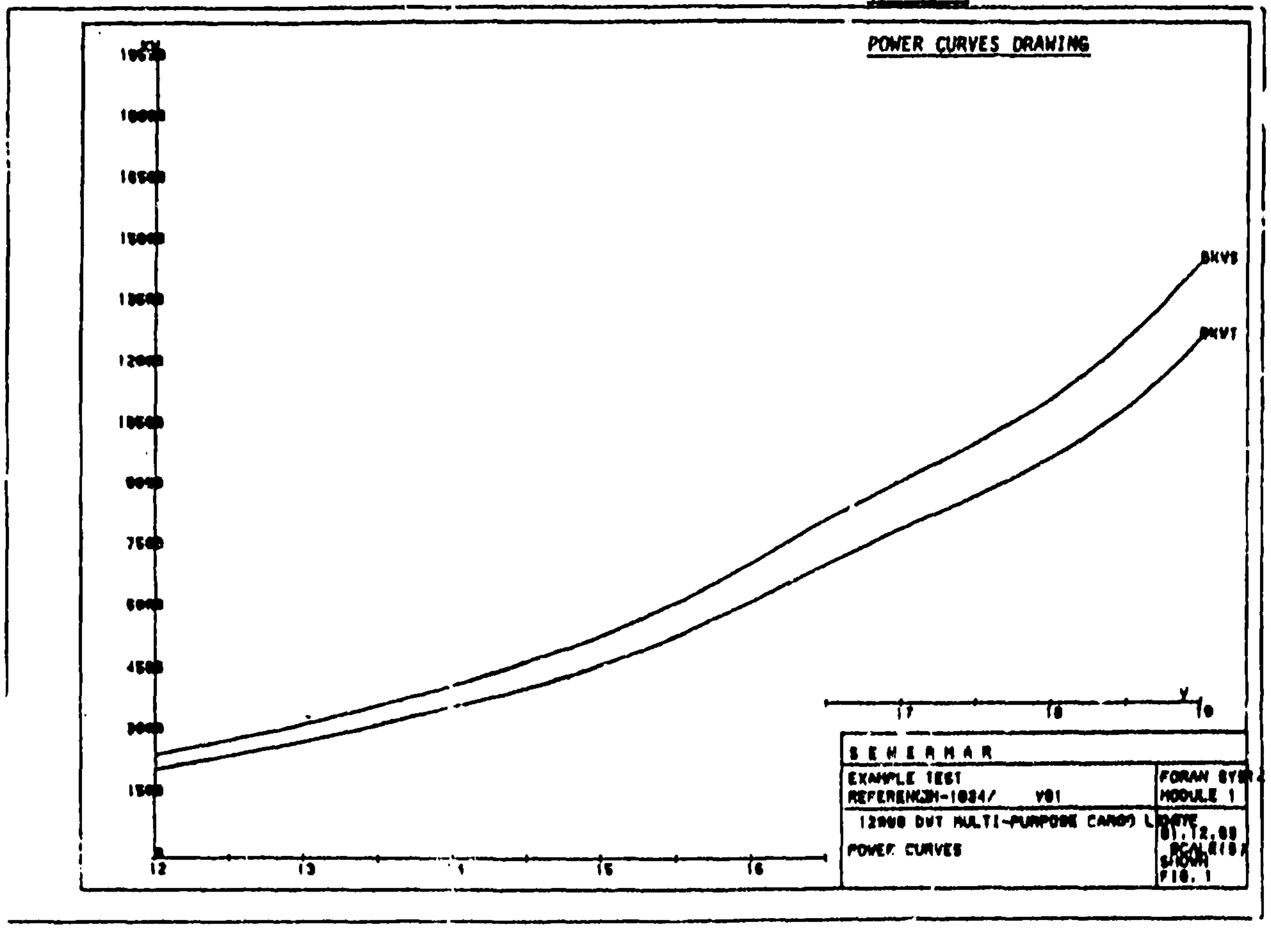
With this module, the inner plate plans made with module F.44 can be recalled and arranged in the drawing of a plate in such a way as to have the minimum scrap. And for the needs of the cutting machine and with a suitable command it will be possible to obtain cutting control of the nesting made.

If the product is to be used by an optical cutting machine, the a command to the drawing machine will obtain a drawing of the nesting concerned (see page 25).

