Jack Davidson

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HEART STUDY

SEAGRANT

UNIVERSITY OF HAWAII

1972

HEART

A Study of the Hawaii Environmental

Area Rapid Transit System

Prepared for:

SEA GRANT OFFICE, University of Hawaii

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INTRODUCTION

Like most metropolitan areas, Honolulu has found a rapidly increasing population, placing increasing demand on local transportation facilities. This pressure results in an ever increasing rate of road congestion, pollution, and traffic accidents.

Construction of new and additional roadways has resulted only in increased usage and greater congestion. Elsewhere, complex cumbersome and inflexible solutions have been applied at high levels of cost, only to result in systems which appear beset with insoluble difficulties, leaving the public dependent upon a system of transportation based on obsolete thinking applied all too often in the "too little, too late" manner.

Honolulu, however, has major advantages placing the city in a superior position to deal with urban transportation problems:

1). The nature of the topography of Oahu is such that metropolitan Honolulu has been channeled into a narrow coastal zone between the mountains and sea, stretching from the Hawaii Kai area to Waianae.

2). The traffic problem in Honolulu has not yet reached a crisis condition, but this will not long hold true unless prompt, bold action is taken.

3). There presently exists a system of canals, located close to sea level, and extending through much of metropolitan Honolulu.

If these advantages are utilized, and a bold forward looking plan is immediately implemented, Honolulu may become the recipient of many benefits.

Taking advantage of the advance in ocean technology and the advent of the second generation of hydrofoil ships, high speed oceanic expresses can connect points such as Hawaii Kai, Downtown, the Airport, and Pearl City in times equal to or less than those presently required for conventional land transport over existing routeways. Inland canals can be modified to permit the use of comfortable, attractive, low pollution vessels for local service in an aesthetically pleasing setting, complemented by mini-bus runs, providing the necessary shuttle service.

This can be done at a cost substantially below that needed for any comparable means of mass transit, whether that cost be measured in dollars, time, or disruption to the community. The advent of new technology in this field can result in low pollution vessels, potential reduction in roadways, and a drastic reduction in the amount of heavy bus traffic, and most importantly: a flexible transportation system.

Vessels can operate on the waterways where required and may be used for many secondary purposes, such as sightseeing, charters, outer island trips, etc..

The application of old solutions to new problems, or the application of mainland solutions while ignoring the uniqueness of Honolulu's situation, will result only in the creation of new problems.

ACKNOWLEDGEMENTS

The generous amount of cooperation and assistance rendered by so many people make it extremely difficult to avoid overlooking anyone but in particular I should like to thank: Drs. John Craven, Jack Davidson, and David Bess, who made this study possible and wholeheartedly support it. Hollis Wright, Marlene Spencer and Gene Konrad who worked so diligently acquiring data and writing for this report. F.A. McHale, E. Ching, J. Perry Hawaiian Dredging, Mr. Sterling Production Manager of Dillingham Shipyard for their generous (and unpaid) assistance in obtaining construction costs. Ralph Patterson and Justis Mueller of Kentron-Hawaii, W.M. Schultz of Boeing for their assistance on the Boeing Hydrofoil. The National Research Council of Canada's Committee for ACV Technology and Mr. Ronald Shaw of Hoverprojects in England for their assistance on ACV data. Peggy Lucas, John Ball of Sea Grant, Ted Lee, Takeo Kikuchi and Steve Nicinski of Look Ocean Engineering Labs, Barry Hill of Marine Options and Chester Kaitoku, Administrative Intern for their aid and assistance. Dr. Matsuda, Admiral Wright of the State Dept. of Transportation, Mr. Carson of City of Honolulu Mass Transit Office, Mr. Magoto and W. Weatherford of Daniel, Mann, Johnson and Mendenhall (DMJM) for their taking the time to communicate and meet with us.

