SYNTHESIS REPORT

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TITLE SESLAB- Development of an experimental tool for design of large SES fast ships

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DATE : 31/10/1996

SYNTHESIS REPORT

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1 Title, Authors names and addresses

"Development of an Experimental Tool for Design of Large SES Fast Ships (SESLAB)

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2 Abstract

SESLAB is a special purpose laboratory vessel designed by an European consortium in the framework of the Brite/Euram project BE7653 **DEVELOPMENT OF AN EXPERIMENTAL TOOL FOR DESIGN OF LARGE SES FAST SHIPS.**

The main objective of the project is the development of the design of an S.E.S. manned model capable to perform systematic and parametric investigations at sea in order to improve the knowledge of the governing laws and of the behaviour of the most relevant components and systems in view of the design and construction of medium/large size S.E.S. vessel.

SESLAB is intended to be a competitive tool alternative to the available ones (towing tank and full scale tests on prototypes or similar vessel) especially when new and advanced design concepts, components and configurations are considered.

The main feature of SESLAB is the flexibility intended as the capability to vary the most important parameters, components and configurations relevant for the design selection and development process.

Under this approach SESLAB is capable to simulate a family of vessels (named *target family)* which dimensions and performances can vary within a wide range covering most of the present and future trend in the area of the medium-large size SES vessels.

3 Introduction

The demand of future fast transport leads to the need of studying the feasibility of SESS with displacement of at least 5000 t and speeds over 50 knots. The difference in the size between existing and required ships is related to a level of uncertainty in the design both of the vessel and of all the main components as fans, seals, ride control systems and propulsion system.
The approach followed up to now in designing small SESS has been strongly related to extensive experience on prototypes of smaller size: the technological risk is strictly related to the design phase at which the allowable numerical and experimental design procedure are not sufficient to guarantee the quality of the design.
Due to this aspects, a new large SES design requires an experimental experience on a large prototype and it is evident that a specific prototype is extremely expensive.
For this reasons it will be extremely useful a SES model able to fill the gap on the experimental design tools in order to guarantee a reliable design of large SESS.
Within this strategic context, the Project is aimed to the design and the development of a new experimental tool able to simulate large SES to be employed in combined transport of persons and commodities on infra-area and inter-area routes. The Project is addressed to a simulation tool related to a family of vessels of medium-large size facing the future market demand.

The main expected technical objectives are:

- The design of an experimental tool useful to perform systematic investigations at sea on the most significant parameters which characterise SES performance
- The design of a flexible model able to simulate at sea the behaviour of a wide range different type and size of SESS

* The design of an experimental tool which enables:
  - Improvement of fan design and technologies
  - Improvement of seal design
  - Improvement of manoeuvring and seakeeping behaviour of SESs

The different competencies available inside the consortium were addressed and integrated in the development of the different part of the project:

Cetena was involved in the following activities:

- definition of design guidelines
- specification of experimental requirements
- platform concept design
- design integration and management
- measurement system specification and design
- shore facilities design
- test procedure definition and specification

Fincantieri was involved in the following activities:

- detailed design drawings
- SESLAB construction cost evaluation

Bazan was involved in the following activities:

- general arrangements and system integration
- weight breakdown and stability evaluation
- cost benefit evaluation
- functional test specification

Emit was involved in the following activities:

- definition of body plan and hull hydrodynamic evaluations
- structural design and F.E. evaluations

Air Vehicles was involved in the following activities:

- specification of experimental requirements
- specification and design of the lift system

Avon was involved in the following activities:

- specification of experimental requirements
- specification and design of the seals system

Lips B. V. was involved in the following activities:

- specification of experimental requirements
- specification and design of the propulsion system

Riva Calzoni was involved in the following activities:

- specification of experimental requirements
- specification and design of the RCS system

4 Technical description

To pursue the objectives previously described, the Project was structured into 5 Tasks:

- Task 1. Design of SESLAB
- Task 2. Main Systems Design
- Task 3. Test and Instrumentation Design
- Task 4. Characterisation of the SESLAB
- Task 5. Design Development

The scope of Task 1 was to define the range of overall characteristics for the fill-scale ships which make up the target of model based emulation in order to design the flexible manned model laboratory.
The scope of Task 2 was to develop the design of the systems necessary to lift and propel the SESLAB taking into account the flexibility requirements.
The scope of Task 3 was to develop the design of the instrumentation needed to carry out all the possible tests on the SESLAB.
The scope of Task 4 was to evaluate the impact of the design technological solutions on the cost elements in order to determine the cost/benefit ratio and to develop the handbook of the experimental test procedures that the SESLAB will can-y out.
The scope of Task 5 was to develop the detailed design and technical specification of the SESLAB and the estimation of its building and operating costs.

Each of the above mentioned Tasks was developed and integrated with the others by adopting the interactive process typical of the ship design and called “basic design spiral”..

Under this approach, five different design loops each addressed to a specific scope were performed

Pre Feasibility Design

- definition of the experimental features to be pursued
- specification of the design requirements and targets
- pre feasibility assessment by means of development of alternative
- concepts designs and by means of trade off studies
- tentative definition of the point design

Baseline Design

- selection and development of most viable design solutions
- preliminary specification and design of platform and main systems
- definition and specification of the measurement system

- preliminary evaluation of SESLAB performances
- point design refinement

Mid Term Design

- final selection of design solutions to be developed
- intermediate platform and main system design
- interrnediate evaluation of the SESLAB performances
- definition and specification of the test topologies and procedures
- development of the measurement system
- definition of the final point design
- preliminary cost estimation and cost/benefit evaluation

Final Design

- final design definition of platform, main component
- final design definition of experimental and measurement systems
- final SESLAB specification
- final evaluation of SESLAB performances
- assessment of the point design
- intermediate cost estimation and cost/benefit evaluation

Detailed Design

- development of the detailed drawings and specification,
- concept design of the shore facilities,
- definition of the SESLAB exploitation plans in view of the main components development,
- definition of the SESLAB functional tests,
- final cost estimation and cost/benefit evaluation.