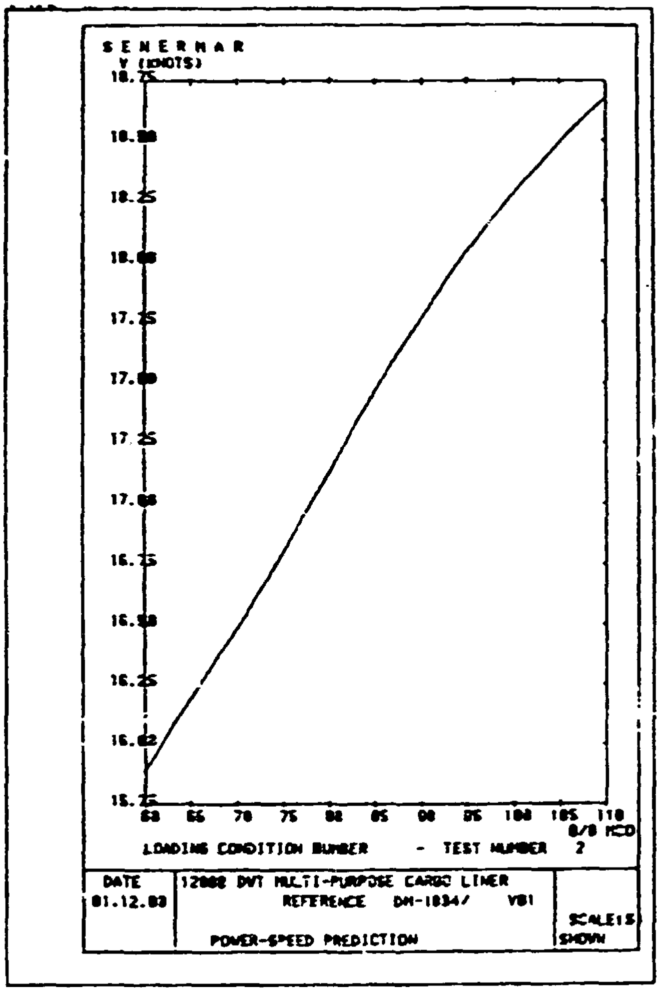
FORAN SYSTEM ORGANIZATION



MODULE F.1

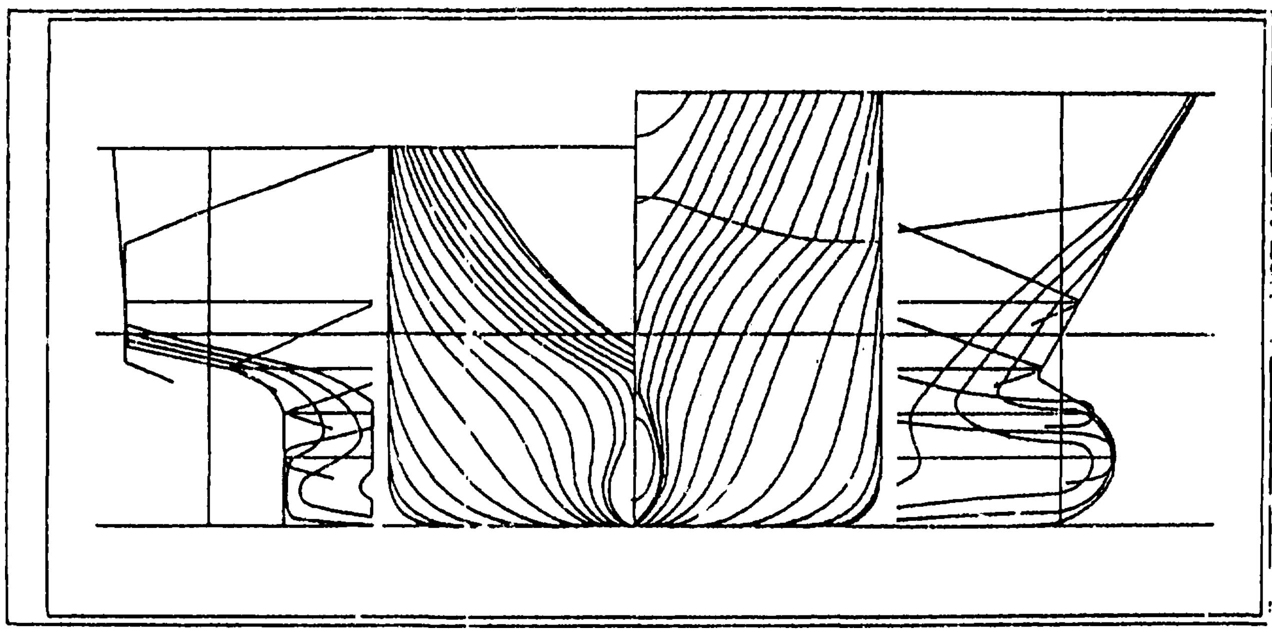

POWER CURVES DRAWING
S E N E R M A R
EXAMPLE TEST
MODULE 1
12000 DWT MULTI-PURPOSE CARGO
POWER CURVES
FIG. 1

MODULE E.1
POWER-SPEED PREDICTION



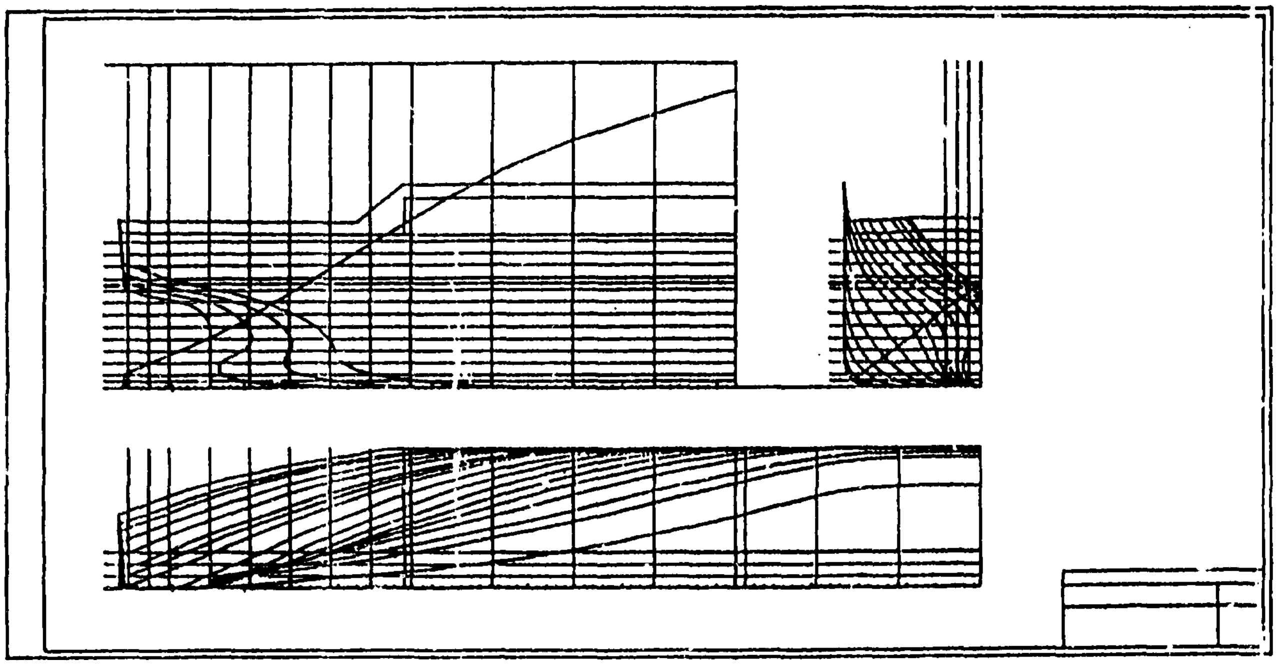
MODULE F.3/F

AFT-FORE BODIES & DETAIL OF ENDS



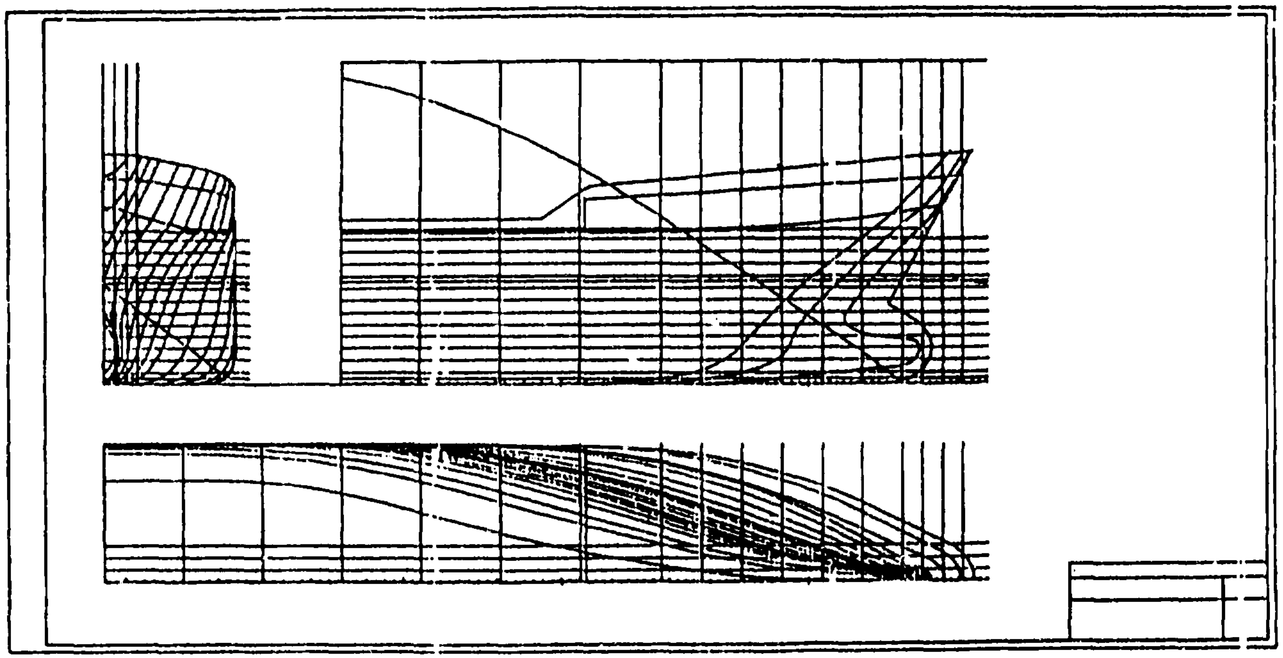
MODULE F.4/D

L I N E S



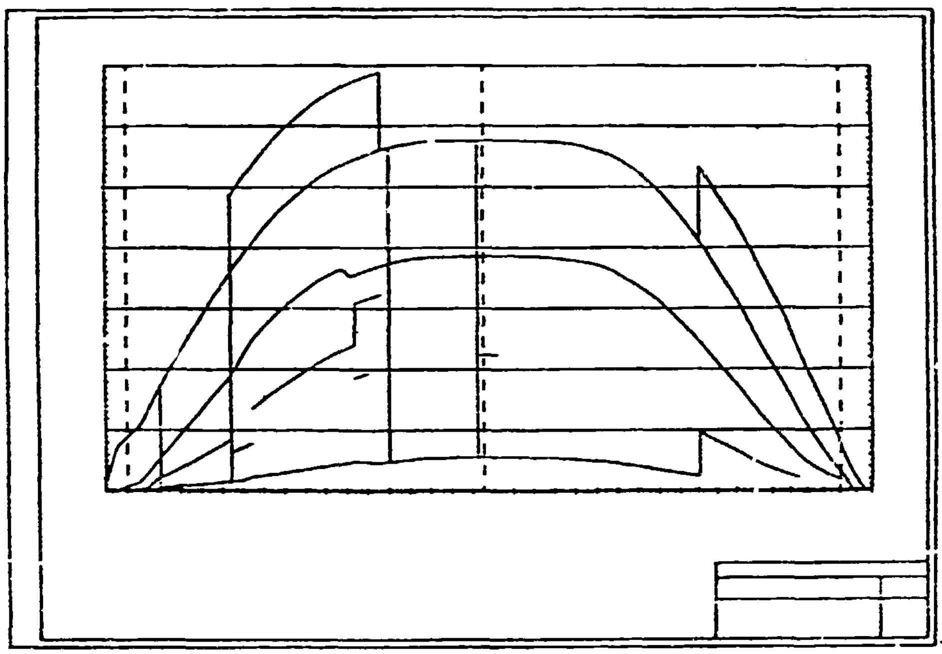
MODULE P.4/11

LINES



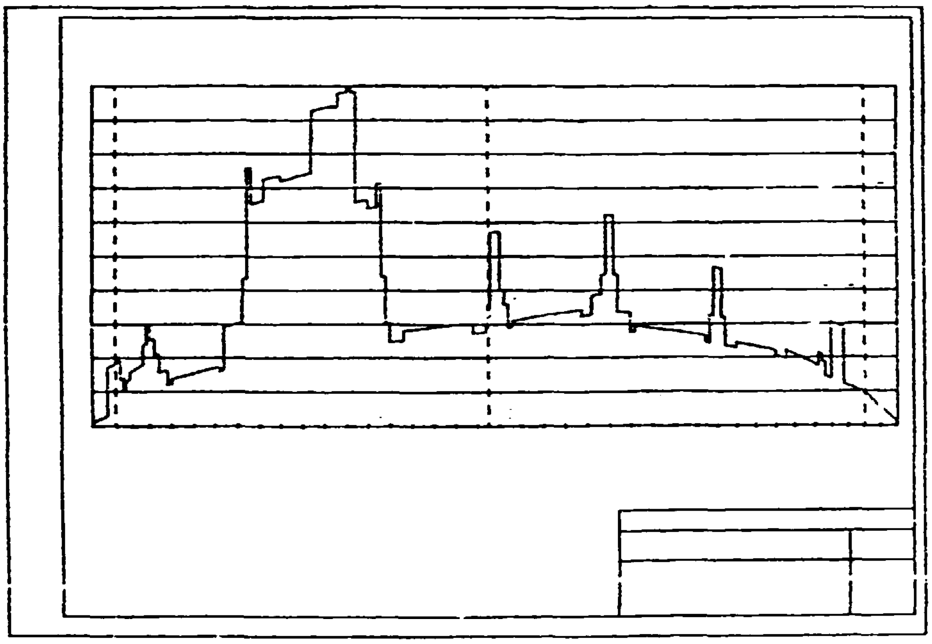
MODULE F.5/1

CAPACITY PLAN



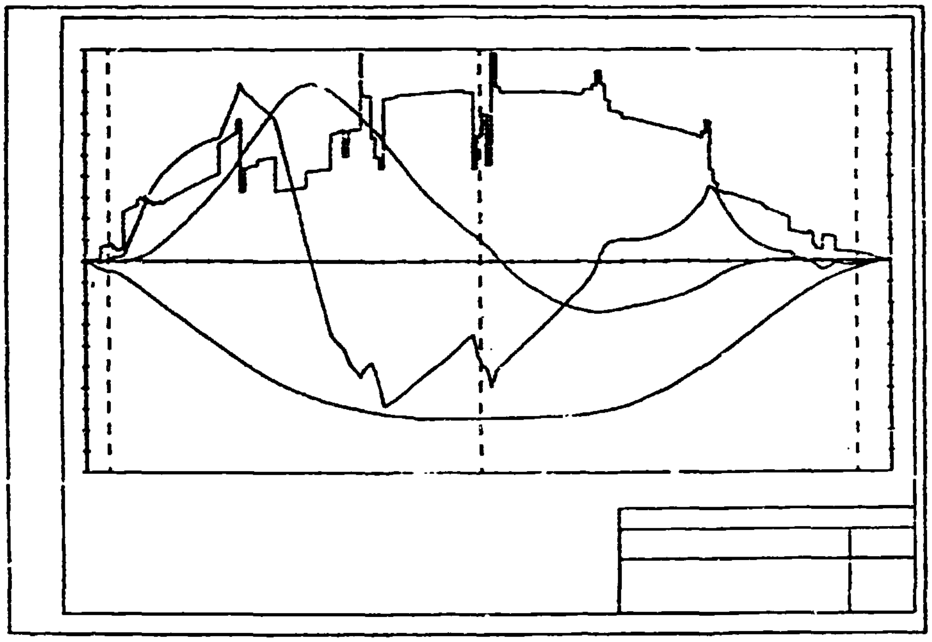
MODULE F.6/1

LIGHT WEIGHT DISTRIBUTION