Finally, but not least, Mrs. Darlene Morioka and Jean Nakata, the secretaries at the College of Business who put up with us in spite of their many other duties and who generously assisted us.

ROGER PETERSON

PROJECT COORDINATOR,

PART I

SUMMARY

PART I

SUMMARY

The proposal to use Honolulu's canals as the basis for a marine mass transit system is not as revolutionary as it might appear at first glance. The canals of Venice, for example, have been used for many years for this very purpose, while ferry systems exist throughout the world.

The state of Washington, San Fransico, and London, to name only a few, are looking at the use of fast waterborne systems to solve some of their transportation problems.

Fast passenger vessel service designed for commuter use may be looked at either as a competitor to existing or projected land modes of transportation, or as a supplement to other systems. In this report they have been viewed as a closely knit partner to supporting bus (full or mini sized vehicles) and the assumption made that a fully integrated system will be required and instituted. This system must have the following criteria to be successful:

1. Generate a substantial traffic volume.
2. Offer a significant time advantage over other modes.
3. Offer a comparable fare structure.
4. Offer good access to residence and work areas.
5. Provide comfort, convenience and reliability.

Leeward Oahu's waters and the canals of Honolulu offer an extremely favorable environment for such a system. Tidal and weather conditions are of a very mild nature. However, considerable physical modification of the canal and bridge system will be required.

The non-commuter usage of such a system is of great concern, and its usage in off peak periods, particularly in the early stages of operation, subject to public acceptance are difficult to predict, should in the long run play an important part in the off-peak performance of the system.

The essential requirements for vessels in the service are:

1. Reliability of the standard demanded by commuters

2. Low noise levels

3. Fast berthing and loading

Calculations indicate that the usage of the proper vehicles will result in block speeds of 40 knots on express and 20 knots on local runs providing comparable or better performance than other modes.

The total capital outlay is expected to be approximately $200,000,000 and construction to be in the area of 2 years once all necessary approval is obtained.

The remainder of this part will be devoted to a summary of the methods used to arrive at the above conclusion and provide detailed information in each of the succeding portions of the report.

To determine patronage levels, a 1970 census study was used, which revealed that Honolulu had a 16% usage of mass transit by the population of the central city. This was compared with other urban areas in the U.S., which revealed that those cities with a designed and operating mass transit system had usage ranging from 23% to 85%, to insure realistic goals a figure of 25% usage was predicted for the HEART system. At this time the 1970 census results were studied, broken down into centers of population, the 25% figure applied and adjusted for predicted growth and the patronage prediction arrived at.

Construction and capital costs were arrived at after consultation with Look Ocean Engineering Labs and officals of Hawaiian Dredging and Construction Company for construction costs. Vehicle costs were determined by meeting and correspondence with organizations such as Boeing, Grumman, Lockheed, British Hovercraft, National Research Council of Canada, and others too numerous to mention in detail.

The same procedure was followed for operational costs with the addition of research of available publications in the University and public libraries and a great deal of information posessed by a member of the project team.

Economics and finance conclusions were the result of consultations with the Economics Department, and the college of Business of the University of Hawaii and extensive use of transportation texts and publications.

Legal and political were the result of surveys, presentations and interviews with such people and organizations as the Hawaii State Department of Transportation, U.S. Coast Guard, City and County of Honolulu, and an extensive review of media releases on the subject of mass transportation.

Finally, through the cooperation of an administrative intern at the state capitol, an extensive array of tax and engineering maps of the proposed routes and terminals was acquired and constitute Part X of the original copy of the report.

PART II

TOPOGRAPHY AND POPULATION

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TOPOGRAPHY AND POPULATION

I. INTRODUCTION

This particular section will cover the topography of the island of Oahu; the canal systems in question; and finally a patronage estimation and usage of the HEART system. In relating the canal system and patronage to the island of Oahu, terminal sites and capacity will be interjected through out this report.