During all the scheduled design loops, the design of the SESLAB main components (platform, lift system, seals, RCS, propulsion and laboratory) was co-ordinated in order to obtain an homogeneous development of the single activities performed by different partners, to guarantee the proper platform/main components integration and at the same time the fulfilment of the whole SESLAB design with the initial objectives and the stated mission profile. To obtain this goal the introduction of design Guidelines, in which all the relevant standards, definitions and units to be used are given, and the development of a pre-feasibility design study were scheduled in the first six months period. All the expected results from the **Prefeasibility Design** phase were obtained, more in detail:

- a family of vessels which design and construction implies a significant technological and economical risk was defined on the base of a market oriented analysis and adopted as SESLAB simulation field
- the feasibility of the SESLAB was assessed through the definition of two alternative platform configurations, the dimensions and the main characteristics of these configurations were defined by means of a market analysis and monographic trade off studies (structures, engine typology, etc); in particular the dimensions were chosen by balancing the need of large sizes to make the vessel weight match the scaled one and the need of small sizes to contain costs and technological risks,
- secondly a critical analysis of the SESLAB performances in terms of flexibility was performed, some incompatibilities and discrepancies were found between mission profile and flexibility requirements from one side and design demands from the other side, which led to reconsider the initial requirements and thus select only the strategic ones on a priority base,

The **Baseline Design** was mainly addressed to:

weight reduction by means of a design optimisation,
- preliminary cost analysis in view of a first cost comparison,
- deeper platform/main component integration,
- definition of a choice rationale based on the initially stated performances/flexibility features.

This phase was successfully performed with the following results:

a minimum weight was found, further weight reductions, which can be mainly obtained by reducing structural scantlings, are not applicable unless increasing costs and technological risks (production practice),
SESLAB flexibility features were optimised; the final selection (of both features and features range) was based on a risks/benefits analysis and giving the priority to those which result strategic for the SESLAB effectiveness and competitiveness, in this respect a reduction of the L/B range was applied for the lower displacements (from 3.5÷6.5 to 5.0÷6.5);this is possible because for very large SES lower L/B ratios are out of the practical interest,
the L/B variation shall be performed on shore or in a dry-dock; the breadth change in loading conditions leads to heavy, sophisticated and expensive solutions,
none of the alternatives developed during the Prefeasibility Design fulfil all the simulation field defined by the target vessel family, more specifically not all the L/13 versus Displacement (only the 78%) combinations are available due to-a weight-excess,
- an alternative platform configuration [solution C) was introduced and selected for the Mid Term Design phase, being an hybrid between solution A and B; this solution derives from an optimisation process addressed to reduce as much as possible the disadvantages of the two former ones.

The Mid Term Design phase was mainly addressed to further develop the finally selected configuration, to integrate and armonise the different main components and the platform as well as to reach a final optimisation of the mission profile, of the operative and experimental requirement.

During this design phase, the final platform configuration was selected. This configuration was the result of compromise among flexibility requirements, building easiness, weight optimisation and structural effectiveness. This configuration consists in a combined design, with three inserted resistant deck structures at bow, in the middle, and at the stern of the ship. The bow and the stem inserts will deal with the loads to due the seals. In order to meet the flexibility requirements of the provided seal location, to minimise the structural weight, and to simply the air tight system design, two identical deck cut outs, where designed in between the three mentioned resistant deck insert.

In order to optimise the design, the SESLAB simulations capabilities as well as the range of the simulated family of vessels were redefined in order to make them match more closely with the actual SES design practice; in particular not realistic parameters combinations were eliminated.

The hydrodynamic performance, in off cushion as well as in on cushion mode, have been successfull y evaluated. Stability has been evaluated in both operative conditions for intact and for damaged ship when the craft is at rest or sailing at forward speed along a straight path. When applicable, IMO criteria have been applied and satisfactorily accomplished.

Furthermore during this design phase a better integration among the cushion and the RCS components was performed, all the relevant parameter combinations as well as the cushion dynamics were analysed in all the possible operative conditions (displacement, L/B, speed, sea state). As a result of this activity the point design of the different systems related to the cushion was

reviewed in order to obtain an optimum balance between the performances of the single components and those of the overall system. The analysis and definition of the behaviour of the cushion system as a whole in rough seas was introduced. The annexed Table 1 contains the SESLAB point design.

The last two design phases **Final** and **Detailed Design** were addressed to further detail the vessel design stating from the Mid Term Point Design, the final evaluations of the SESLAB performances both from the nautical and from the experimental point of view were carried out.

The most relevant result of the Final Design phase is that the design drawings were submitted to a classification society (Italian Naval Register) in order to obtain a pre-certification of the performed drawings and calculations

The pre-certification analysis is based on the safety and operational requirements given by the new I. M. C). High Speed Craft Code taking into account the specific singularities of the vehicle and its operative purpose.

The impact on the design arrangement on the weight and costs of this analysis was taken into account during the Detailed Design phase.
The cost evaluation was performed following, where possible, the typical preliminary cost evaluation procedure currently used by shipbuilders, **A** direct estimation was performed for all those parts or details far from the common ship construction practice.