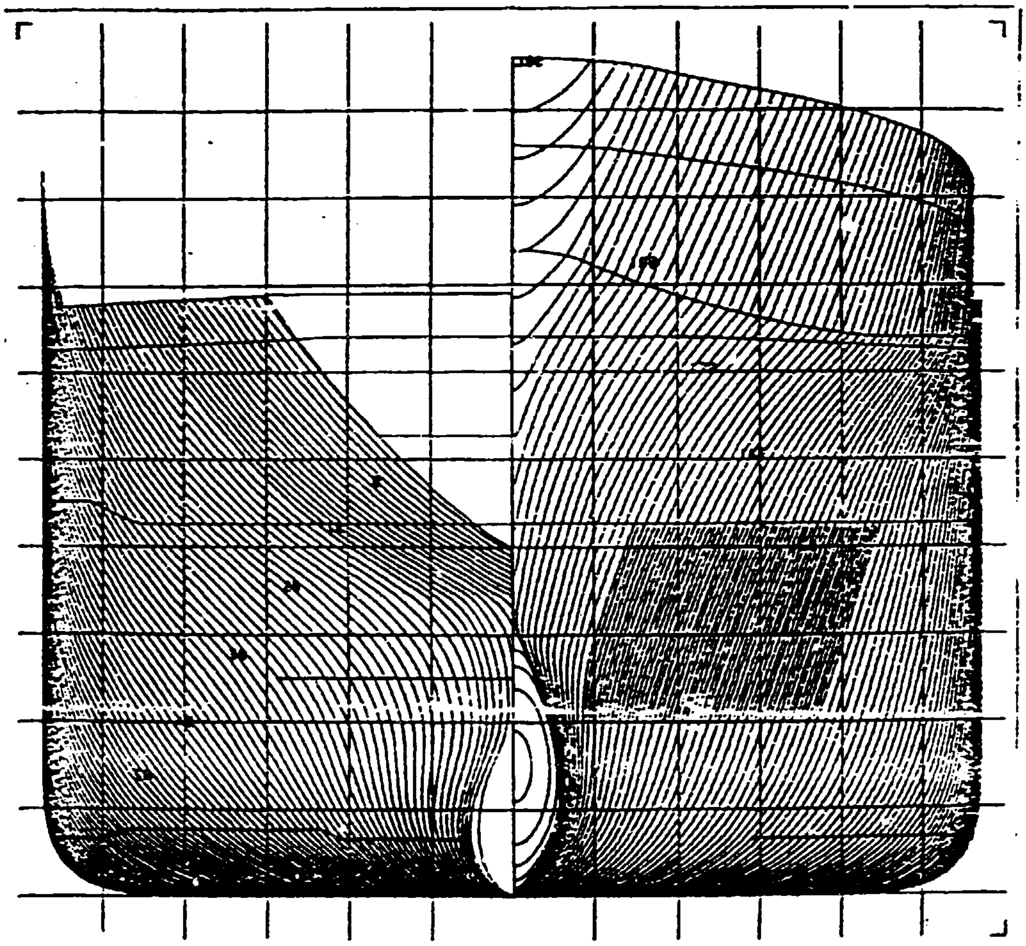
MODULE F.6/2

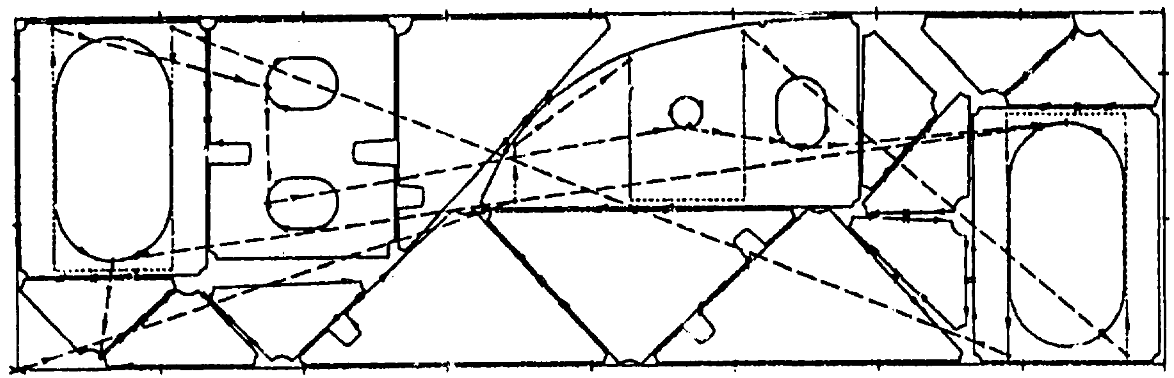
LONGITUDINAL STRENGTH



MODULE F.8

BODY PLAN





```
ENTER COMMAND
DISP NEST
NEST : EX12/DICK
NEST-DIMENSIONS       :   8000.x  2400.x 12.0
TOTAL AREA PARTS      : 14.104 M2
NUMBER OF PARTS       :  16
NR CUTTER-PATH VARS   : 1813
SCRAP-PERCENTAGE      :    26.1
CUTTING-LENGTH        :   82120
CUTTING-OFF           :   20817
MARKING-LENGTH        :   11607
NR-TORCHES-ON         :       7

ENTER COMMAND
```

III. QUALITY CONTROL AND QUALITY ASSURANCE

A. General

Technological developments have been marked by the emergence of modern industries and, simultaneously, an increase in complex technical problems. In order to facilitate good and objective technical achievements, new technical concepts and disciplines have been created that are known collectively in the advanced industrial countries as quality control. The basis for the concepts of quality control are as follows :

> A manufacturer must deliver to the buyer not only a product at an agreed price and time, but must also ensure and prove that the quality of the product conforms with the conditions of the purchase agreement. This can be achieved only when, on the one hand, all the factors of production meet requirements, but also, on the other, when there is systematic and continuous control during the manufacturing process.

The factors of production that are subject to such controls are :

1. The methods of design, construction and production
2. The quality of experts and workers
3. The quality of materials used
4. The quality of the production equipment.

The aim of these controls are not only to ensure good technical achievement as the condition for good quality products that will satisfy customers, but also to prevent and limit mistakes in production methods and output so as to keep the costs of production down. Since these are very important matters, separate section of quality control and quality assurance staff is formed.

