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Catamaran Barges for Cargoes at Extreme Temperatures

Proposal: Submitted by
the Department of Naval Architecture
and Marine Engineering
to
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PROPOSAL TO
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CATAMARAN BARGES FOR CARGOES AT EXTREME TEMPERATURES

Submitted by
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Naval Architecture and Marine Engineering

THE UNIVERSITY OF MICHIGAN

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TITLE OF PROPOSED PROJECT

Catamaran Barges for Cargoes at Extreme Temperatures

RESPONSIBLE ADMINISTRATIVE OFFICER

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CATAMARAN BARGES FOR CARGOES AT EXTREME TEMPERATURES

A Proposed Feasibility Study

This proposal is stimulated by the observation that the ocean traffic in refrigerated and cryogenic liquid cargoes could be many times as great as it now is. A new concept in this transportation, free from the deficiencies of the present methods, would be generously rewarded.

1. THE PRESENT MARKET AND THE MEANS OF TRANSPORT

The present ocean traffic in liquified methane, anhydrous ammonia, and other low-temperature cargoes is very small compared with the potential demand. Alaska, for example, has a large supply of gas but no population to use it, while Japan has the population but no gas. Agricultural countries without the industrial facilities to produce ammonia could become profitable customers if transportation were cheap enough.

Low efficiency and high costs are confining the traffic to a few favorable markets. The solutions thus far obtained to the problems of this operation still result in high capital and operating costs per ton mile and cannot be said to have been sufficiently completed. Some principal deficiencies are as follows:

- o Provision for thermal expansion requires either very expensive rectangular tanks (patented) or cylindrical tanks that waste space.

The rectangular tanks are not only expensive in themselves but introduce difficult problems in supporting foundations.

- o Low cargo density results in inadequate draft in proportion to free-board, great sail area of the barge or ship, and commonly requires permanent ballast that must be transported at the same expense as paying cargo.
- o Manned vessels must comply with expensive safety requirements. Unmanned barges are difficult to tow at sea and have high resistance due to the drag of yaw-stabilizing skegs.

These are the reason why present methods of transporting low-temperature liquids are awkward and expensive. The demand for economical transport of such commodities is so great, however, as to stimulate the quest for methods not characterized by these costly and inefficient features.

2. THE POTENTIALITIES OF THE CATAMARAN

It is obvious that, provided sufficient speed can be attained without prohibitive power requirements, the unmanned barge can transport bulk cargoes more economically than can the conventional manned ship. This proposition hardly requires proof. For low-density cargoes, the catamaran offers the possibility of overcoming the principal disadvantages of the conventional barge:

- o The width of the catamaran in proportion to length inherently produces a greater stabilizing moment through the towing bridle and hence more willingness to follow the tug, less loss from yawing, and greater speed made good from point to point on given power.
- o The narrow pontoons of the catamaran produce less turbulence at the stern and hence enable stabilizing skegs to work with greater efficiency

--greater stabilizing moment with less resistance.

- o The slender pontoons of the catamaran have less wave-making resistance than the necessarily fat conventional barge.
- o The catamaran would never require ballast.

In addition to this potentially lower towing resistance, the catamaran concept offers the possibility of other economies not practicable with the conventional barge:

- o The demi-hulls, or pontoons, of the catamaran can be built entirely of tubular components, exploiting the well-known structural economy of the tube.
- o Tubular design would result in the simplest possible method of construction with maximum labor-saving.
- o Tubular hulls allow adoption of cylindrical tanks, much cheaper than rectangular tanks, without wasted space.

The potential profitability of a vessel having less towing resistance, being simple to construct, and able to employ low-cost tanks, is so great that this concept will eventually be investigated by some imaginative enterpriser. The first developer may obtain patent rights that will discourage competition.

3. THE NEED FOR RESEARCH.

On basic principles, definite reasons can be given for the possible advantage of the catamaran in transport of cryogenic or refrigerated liquids. No axiomatic statement can be made that that the scheme will not work, because no physical laws refute the hypothesis, and no catamaran for this service has

ever been tried. Nevertheless, probable as the advantages of the catamaran may be, there is at present no record of experience to build on, no history of mistakes to avoid in design, construction, or operation of such a concept. The answers to some questions are not yet known.