A. Oahu Topography

The island of Oahu is the major populated island in the chain, approximately 2600 miles from the west coast of the U.S. The island is approximately 40 miles in length and 20 miles in width, with the Koolau mountain range bisecting the island of Oahu.

The area which this report will cover is from Hawaii Kai, southern part of the island, to the Waianae Coast in the North West cornor. The HEART system is projected to cover the west coast of the island, commonly known as the Leeward side.

The type of land on the island is of a volcanic nature with mountain ranges in the center, while the population is concentrated in the coastal zone of the island. The majority of this zone is located below the 10 foot contour line.

This 10 foot contour line, is very important to the HEART system. It means that the cost for dredging present canals to facilitate navigation of vehicles will not be enormous. Once past the 10 foot contour line costs triple in size. Thus the topography of the island is important in relation to present canal systems, and population which the system can serve.

Another area of importance, is the water surrounding this tropical island. Since the chain of islands are located in the center of the Pacific Ocean, no problem is seen of shortage of suitable water for Hydrofoil and other vehicle usage.

There is one minor area which must not be over looked, and that's the reefs surrounding the island. It's a minor point because there are only two particular areas in which channels will have to be built to accomodate the Hydrofoil operation, the entrance to the Natatorium, and at the Airport canal. The remaining entrances for craft have existing channels deep enough to allow hydrofoil usage.

Other factors pertinent to the water's surrounding the islands are wave height and storms. The area from Hawaii Kai to Waianae has a very small percentage of large waves and surging storms, due to it's location on the leeward side. Most storms converge on the north shore of the island thus haveing little effect on the HEART system. No problems are foreseen for vehicle usage.

B. Canal System

At this point the report will show how the present canal system on Oahu, has a large bearing on the topography of the island. The relation of the 10 foot controu line to the present canal system has a great bearing on the operation of the HEART system, for inland locals as well as shuttle vehicles.

The 10 foot contour line will also be important to the serviceability of this system in that the canals will be readily accessible to the population. This will be shown in the last section of the topography report.

The following chart will show the canals in question, their present condition, and inland potential in distance to the 10 foot contour line:

CANAL	CONDITION	DISTANCE TO 10' LINE
NIU	Cement lined portion of way, having several sharp curves. Housing quite close to c nal edge.	.37 miles
WAILUPE	Portion being cemented up stream, down stream being in quite bad shape. Housing once again quite close to c nal edge.	.37 miles
KAPAKAHI	The first 1/8 mile is wide enough for oceanic express, plus maintained. Remaining canal is quite narrow and no concrete. Also disecting a golf course.	.71 miles
NATATORIUM	At present no canal exists, from beach to Ala Wai canal. Canal is in the limits of the 10' line.	------
ALA WAI	The width of canal is sufficient, but depth has be corrected. Canal is cement lined at present. Within the 10' contour line.	------
MANOA-PALOLO	Cement lined, with housing up to canal edge. Canal is being maintained.	.4 miles (mountain side of H-1 freeway)
NUUANU	Width is sufficient, 120', and cement lined, so little work needed.	.64 miles
KAPALAMA	Fair condition, being cement lined with two roads running parallel to canal. No housing problem foreseen.	1.14 miles
MOANALUA	Cement line, but sharp curves which hamper vehicles, width seems sufficent located in a industrial area.	1.5 miles
AIRPORT	Canal only exists about 1/8 mile inland remaining needs to be land dredged with no interference with any type of building. All within the 10' contour line.	-------
KALAUAO SPRING	No cement lining, very narrow, crossing a throughfare. Limit of usage is to the Pearl Ridge Shopping Center. Area proposed is withing the 10' contour line.	-------

Realizing the condition of canals, and distance inland required, a very controversial question arises, that of ownership of canals, and the adjacent land. This question will have to be researched in great detail, since ownership of the canals is either city, state, fedeial, or privately owned, thus causing a great legal conflict (See Part VI, Legal & Political).