In order to support successful realization in PT PAL, the Board of Directors established the basic organisation and procedures for quality control and quality assurance in February 1983. In addition, this section is under direct control of the Chairman of Directors.

B. Objectives in Establishing a Quality Control and Quality Assurance Section in PT PAL

1. The Short Term Objective is to achieve standards for PT PAL with regard to quality and control procedures, that conform with regulations for both national and international classes in order to obtain products that can satisfy customers. It will be quite heavy work to achieve this aim and it will take a long time, but the results can already be seen. For instance, if customer's supervisors formerly asked for control of 15 % of all hand-welded joins, today they approve of only 10 %.

2. The Final Objective. When the quality of the work of experts and workers is already good, they will be able to control for themselves their own output in the places where they work, just as is done in the advanced industrial countries abroad, where quality control and quality assurance is limited to welding control in important places and the sampling method for control of materials and the products of construction. It is hoped that it will be possible to obtain a PT PAL Standard that can be recognised by Class & Owner Surveyors, so they can approve Quality Assurances from PT PAL just on the basis of the control documents made by PT PAL, without themselves controlling operations on site. This is what is done in the advanced industrial countries, and it can reduce both production time and cost.

C. Duties and Obligations

PT PAL INDONESIA Quality Control and Quality Assurance has the duty and obligation of assisting the Chairman of Directors in carrying out programs and policies for quality control and assurance of every one of PT PAL's products. For this purpose, the Quality Control & Assurance Section must first study the specifications for ships or other products already approved by shipyards, classifications and owners. The rules, quality standard and inspection method to be used in reaching the objectives can be determined from these specifications.

The inspection method designed by Quality Control & Assurance is supplemented with the inspection of items and check sheets in the interests of over-all inspection.

In the context of the ship-building entrusted to PT PAL, including two 3,500 DWT tankers, Quality Control & Assurance has established a Welding Procedure for use as guide in welding work for construction of the hull and piping on site.

This welding procedure is carried out by recording the quality of the material, the type and size of electrodes, the voltage, amperes, etc. in conformity with the Welding Procedure Specification. After this, a visual inspection, radiography tests and destruction tests are made, the outcome being supervised by classifications based upon ASME, AWS etc. standards.

D. Documentation and Evaluation

As proof that supervision and tests have been carried out by the PT PAL Surveyors, the class surveyors and owner's surveyors, every stage in the execution of the work is equipped with the relevant documents and evaluations that have been ratified by all three parties.

E. Inspection Method

1. Flow Chart of Inspection

STAGE	JOB ITEMS	INSPECTION ITEMS
	MILL	MATERIAL RECEIVING
Fabrication	SHIPYARD'S STOCKYARD	MATERIAL CHECK
	MARKING	MARKING CHECK
	CUTTING	CUTTING CHECK
	BENDING	CURVED PLATE FORMING CHECK
	PLATE JOINING	AUTO WELDING CHECK
Subassembly	ARRANGEMENT (TRANSPORT)	
	FITTING	STRUCTURAL CHECK
	WELDING	WELDING CHECK
	PLATE JOINING	AUTO WELDING CHECK
	MARKING & CUTTING OF PLATE	

STAGE	JOB ITEMS	INPECTIONS ITEMS
Assembly	ARRANGEMENT (TRANSPORT) ↓	
	FITTING ↓	STRUCTURAL CHECK
	WELDING ↓	WELDING CHECK ACCURACY OF DIMENSION DEFORMATION CHECK
	PAINTING ↓	
	STORAGE ↓	
Erection	ERECTION OF BLOCKS ↓	
	SETTING OF BLOCKS ↓	
	FITTING OF BLOCKS ↓	STRUCTURAL CHECK
	WELDING OF BLOCKS ↓	WELDING CHECK DEFORMATION CHECK
	INSPECTION IN BUILDING DOCK ↓	
	UN - DOCKING	

2. Inspection Items (Main)

ALL INSPECTION SHALL BE DONE IN ACCORDANCE WITH QUALITY STANDARD AND WELDING PROCEDURE SPECIFICATION.

(1) MATERIAL CHECK
CHARGE NO.
THICKNESS
SURFACE CONDITION & IDENTIFICATION
CHECKS SHALL BE CARRIED OUT WITH SAMPLING METHOD
(ABT 10 %)

(2) MARKING AND CUTTING CHECK
INDICATED DIMENSION
ACTUAL DIMENSION
ERROR
GAS NOTCH
SURFACE OF GAS CUT
CHECKS SHALL BE CARRIED OUT WITH SAMPLING METHOD
(1 MEMBER/DAY)

(3) CURVED PLATE FORMING CHECK
TEMPLATE
LONG. SIGHT
TRANS. SIGHT
FORMING TEMP.
CHECKS SHALL BE CARRIED OUT WITH SAMPLING METHOD
(2 MEMBERS/WEEK)

(4) AUTO WELDING CHECK
WELDING CURRENT
DO VOLTAGE
DO SPEED

BEAD APPEARANCE

WELDING MATERIAL

CHECKS SHALL BE CARRIED OUT WITH SAMPLING METHOD

(ABT 10 %)

(5) STRUCTURAL CHECK

MISFITTING

MISSING

MISALIGNMENT

GAP

DEFORMATION

REMOVAL OF TEMPORARY PIECES

SMALL SLOT ETC.