As the main conclusion, the cost analysis showed, that it is possible to obtain from the SESLAB not very expensive data related with SES technology free of scale effects. The cost of these "free of scale effects data" is about of the same order of magnitude than the price to be paid for a complete SES model test programme performed in any of the most relevant European model basins.

The test programme and the procedures for each single test typology were defined and standardised taking into account the SESLAB experimental capabilities. An user manual was issued containing all the necessary information to perform the experimental campaign (test selection, measurement features, data acquisition and analysis, results presentation).

5 Results

The main feature of SESLAB is the flexibility intended as the capability to vary the most important parameters, components and configurations relevant for the design selection and development process.

Under this approach SESLAB is capable to simulate a family of vessels (named *target family)* which dimensions and performances can vary within a wide range covering most of the present and future trend in the area of the medium-large size SES vessels.

For practical reasons the target family is defined by two vessels which represent respectively the higher and the lower ends of the simulation size range (length range 65+160 m, displacement range 500÷5000 t; speed range 40÷70 kns). The choice of these two vessels is based on a marked oriented statistical analysis refined during the SESLAB design to obtain a better balance among the SESLAB performances, costs and technological risks.

The SESLA13 main dimensions were chosen as a good compromise between two different requirements:

- SESLAB should be as close as possible to the full scale dimensions of existing medium SE% to reduce as such as possible the scale effects acting on the performance simulation;

- when dealing with large size SESs, scale ratio should be intermediate between towing tank actual practice and unity.

A fine tuned scale ratio and mus or the main dimensions was finally obtained by means of trade off studies in which the effects of a scale ratio variation on the SESLAB performances are investigated.

The SESLAB main flexibility features can be summarised as follows:

- Variation of the Full Loaded Displacement of up to the 35% of the light weight by means of water ballast systems

- parametric variation of the cushion length over beam ratio from 3.5 up to 6.5 by means of proper deck fitted onto the cross deck

- capability to measure the wet deck submergence (slamming) occurrence for different wet deck heights

- capability to adjust the natural heave frequency of the cushion by means of instantaneous variation of the cushion stiffness

- possibility to chose among 3 different bow and stern seals concepts, alternative seals air supply means, variable bow and stem seals longitudinal positions

- possibility to chose among 4 different main lift locations and adjust the air flow and pressure by varying the number of intakes and fan speed

- integrated RCS based on Air Cushion Vent Valves, Air Cushion Inlet Guide Vanes, "T foils", Seal Vent Valves

- possibility to change the geometry of the water jet intake and impeller

The tests which can be performed with SESLAB can be shared into four main topologies:

- Powering

The speed/power curves of the vessel in calm water will be investigated during such trials, whose aim will be the prediction of large size SES performance.

Effects of trim at rest (i.e. LCGs), cushion/seal pressure (Pc/Ps) and Lift/Weight (L/W) ratio on powering performance will be investigated, too.

- Manoeuvrability

The assessment of the manoeuvring parameters, namely turning ability and pull-out, will be carried out in calm waters by carrying out standard tests such as turning circle and zig-zag manoeuvre, at changing speed, rudder angle, etc.., with the parametric variation listed above.

- Seakeeping

Ship Motions in rough waters will be measured and computer model validated. The investigation will include an assessment of degradation of vessel performance due to sailing in rough seas (i.e. added resistance in waves).

A combination of parameter variation as above with changing speed and wave intensity is intended to be investigated.

- Lift System Start-up

Ship Motion on-cushion with the Lift System in operation and the Propulsion System stopped will be performed considering also the possible type of seal, fan etc., and monitoring the Lift power.

6 Conclusions

To conclude it is possible to point out some consideration about the performed work and the obtained results:

- this research represents an effective example of cooperation among European shipbuilders, manufacturers and research institutes in order to face the competitiveness of Far East industries engaged in the marine field
- this research has shown the SESLAB technical and economical feasibility.
- the technical feasibility has been confirmed by the detailed development of the design.
- the economical feasibility has been carried out comparing the operating SESLAB costs with the price to be paid in any of the most relevant European model basins

7 Acknowledgements

The Project **"Development of an experimental tool for design of large SES fast ships"** was developed in the framework of the Brite/Euram II Programme

8 References

Within this Project the following technical reports were carried out:

Title	Issuer	Date
Report on detailed project planning	Cetena	01/95
Platform experimental test requirem.	Cetena	09/94
Fan System experimental test requirem	Air vehicles	08/94
Seal experimental test requirements	Avon	08/94
Propulsion experimental test requirem.	Lips	10/94
R.C.S. experimental test requirements	Riva Calzoni	08/94
Preliminary specification of experimental test requirements	Cetena	07/94
Final specification of experimental test requirements	Cetena	10/94
Preliminary choice of fan system configuration for Baseline Design	Air vehicles	01/96
Preliminary choice of seals system configuration for Baseline Design	Avon	08/94
Desire Guidelines Report	Cetena	05/94
Pre-feasibility Study Report	Cetena	09/94
BLA-Propulsion Preliminary Prediction	Emit	11/94
BLB-Propulsion Preliminary Prediction	Emit	11194
Report on SESLAB Hydrodynamic Perform and related drawings for Baseline Desire	Emit	11/94
BLA - Longitudinal Strength Check	Emit	11/94
BLB - Longitudinal Strength Check	Emit	11/94
PF - Laboratory Equipment Definition	Cetena	08/94
BLA-Laboratory Equipment Specificat.	Cetena	11/94
BLB-Laboratory Equipment Specificat.	Cetena	11/94
BLA-Laboratory Instrumentation Specification.	Cetena	11/94
BLB-Laboratory Instrumentation Specification	Cetena	11/94
BLA-Laboratory General Specification	Cetena	02/05
BLB-Laboratory General Specification	Cetena	02/'05
Preliminary choice of propulsion system configuration for Baseline Design	Lips	11/94
Preliminary choice of cushion control system configuration for Baseline; Design	Riva Calzoni	12/94
Report and drawing set of SESLAB general arrangement for Baseline Design	Bazan	11/94
Reports on SESLAB Structural Design and related drawings (including mid-ship section) for Baseline Design	Emit	11/94
Hydrostatic, Stability and Weight breakdown report for Baseline Design	Bazan	11/94
Report and drawing on the preliminary gauges plants and measurements system configuration for Baseline Design	Cetena	02/95
Report on flexibility and measurements requirements for Baseline Design	Cetena	12/'94
Report on the software tool requirements (including data analysis requirements and local network software requirements)	Cetena	02/95
Baseline design report	Cetena	03/95
Mid Term design report	Cetena	11/95
Report of technical specification of the SESLAB for Mid Ten-n Design	Bazan	10/95
Report on Auxiliary system configuration for Mid Term Design	Bazan	10/95
Report on SESLAB Hydrodynamic Performance and related drawings for Mid Term Design	Emit	12/95
Report on SESLAB Hydrodynamic Performance for different target vessels configurations	Emit	11/95