The following chart of canals and areas of service will show major owners of these particular areas:

AREA	CANAL	MAJOR OWNER'S
HAWAII KAI		Bishop Estate is owner with subleased adjacent land.
NIU VALLEY	NIU STREAM	City and County of Honolulu own from beach to Kalanianaole Highway, with 5' easement rights. From Kalanianaole Highway to 10' contour line ownership is very vague.
AINA HAINA	Wailupe Stream	A mixture of City and County of Honolulu and small land owners.
KAHALA	Kapakahi Stream	City and County of Honolulu own from beach to Kahala Ave., with parks adjacent to each side of stream. Remaining stream to the shopping center is owned in its entirety by the Bishop Estate.
NATATORIUM		Area completely owned by the City and County of Honolulu.
ALA WAI	Ala Wai	City and County of Honolulu are owner's and maintain the canal.
MANOA-PALOLO	Manoa-Palolo	Joint City & State up to Kapiolani Blvd. Remaining- canal has multi-ownership, with no form of easement rights.
HONOLULU HARBOR		
NUUANU VALLEY	Nuuanu	Complete ownership of canal by the C&C of Honolulu.
KALIHI	Kapalama	C & C of Honolulu owners up to 10' line, with 2 streets running parallel to canal.

AREA	CANAL	MAJOR OWNER'S
SALT LAKE	Moanalua Stream	Three major owners, being C&C of Honolulu State of Hawaii, and the Federal Government.
AIRPORT	Airport	Department of Transportation, State of Hawaii are sole owners of property.
PEARL HARBOR		U.S. Government has complete rights to waterways in area.
PEARL RIDGE	Kalauao Spring	Bernice P. Bishop Estate owns from beach to Kamehameha Highway. From Kamehameha Highway to shopping center ownership is not presently known.

As can be seen from the chart ownership varys between private and gvernmental agency control. A large legal entailment will occur in trying to acquire canals and adjacent land needed for widening of the canals.

There are three major canals where problems of acquisition will occur, being Manoa-Palolo, Niu Stream, and Wailupe Stream since housing has come right up to the canals with no form of easement shown. Not saying that problems will not arise in other areas, but these three areas are of the greatest concern.

The canal and stream system presently in existence in Oahu has a great potential for usage in the HEART system. Again the point the legal reprecussions should be stressed for the canal system, seen as the only real problem seen for canal usage by local and shuttle vehicles.

C. Population

Population will be dealt with by centers of population as served by the canal system, a patronage possibility in relation to the canal system, and fare structure.

To evaluate the first point, the following chart will show the population that exists around projected stops on the HEART system. These figures were obtained from the 1970 "Census by Tract", being approximately in a one mile radius of the projected stops:

AREA	STATION	POPULATION
Hawaii Kai	Hawaii Kai	12,572
Niu Valley	Niu	5,123
Aina Haina	Aina Haina	6,485
Waialae-Kahala	Kahala	30,819
Natatorium	Natatorium	7,342
Waikiki	DeRussy	13,124
Ala Moana	Ala Moana	6,919
Manoa + McCully	Manoa-Pallolo	104,830
Downtown	Honolulu Harbor	6,593
Nuuanu Valley	Nuuanu	39,416
Kalihi	Kapalama	57,015
Salt Lake	Moanalua	13,243
Airport	Airport	421,340
Hickam	Hickam	31,005
Pearl City + Aiea	Pearl Ridge	36,052
Waiphu	Middle Loch	16,134
Barber's Pt.	Iroquois Pt.	15,747
Waianae	Waianae	24,077

There are three stations that need to be explained in a greater detail. First, the Airport area, which includes only 5340 actual residents living in the area. The remaining 416,000 population is the influx of tourists arriving at the airport. Present figures show that 8,000 s trips each way to Waikiki are taken by tourists. The projected daily trips for 1980 is 14,000 trips each way to Waikiki which will almost double potential passenger population.