CHECKS OF BLOCK ASSEMBLY SHALL BE CARRIED OUT COMPLETELY BY CHECK SHEET NO.1

FOR SUB-ASSEMBLY, CHECKS SHALL BE CARRIED OUT WITH SAMPLING METHOD

(ABT 10 %)

(6) WELDING CHECK

CRACK

WELD MISSING

UNDER CUT

OVER LAP

RETURN WELD

BEAD APPEARANCE

GAS NOTCH

ARC STRIKE

SLAG

BACK GOUGING

LEG LENGTH

CHECKS OF BLOCK ASSEMBLY AND ERECTION WELD SHALL BE CARRIED OUT WITH SAMPLING METHOD

(ABT 10 %)

(7) ACCURACY OF DIMENSION (BLOCK)

DEVIATION OF INTERIOR MEMBERS FROM PLATE

(LONG. GIRDER. TRANS. FLOOR)

DEVIATION OF PANNELS FROM REFERENCE LINE

DISTORTION OF BLOCK

PRINCIPAL DIMENSION OF BLOCK

CHECKS SHALL BE CARRIED OUT WITH SAMPLING METHOD

(ABT 10 %)

(8) WHOLE SHIP

PRINCIPAL DIMENSION

(LENGTH, BREADTH, DEPTH)

DEFORMATION OF HULL FORM

(FLATNESS OF KEEL DOCKING - UP AND RISE OF FLOOR)

CHECKS FOR ECH SHIP SHALL BE CARRIED OUT

IV. THE USE OF WIND POWER FOR SHIPS

A. Background

1. The price of fuel oils is one of the chief factors in the operational costs of ships. With the continuing increase in the price of fuel oils, there will be a reduction in the cash flow of a shipping enterprise.
2. The burning of fuel oils leaves a residue that adds to the pollution of the environment.
3. Fuel oils are a non-replaceable natural resource, and so their increasing use as a source of energy will cause them to be exhausted quickly.
4. For these reasons, alternative sources of energy are being sought.

Because the use of nuclear energy is still not safe enough and since the large amount of energy generated by nuclear fission is economical only for large ships (30,000 DWT and over), tests are being made with the use of wind power as the primary source of energy for ships.

In addition to the aspects of economising fuel oils and of restraining the operational costs of a ship, the use of wind power for ships can be promoted again only with the existence of computers which hold the role of chief supplementary equipment in developing and applying aero and hydro-dynamics, which are so important for sailing ships.

B. The Research Project

1. The Objective : To utilise wind power both as chief and as supplementary energy for ships.

2. Concepts : The outcome of studies in the use of wind power for ships will be useful only if the studies are carried out on the system "Ship & Sails" and under the conditions prevailing in their area of operations.

3. This means that the wind propulsion system of a ship must be studied. A wind propulsion system depends upon :
   a. The form and measurements of the ship
   b. The sail system chosen
   c. Conditions in the area of operations as regards wind, water and waves.

4. To this end, a research project has been set up to build the prototype ship "Surya". This project is being carried out under an agreement for cooperation between the Ministries for Research & Technology of Indonesia and the Federal Republic of Germany, drawing the following bodies into the work :
   a. The Agency for the Assessment and Application of Technology and PT PAL : for research and construction of the ship
   b. Hamburger Schiffbau Versuchsanstalt : for coordination, aerodynamics and towing-tank
   c. Institut fuer Schiffbau der Universitaet Hamburg : for wind-tunnel and alternative sailing system
   d. Weiss, Forschung & Entwicklung GmbH : for construction of the sail system and cargo-handling system
   e. Institut fuer Entwerfen von Schiffen der Universitaet Hannover for pre-design and route simulation
   f. Wesselmann, Ing. Buero.

C. Conduct of The Research

In order to obtain concrete data that can be applied for choosing the ship and sail system, the following steps are being carried out :

1. Statistics are being compiled in Indonesia about wind directions and strengths and about currents and wave conditions on the chosen routes. Data from these statistics are used as data for research and trials of models in wind-tunnels and towing tanks in West Germany.

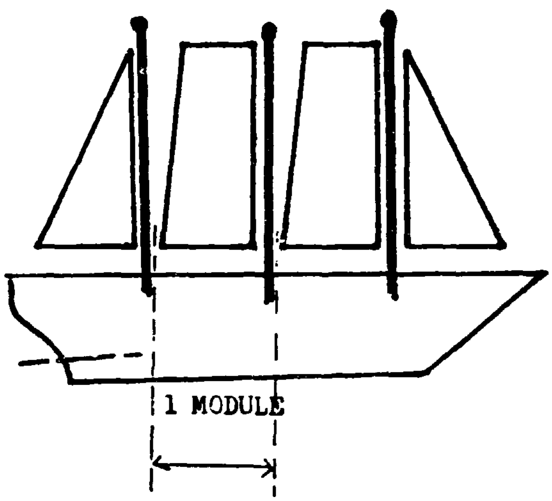
2. After evaluation has been made of the results achieved with the wind propulsion system for 9 models and evaluation of its application viewed from the economic and technical angles and that of the conditions in the area of operations, a basic form of sail system has been obtained with the optimum advantages for Indonesian conditions :
   a. a gaff sail schooner
   b. a stayed mast with the form of I
   c. a roller mast system with triangular sails fore and aft and trapezium-shaped sails in the middle
   d. because the sails are large (since the wind is not strong) and must be reefed quickly and easily, the system of reefing on vertical luff rollers has been chosen
   e. the sail system and the cargo-handling system should be integrated and it must be possible to handle them quickly and easily.

3. The prototype ship "Surya" is to be made on the basis of these ideas, and will be studied and tested for a variety of weather conditions :
   a. with engines and without sails
   b. with both sails and engines
   c. with sails and without any engine.