Title	Issuer	Date
Report on SESLAB Hydrodynamic Loads for different target vessels configurations	Emit	09/95
Report on SESLAB Hydrodynamic Propulsion Requirement for different target vessels configurations	Emit	11/95
Reports on hydrodynamic design of RCS control surfaces	Emit	09/95
Reports on SESLAB Structural Design and related drawings (including mid-ship section) for Mid Term Design	Emit	07/95
Report on the definitions of the SESLAB structures and their characterisation with respect to flexibility requirements	Emit	06/96
Rep. on possible alternative structural solutions	Emit	01/96
Structure drawings	Emit	06/95
Report on the3D overall Finite Element calculations	Emit	06/96
Report on the 3D F.E.calculations on a transversal strip of the chosen solutions in the loading conditions (one waterborne and two on cushion) for two L / B ratios	Emit	06/96
Report on 3D F.E. calculations on structural design for local structural design	Emit	06/96
Hydrostatic, Stability and Weight breakdown report for Mid Term Design	Bazan	10/95
Reports of the SESLAB lift system design (including drawings and technical specification) for Mid Term Design	Air vehicles	03/95
Report on fan system delivery requirements including compensation of cushion air compressibility	Air vehicles	06/95
Reports of the SESLAB seal system (including drawings and specification) for Mid Term Design	Avon	06/95
Report of the SESLAB cushion control system design (including drawings and specification) for Mid Term Design	Riva Calzoni	07/95
Report on valve definition and valve actuator design criteria	Riva Calzoni	07/95
Report on integrated RCS study	Riva Calzoni	07/95
Reports on the SESLAB propulsion system (including drawings)for Mid Term Design	Lips	03/96
Report on measurements requirements Mid Term Design	Cetena	05/95
Report and drawing on gauges and analogic preliminary design (including configuration and characteristics) for Mid Term Design	Cetena	08/95
Report and drawing on the preliminary design of digital processor and data acquisition system for Mid Term Design	Cetena	08/95
Report on configuration variation system	Cetena	06/95
Report on the SESLAB cost/benefit analysis for Mid Term Design	Bazan	10/95
Handbook of the SESLAB test capability	Cetena	03/96
Report on cost assessment for the Mid Term Design	Fincantieri	03/96
Final design report	Cetena	6/96
Report and drawings set of SESLAB general arrangement for Final Design	Bazan	03/96
Report of technical specifications of SESLAB for Final Design	Bazan	03/96
Report and conceptual drawings of the system for the Final Design	Bazan	03/96
Report on SESLAB Hydrodynamic Performance and related drawings for Final Design	Emit	12/95
Reports on SESLAB structural design and related drawings (including midship section) for Final Design	Emit	03/96

Title	Issuer	Date
Compartimentation and capacity plan for the Final Design	Bazan	03/96
Hydrostatic, stability and weight breakdown report for Final Design	Bazan	03/96
Reports of the SESLAB lift system design (including drawings and technical specifications) for Final Design	Air vehicles	09/96
Report on the procedures for changing the SESLAB lift system configuration	Air vehicles	07/96
Reports of the SESLAB seal system design (including drawings and specifications) for Final Design	Avon	02/96
Report on the two optimised final design solutions	Avon	02/96
Report on the procedures for changing the SESLAB seal system configuration	Avon	05/96
Report on control algorithms design criteria	Riva Calzoni	04/96
Report of the SESLAB cushion control system design (including drawings and specifications) for Final Design	Riva Calzoni	03/96
Report on the procedure for changing the RCS configuration according to seal and lift configuration	Riva Calzoni	04/96
Report on the two optimised final design solutions	Riva Calzoni	04/96
Reports of the SESLAB propulsion system design (including drawings) for Final Design	Lips	06/96
Report on the two optimised final design solutions	Lips	06/96
Report on the procedure for changing the SESLAB hydro-jet intake configuration	Lips	06/96
Report and drawings on the design of digital processors and data acquisition system for Final Design	Cetena	01/96
Report and drawings on gauges and analog instrumentation final design (including experimental gauges test results) for Final Design	Cetena	01/96
Report and drawings on instrumentation wiring and interconnection design (including detailed gauges plant, instrumentation, interconnection plant and arrangement) for SESLAB Final Design	Cetena	05/96
Report on the SESLAB software tools for data acquisition, elaboration and analysis (including instrumentation management software and local network software) for Final Design	Cetena	05/96
Report on the SESLAB cost/benefit analysis for Mid Term Design	Bazan	10/95
Report on the SESLAB cost/benefit analysis for Final Design	Bazan	04/96
Handbook of the SESLAB test capability	Cetena	03/96
Report on cost assessment for the Mid Term Design	Fincantieri	03/96
Design of the shore facilities to perform the L/B variation	Cetena	06/96
Report on the structural behaviour of the SESLAB during the ashore operations for L/B variation	Cetena	08/96
Report on the experimental exploitation of the SESLAB with respect to lift system	Air vehicles	08/96
Report on experimental exploitation of the SESLAB with respect to seal system	Avon	09/96
Report on the experimental exploitation of the SESLAB with respect to RCS	Riva Calzoni	07/96
Report on the experimental exploitation of the SESLAB with respect to water-jets	Lips	09/96
Report on the detailed SESLAB sensors arrangement	Cetena	08/96
Detailed drawings of the SESLAB design	Fincantieri	08/96