A catamaran does not automatically have less resistance than any given single hull. Exploitation of the peculiar qualities of the catamaran, however, may produce a level of performance not possible for the conventional hull under the circumstances. What are the design rules?

A catamaran of the same length and displacement as a single-hulled vessel has greater wetted surface area and hence greater frictional resistance, but generally less wave-making resistance, while at the same time the tow-stabilizing skegs on the single hull increase its resistance by 25 percent or more. Will the decrease in resistance of the catamaran because of its easier towability outweigh a possible increase because of greater wetted surface?

The structural design of catamarans is not a conventional exercise. How must the catamaran be designed for minimum steel weight? What are the proper strength criteria for catamaran structures? How are the structural problems to be solved?

While there is the possibility that tubular construction by simplified methods will cost less, it is possible that the steel weight of the

catamaran will be greater than that of the conventional barge lifting the same cargo deadweight. Will the extra material cost of the catamaran be balanced by saving in labor cost of hull and tanks?

Study of barge transportation economics must include not only the acquisition costs of barges but the capital and operating expenses of the entire system, including tugs and terminals. Will the catamaran system be more profitable than the conventional system, both operating under the same conditions?

An essential factor in the study of any operating system is the environment. Will the catamaran system be more profitable generally, or do its advantages obtain only in particular circumstances? What are these circumstances?

PROPOSAL

The University of Michigan, Department of Naval Architecture and Marine Engineering, proposes to undertake research for the purpose of answering the foregoing questions on the feasibility of catamaran barges to transport cryogenic or refrigerated liquid cargoes. This research shall be for the mutual benefit of a sponsor or a consortium of sponsors and the Department of Naval Architecture and Marine Engineers, its faculty and students.

The proposed research effort is to be divided into two phases. The first phase comprises investigation of the problem, identification of particular problem areas, concept formulation, analytical study of structure, mechanical engineering and thermodynamic requirements, resistance calculations, conceptual study of towing system requirements size of tugs, towing behavior, and speeds, the revelations of these studies then being applied to a simulated model of the operating system which can be analyzed parametrically by computer. The results of the Phase I effort would be embodied in a report to the sponsor showing the findings of the study and describing the conditions for feasibility of the catamaran concept. The results of Phase I would provide information for judgment on the advisability of proceeding into Phase II.