Next area in question is the Pearl Ridge shopping center stop. The population figure also includes Wahiawa, due to the potential usage of commuter traffic to the downtown area, and places of employment.

The last area is Waianae, which is actually a projected future stop, This particular area has a great growth potential, plus the people living in this area have the priority need for a mass transit system.

The last point to be made in population is the patronage potential of the HEART system. The method used was derived from the 1970 "Census of Tracts", and deriving a percentage of which the potential usage is projected.

The estimated yearly revenue passengers are 89,660,690. This was derived by using a figure of 25% for population on the prior chart. Then taking the 25% of population and using a verage of two trips per day over a one year period.

If the system becomes publicly acceptable, a national figure of 2% is used for a growth potential. Using the revenue expected, which follows:

89,660,690 Yearly Revenue Passengers
(ONE FARE)

RATE (cents)	TOTAL REVENUE	DAILY REVENUE
.50	$44,830,345	$122,822
.45	40,347,310	110,540
.40	35,864,276	98,258
.35	31,381,241	85,975
.30	26,898,207	73,693
.25	22,415,172	61,411
.20	17,932,138	49,129
.15	13,449,103	36,847
.10	8,966,069	24,564
.05	4,483,034	12,282

With the canal system in operation, approximately 80% of the Leeward population will be within a one mile radius of any express or local terminal.

In conclusion, the topography of the island creates a positive factor for the HEART system, in that the canals are available up to the 10' contour line, bein where the major portion of the population lives. Also the island is a coastal form of living, thus giving accessibility to the ocean a prime usage factor.

One other final point to be made is the fare structure of the HEART system. There seems to be only three plausible structures available: being one flat fare for the entire system; two fares, one being for a super express and remaining routes are the same rate; the last one being a zone fare, by dividing the island into several sections.

Also, not mentioned before is a free fare for the public, which would be widely accepted. But operation costs would be the big question arising from this form of operation. (See Part V)

PART III

VEHICLES

PART III

VEHICLES

I. MARINE VESSELS

The HEART system requirements dictate that a careful analysis be made of vessel characteristics and performance in order to achieve optimal efficiency and economy in usage.

There are in general, three types of routes within the system and these have been defined by speed requirements;

High Speed Oceanic Express routes: Here we have set requirements of block speed of 40 MPH. When making allowances for delays this means a cruise speed of 45 MPH.

High Speed Semi-Express routes: Routes that are not defined as express, but which have considerable distances between some or all of the stops and which will require cruise speeds of 35 MPH.

Locals: Inland, shuttle and short routes not requiring and incapable of utilizing excessively high speeds, cruise speed here has been set at 20 MPH.

To satisfy these needs, there are a number of various type and size craft available, each posessing its own characteristic strengths and weaknesses. Basically, these can be listed as:

Conventional Vessels
Planing Craft
Semi-Submerged Ship
Air Cushion Vehicles
Hydrofoils

Each type will be explored individually in the first part of the section. Then a comparison and conclusion portion will be presented. Finally , This section will be closed by appendices listing data and certain specific craft for informational purposes.

No attempt has been made, nor is there any claim made that every type or design has been presented here. Time and budget limitations prohibit such an undertaking and in addition one must always bear in mind the possibility of changes in technology. No greater mistake can be made than making an initial decision and ignoring new developments. While continuity of purpose and consistency are certainly desireables, they should not be adhered to so rigidly as to become disadvantage.

A ready example is that of Air Cushion Vehicle and Hydrofoils which are herein explored. Only a short time ago, it would have been impractical to consider such craft suitable to the rigorous requirements we have specified. But changes in technology have altered that situation so radically as to not only render it feasible to consider them but foolish to overlook them.

A. Conventional Vessels:

Conventional vessels will be defined as those operating as displacement vessels at all speeds and wi-l include such designs as "V" bottoms, catamarans and other designs that do not rely on some form of auxiliary lifting surface.