Title	Issuer	Date
Technical specification of the SESLAB	Fincantieri	08/96
Test plan for the SESLAB sea trials	Bazan	07/96
Test plan of shore facilities	Bazan	07/96
Report on the SESLAB cost breakdown	Fincantieri	03/96

TABLE 1 **SESLAB** POINT **DESIGN**

GEOMETRY		
Full Load Displacement range	FLD	77+ 92.2 t
Overall length	LOA	37.0 m
Overall beam range	BOA	7.22 ÷ 11.64 m
Cushion length	Lc	33.14 ÷ 33.5 m
Cushion beam	Bc	5.16 ÷ 9.58 m
Lc/Bc range		3.5 ÷ 6..5
Maximum draft range	Hull borne	1.3 ÷ 1.46 m
Minimum draft range	Cushion borne (FLD max 90% lift) (FLD min 80% lift)	0.44 m 0.46 m
Wet-deck height	Hwd	2.55 m
Cushion pressure range	Pc	2.5 ÷ 3.6 kPa
Lift/weight ratio range	L/W	0.80 ÷ 0.85
POWER PLANTS		
Propulsion power		1130 kW
Propulsion type		2 x TURBOMECA Gas Turbine MAKILA TI
Propellers		2 x LIPS Waterjet
Lift power		4-6 Deutz Diesel EngineBF6M1013CP(195 kW) 4-6 Centrifugal AVL coaxial fans, double suction
Rear seal fan		1 x Land Rover Diesel Engine 200TDI (83 kW)
Electrical power:		2 x Diesel Engines Deutz TD 229-6 (65 kW) 2 x Generator set (75 kVA)
PERFORMANCE		
Top speed on cushion range SS.0		25 ÷ 38 knots
OPERA TIONAL		
Operational max wave height (H1/3)		up to 1.07 m
ENDURANCE		
Range in SS.0		6 h. at top speed and 2 h. at half top speed.