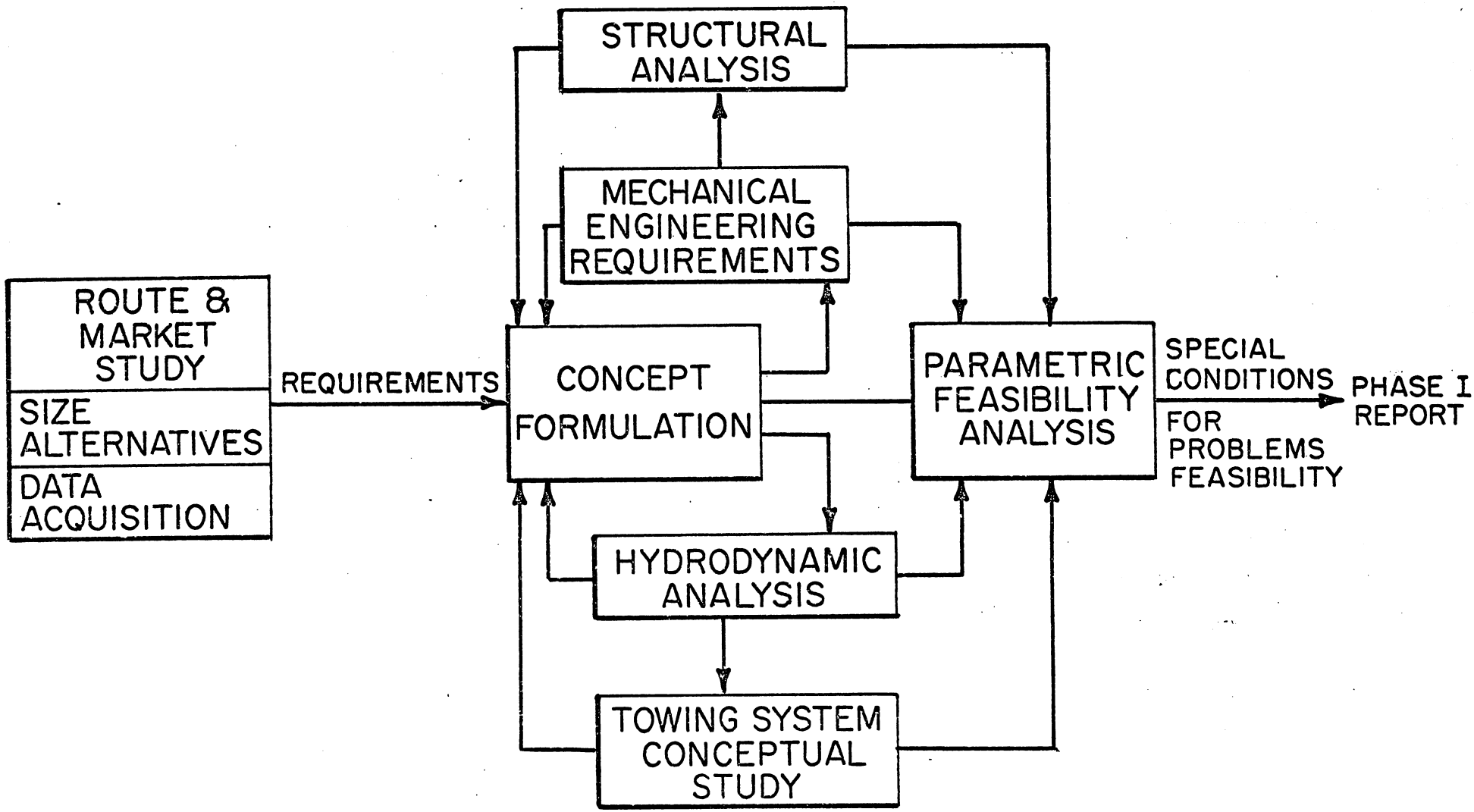
During Phase II specific concepts are to be formulated and evaluated. The effort during Phase II will comprise preliminary design of several concepts indicated by the discoveries in Phase I, hydrodynamic model testing, detailed structural analysis and weight calculation, description of the operational system including required tugs, and economic analysis including cost estimating, performance evaluation, and system profitability.