These craft are readily available, have been constructed in great numbers in all sizes. They are simple, rugged and reliable. No problems of technology are anticipated, repairs and maintenance facilities are readily available. Qualified personnel, both for operation and maintenance, are also readily obtainable in more than adequate numbers.

They however have major disadvantages for HEART system use. Speeds are severely limited with conventional vessel design and costs rise severely with speeds in excess of 20 knots while wake and wash increase almost proportionately with speed. Manuvering, adequate at low speeds becomes critical at higher speeds, in particular, stopping distance and turning radius increase to dimensions of great concern.

While rugged and safe in bad weather conditions, ride comfort degenerates rapidly with increased sea state and it is highly doubtful if this type vessel would receive public acceptance for any use but inland routes and its speed limitations present serious doubts to its suitability to the HEART system. However, if deemed suitable there are many existing designers and manufacturers of these craft.

B. Planing Craft

Planing craft utilize modified hull design to overcome some of the disadvantages inherent in a conventional design. The vessel at low speeds operates as a conventional displacement vessel but as speed increases the vessel rises up on to anywhere from 2-4 planing surfaces ("skis") minimizing the amount of hull in contact with the water, reducing drag, wash and wake. The amount of power required decreases greatly below that of a conventional vessel. The type of craft we are considering are known generally as "Hydroski" boats.

Speed capability is considerably better then conventional class and manuverability is increased though stopping distances are not that much greater than conventional. Sea keeping capability is not greatly improved over conventional and this limits their consideration to inland use.

The greatest problem involved with use of these craft is that their design render them impractical for double ended construction and their use on dead end canals will require incorporation of turning basins and/or turntables.

Two designs of hydroski boats are known to be in existence, one by a man in Honolulu, Mr. Harold Fuller and one by the Lockheed Shipbuilding and Construction Company. Design and construction of each vessel will have to be determined and negotiated on a custom basis at the present.

C. Semi-Submerged Ship

This is a new design, representing an entirely new development in Naval Architecture presenting favorable implications for use.

The design is based on two catamaran type hulls, that are fully submerged, connected to a platform above the water by Hydrodynamically streamlined sidewalls presenting a minimum at surface to the water/air interface.

Speed capabilities are on a par with the hydroski design (25 kts.) but seakeeping qualities have been greatly increased. The design shows considerable promise of meeting criteria for oceanic use on semi-express routes or in larger configurations of interisland use.

The prototype is being constructed by the U.S. Navy's Naval Undersea Center and should arrive in Hawaii around 1973. It has been designed for military application but its performance should be carefully monitored and evaluated with an eye towards future civilian employment.

D. Air Cushion Vehicles (Hovercraft)

These are vehicles employing a series of lifting fans to enable the main portion of the craft to be suspended above the earth's surface on a cushion of air. The term earth's surface is used because depending on the type of ACV (Air Cushion Vehicle) design selected, it can operate over land and water or over water alone. When operating over water it posesses the capability of operating as a displacement vessel should the need arise.

Those posessing land and water capability are classified as amphibious and those with water capability as non-amphibious. A glossary of ACV and hydrofoil terms is provided as an appendix to give more complete information and reduce the amount of material required in the main text.

Hawaii's environment dictates that amphibious ACV's be rejected as unsuitable since these craft require use of large air propellors for propulsion, and the noise level is unacceptable.

However, where the requirement for high speed and shallow draft exists, the so called CAB (Captured Air Bubble) craft can be utilized. These vehicles use either water propellors or water jets for propulsion, and they are much quieter than the amphibious version though limited only to water.

ACV's however, are built in limited numbers in the United States, primarily for military use, and though readily available in England, in the United States they have been classed as ships, (in England they are classed as aircraft). This has brought them within the application of the Coast wise Laws of the United States (commonly called the Jones Act), effectively prohibiting purchase of English built craft. There are licensees in the United States for construction of English designed craft, but to date none have accomplished much in the field of CAB craft, limiting themselves to amphibious crafts. ACV's are also limited by design requirements from double-ended construction.