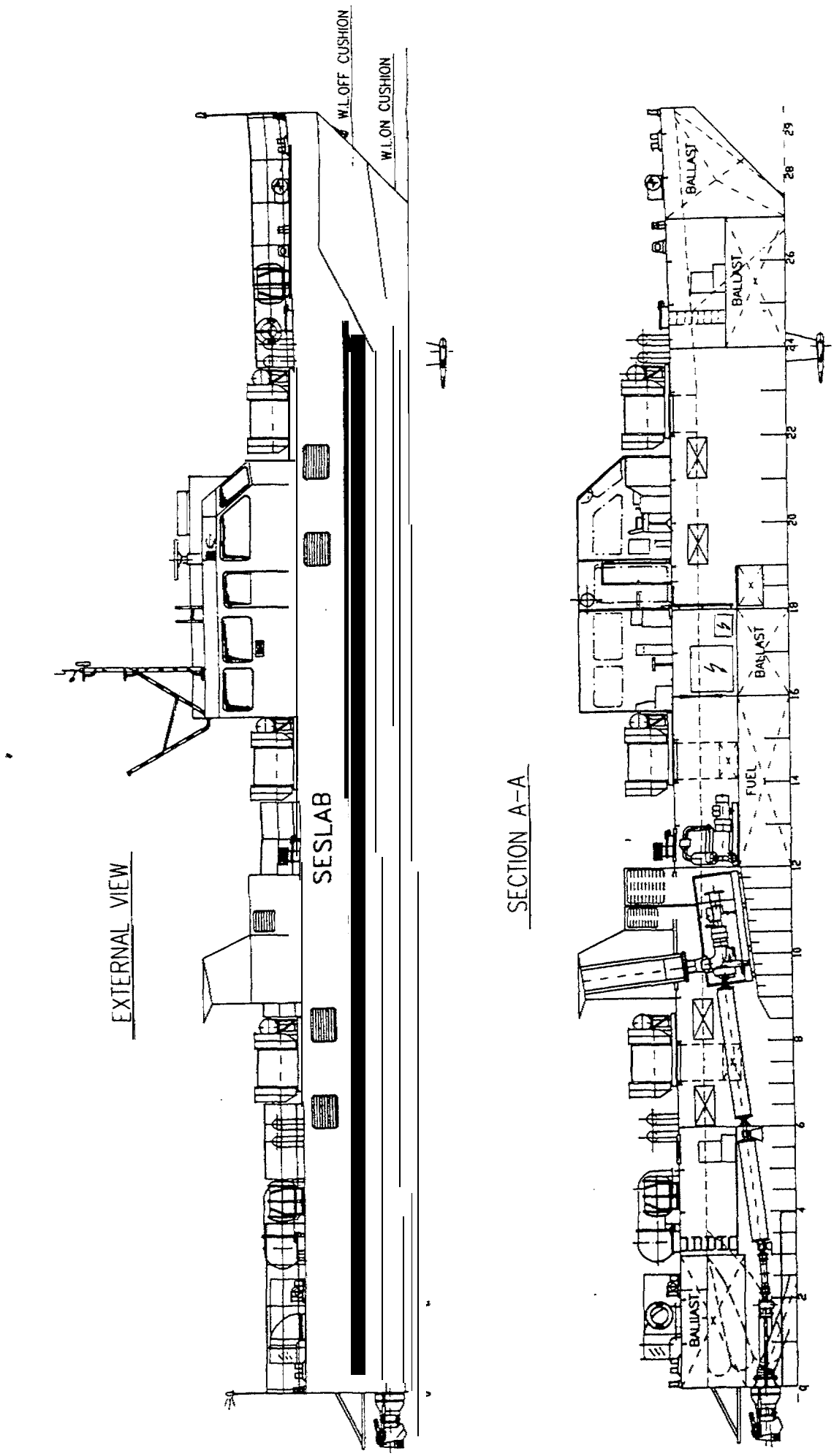


Fig 1: SESLAB General Arrangement: external view and longitudinal section