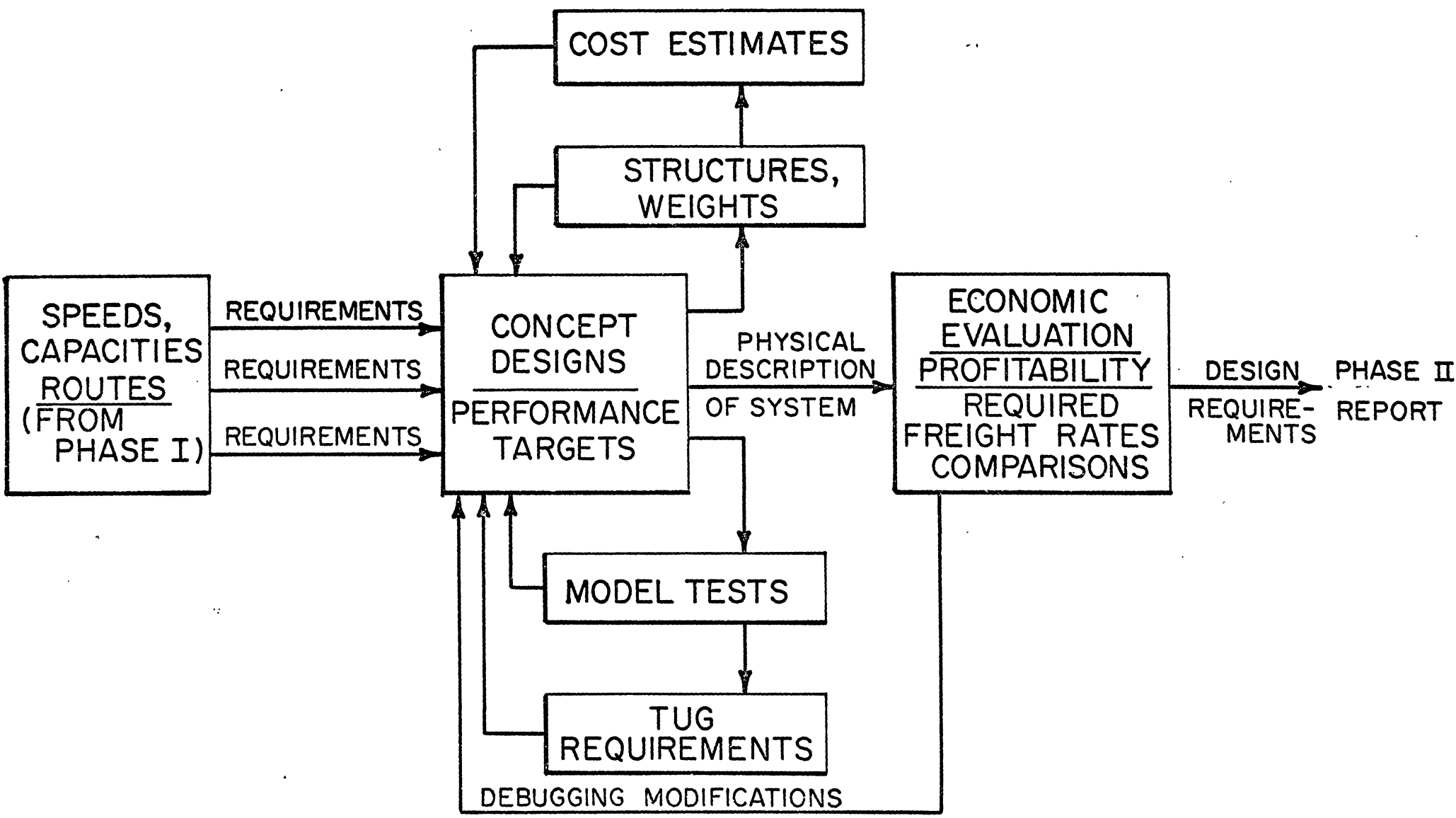
The Phase II report will provide the sponsor with design parameters, engineering criteria, particulars of hull form and structure, and general system requirements for proceeding into engineering design of an actual system.