   From these studies and tests more complete data will be obtained for building the definitive "Surya" ships.

D. Application of Study Results

It can be concluded from the studies made of cargo flows on the routes chosen, that effective types for "Surya" ships are those of sizes 900 DWT; 1,450 DWT and 2,050 DWT. The type that is going to be built immediately is that for 900 DWT with construction design of the 2,050 DWT type, and with a 3-mast system of sails, with 2 triangular sails fore and aft and 2 trapezium-shaped sails in the middle. A system of ship construction with modules will be used to obtain the 1,450 DWT and 2,050 DWT type ships.



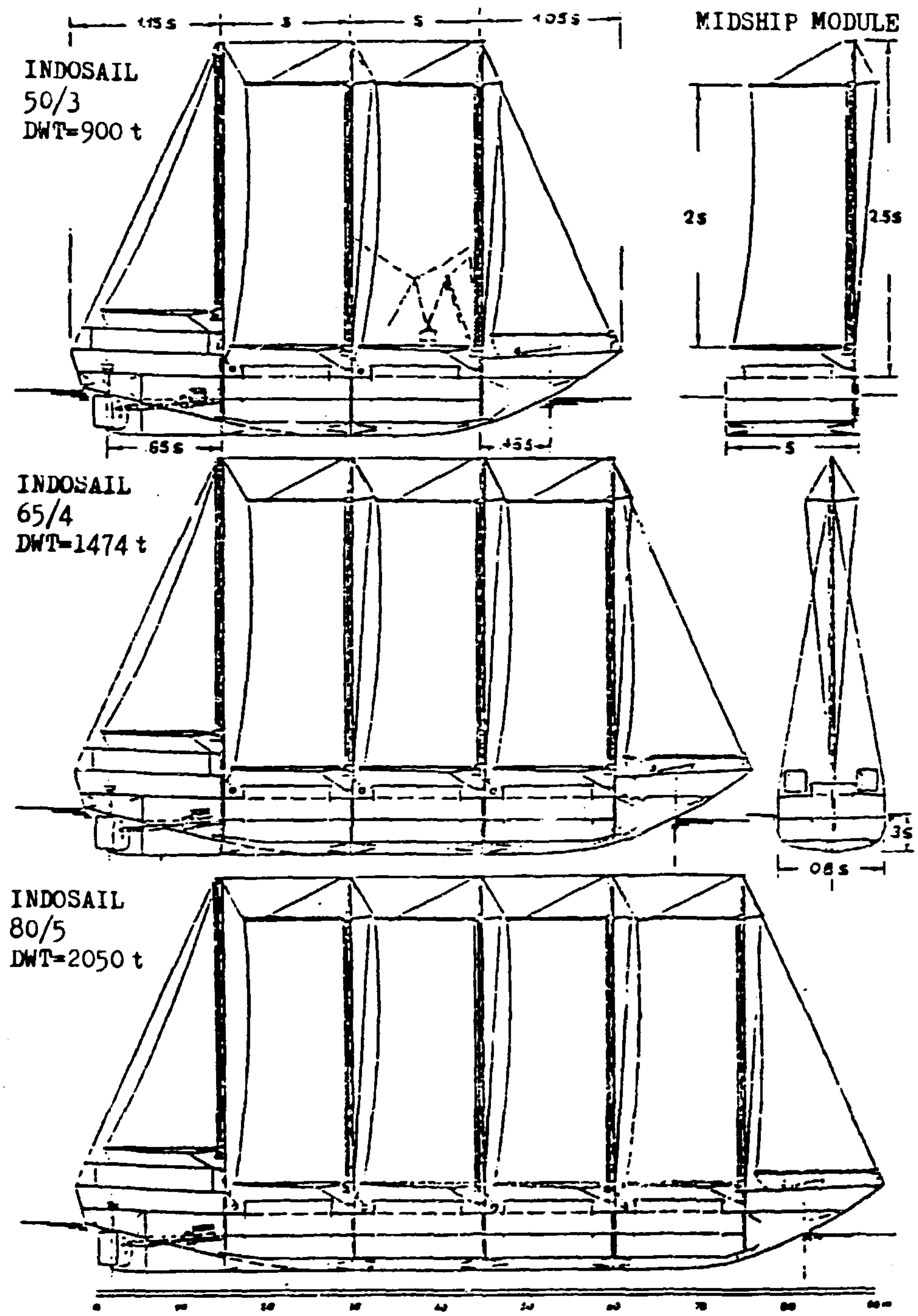
No.	Type	Number of Masts	Period for Studies & Testing
1.	900 DWT	3	1 year
2.	1,450 DWT = 900 DWT + 1 module	4	1 year
3.	2,050 DWT = 1,450 DWT + 1 module	5	1 year

E. Conclusions

1. The "Surya" ships can not supplant the numerous traditional sailing ships but are suitable for operation in the regular liner service.

2. Comparative data for a 900 DWT "Surya" ship and a Motor Ship of the same weight, showing loading & unloading and sailing times, is as follows :

No.	Items	"Surya" Ship	Motor Ship
1.	Speed (knots)	7	9
2.	Time in Port + Time Sailing per annum (hours)	6,705	7,092
3.	BHP	120	450
4.	Fuel Oil used per annum (tons)	159	658
5.	Fuel Oil cost per annum (Rp)	52,847,280	220,197,000
6.	Saving per annum (Rp)	168,000,000	-
7.	Price of Ship (Rp)	1.7 billion	1.1 billion



MODULAR CONCEPT FOR INDOSAIL COASTAL SAILERS