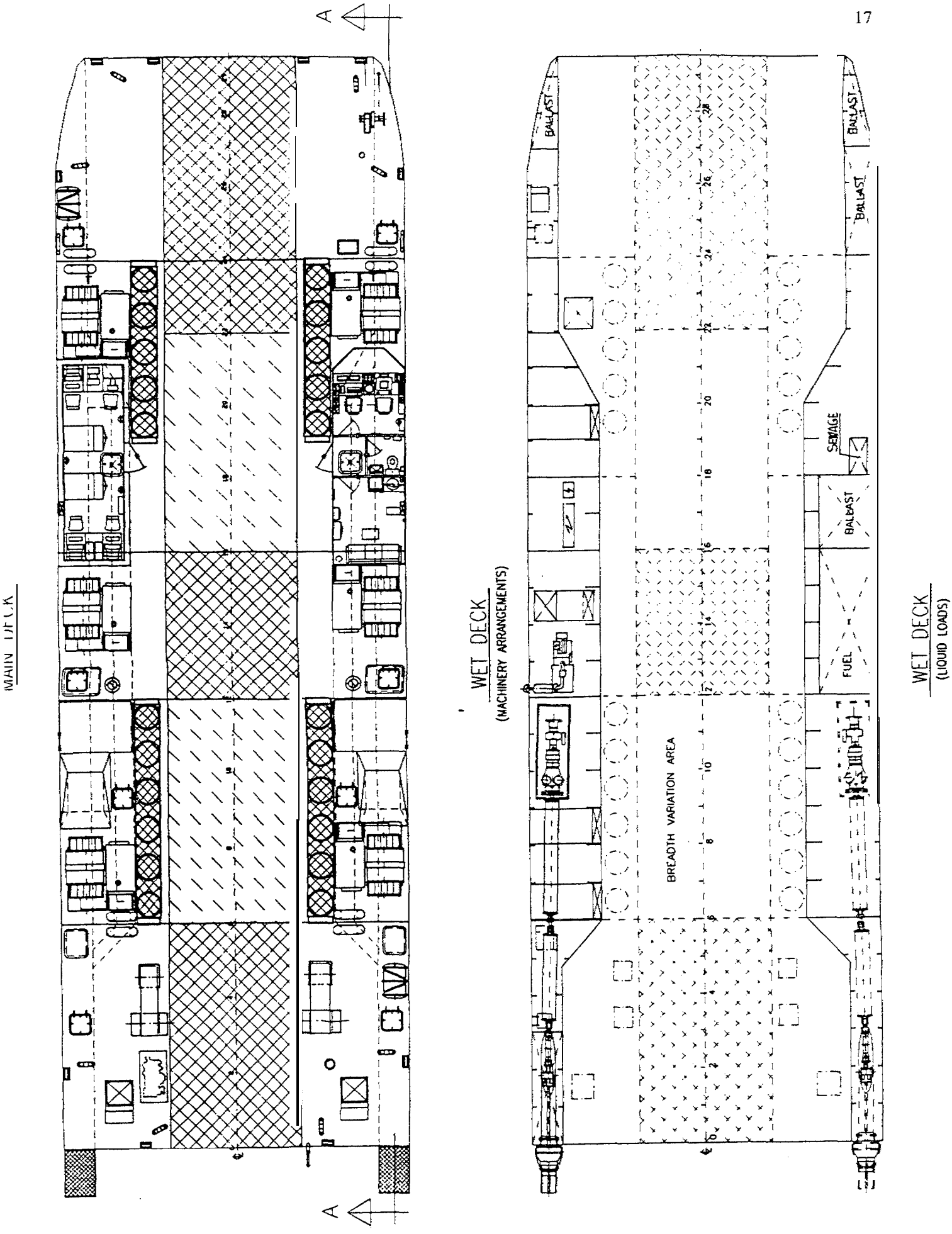
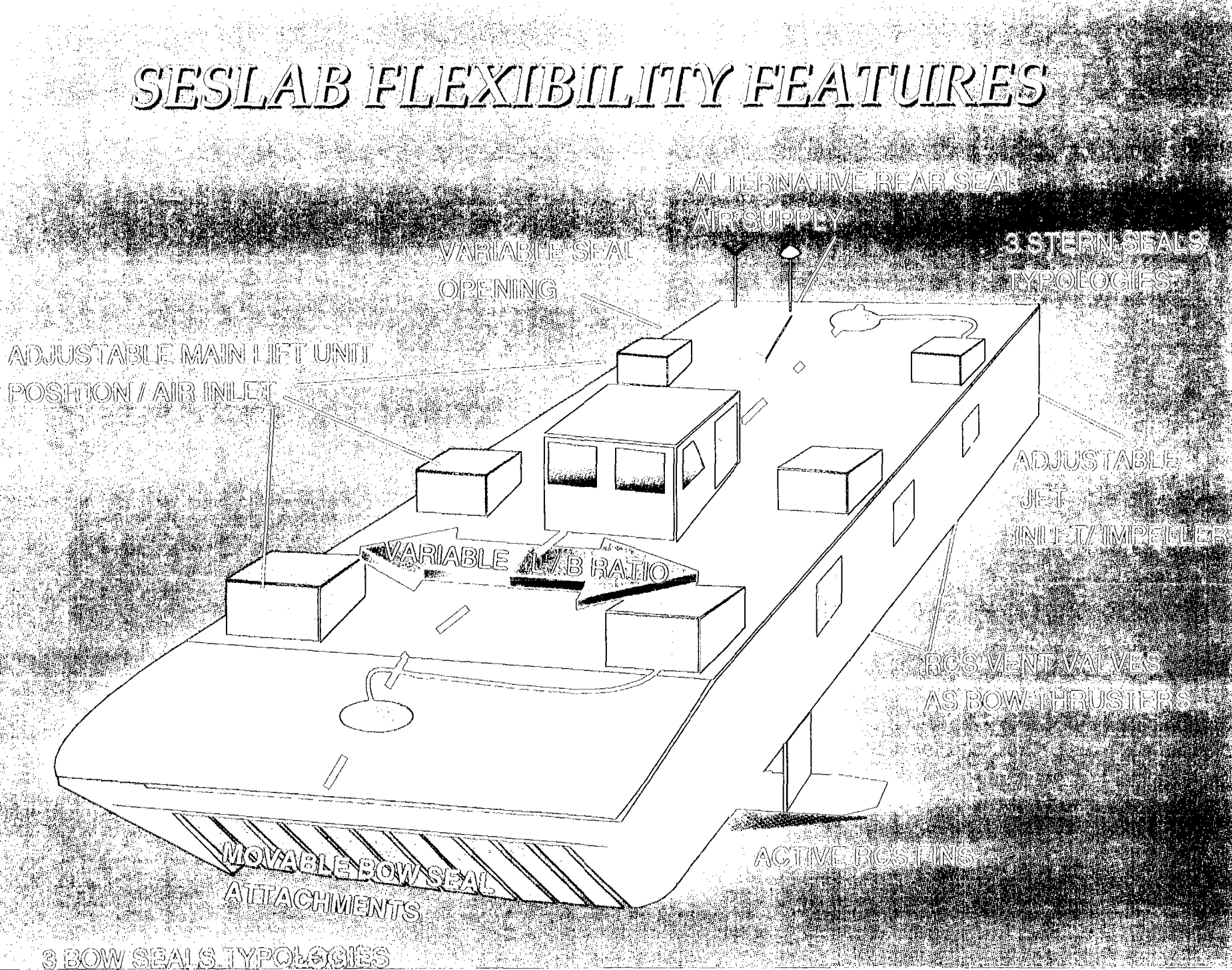
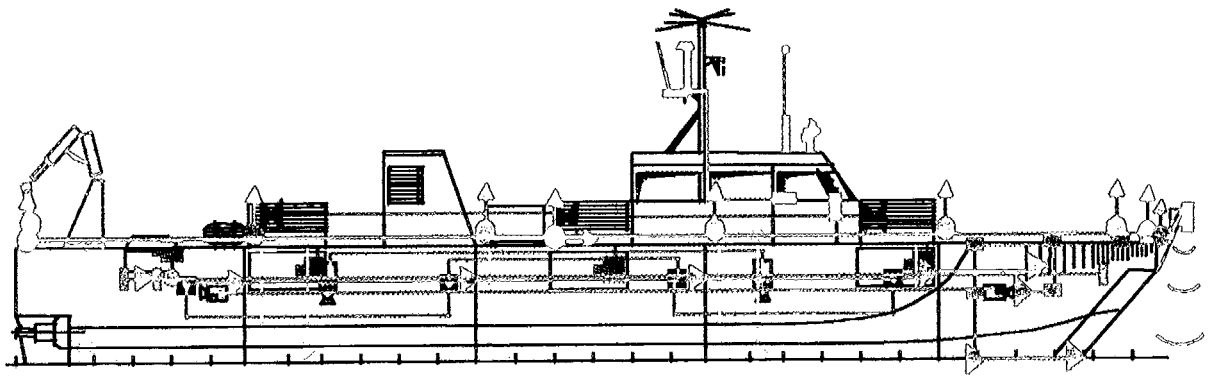