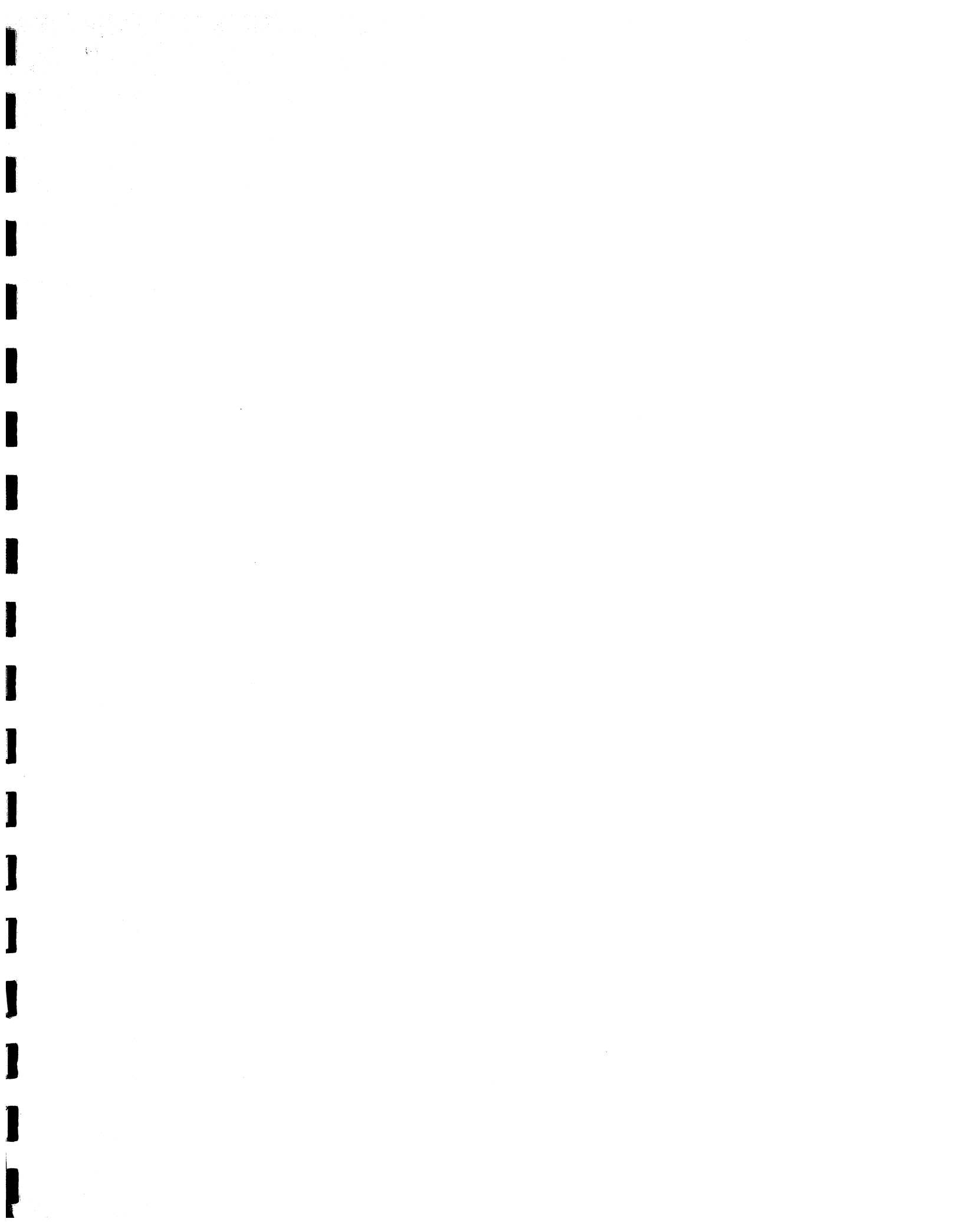
While the Phase I effort is not intended to produce an actual design for a gas-transport vehicle, it is imperative that the scientific background, the economic and physical environment, the principles of catamaran mechanics and hydrodynamics, be understood well at the beginning. The catamaran concept for cryogenic cargoes is entirely new. No reports in the literature supply any previous thoughts on the problem, except to suggest lower resistance due to narrow hulls. The first task must be to identify those problems requiring solution before a final feasibility study can begin. Before solution of these problems is undertaken, the most economical and reliable methods of solution must be found.

Analytical solutions must be tested by physical experiment in the most economical way possible. Most of the structural and hydrodynamic verification can be obtained in the University's model tanks, where resistance, towing qualities, and stresses can be measured. Discoveries during these tests will no doubt suggest modifications during Phase II. The work during Phase II should have answered all the critical questions and should supply all the basic information for final engineering design. The remaining engineering work after Phase II, in fact, should consist only of non-critical details.

The possibility that Phase II will not be reached, of course, must be acknowledged. There is at present not sufficient knowledge whether or not the catamaran gas-carrier will be profitable. Both sponsor and investigator must be prepared to accept an unexpected discovery during Phase I or later, showing that some fundamental law of physics forever precludes a successful vehicle of this description, or else that success must await further advances in technology. No such facts are visible at this moment. On the contrary, our opinion is that the concept has enough merit to warrant consideration.







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