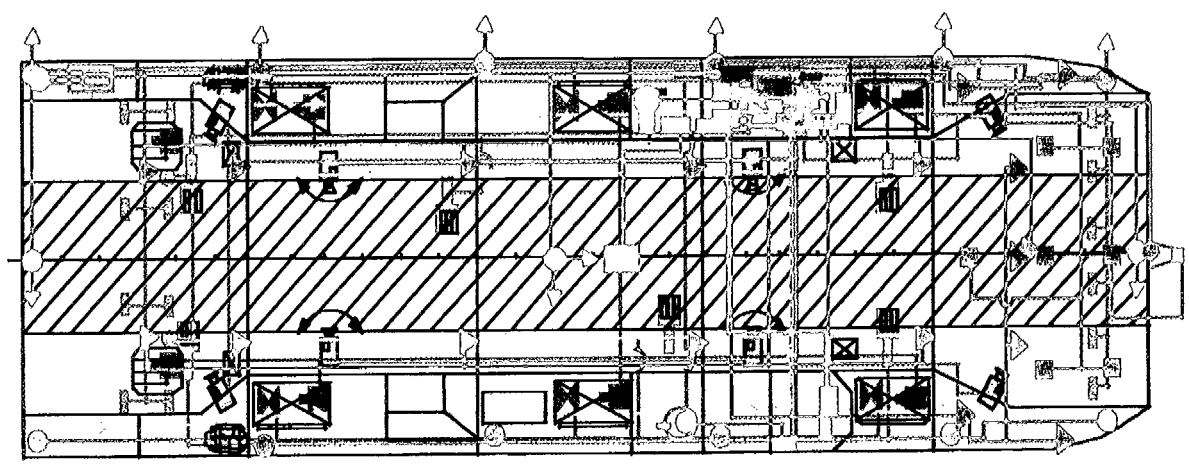
Fig 2: SESLAB General Arrangement: main deck and wet deck

SESLAB FLEXIBILITY FEATURES



MEASUREMENT SYSTEMS





SHIP MOTION MEASUREMENTS

FAN SYSTEM MEASUREMENTS

ENVIRON.COND. MEASUREMENTS

SIDE HULL VIBRAT. MEASUREMENTS

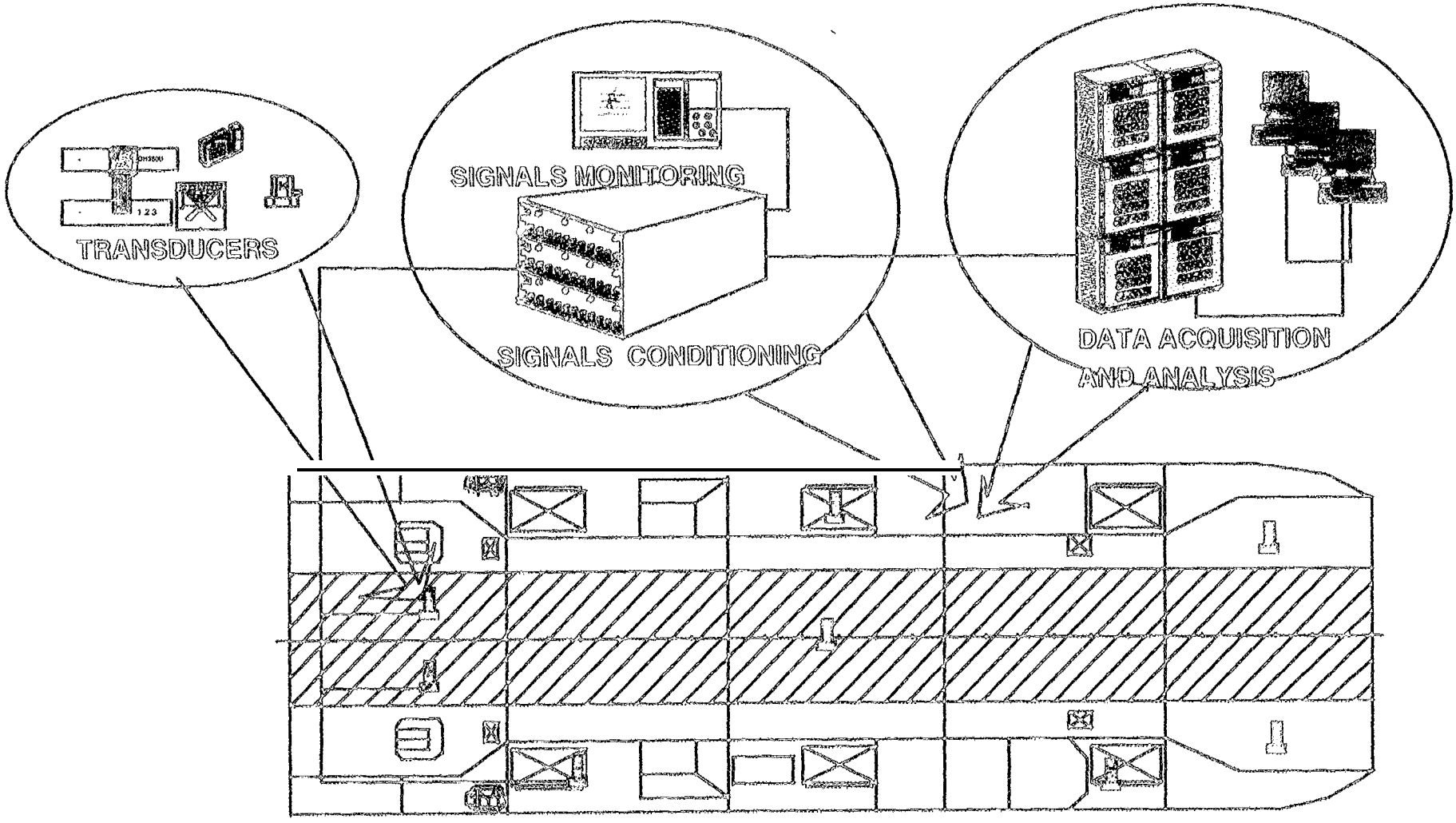
GAS TURBINE MEASUREMENTS

CUSHION PRESSURE DISTRIBUTION

SLAMMING FORCE AND OCCURRENCE MEASUREM.

DYNAMIC LOADS MEASUREM.

SESLAB LABORATORY ARRANGEMENT



STRUCTURAL DESIGN