E. Hydrofoils

These are vessels that "fly". The craft utilize auxilary lifting surfaces to support the hull proper clear of the water surface. Basically, the principle is the same as that of aircraft (though the surfaces are called foils rather than wings), but because water is so much denser than air, we get 815 times as much lift on a foil surface than a comparable area would have in air, resulting in small area requirements.

The great reduction in wetted area results in greatly reduced friction, producing speed capabilities in excess of forty-five knots.

Until the advent of the fully submerged foil, automatically stabilized craft, the sea keeping qualities of hydrofoils were as limited as those of conventional craft, while the fixed foil characteristics of the earlier craft required great depth in channels and berthing areas.

However, the arrival of "second generation" hydrofoils solved this problem, the provision of fully retractable foil systems make the draft requirement a modest one.

Propulsion is accomplished through water propellors or water jets, and all weather capability is a standard provision.

Though somewhat more complicated than conventional craft in the fully submerged foil configuration, they are considerably less complicated than ACV's. In addition, the U.S.S.R. posesses a shallow water version called the "Raketa" which requires as little as three feet of water. This design has been limited to Russia, and is not presently available elsewhere.

A more complete description of hydrofoils will be found in the glossary appendix to this section.

Hydrofoils also posesses the design restriction of not being practical for double-ended construction.

F. Discussion and Conclusions

After careful consideration and evaluation the following quick summarizations can be made:

1. Conventional vessels: severly limited in some respects, economical to build and operate but would represent a relatively severe compromise if utilized.

2. Hydroski Craft: probably most suitable for inland routes, should be economical to build and operate but require more definition and research.

3. Semi-Submerged Ship: a most promising development, for oceanic use, but because of overall height not suitable for inland use and considerably too slow for express usage.

4. ACV's: versatile vehicles but expensive in acquisition and operational costs. Usage will require careful definition of parameters and should be carefully considered to take maximum advantage of their strengths while minimizing their weaknesses of noise and cost.

5. Hydrofoils: definitely the only vehicle suitable for oceanic express use in the fully submerged foil configuration. Possible contenders for semi-express routes and quite possibly as inland vessels if the shallow draft design becomes available outside of the Soviet Union.

Thus the following conclusions may be drawn about vehicle selection and usage by route:

Oceanic Express: fully submerged, auto-stabilized hydrofoil vessels, probably Boeing 929 craft since they appear to be the available craft that meets the requirement of speed (45 kts.), and passenger capacity (250 pass.).

Semi-Express: a smaller version of the oceanic express boat, perhaps the Grumman Dolphin (45 kts., 85 passengers), the Semi-Submerged

Ship (25 kts., 250 passengers), and where passages and depth are limited, CAB craft such as the Hovermarine H.M. 2 (35 kts., 80 passengers) or the Denny Waterbus.

Locals: preferably Hydroski boats if they can be obtained in the proper size and configurations. Alternatively, shallow draft hydrofoils or conventional vessels may be considered.

II. LAND VEHICLES

The land vehicles used will be existing types (Bus and Mini-bus). The HEART system will permit a great utilization of Mini-bus types with their lower pollution levels and greater economy and manuverability.

Larger buses can be used for outlying areas or on special express routes and it can be anticipated that this will utilize all or almost all of the existing bus fleet owned by the city.

Careful analysis and integration of bus routes and schedules with water routes and schedules will provide a flexible and economical system of transportation.

No detailed analysis of busses will be made since this information is standard and readily available.

(SECTION II APPENDIX A)

GLOSSARY

ACV. Air Cushion Vehicle.

AEROPLANE FOIL SYSTEM. Foil arrangement which the main foil is located forward of the centre of gravity to support 75-85% of load. The auxiliary foil located aft supports the remainder.

AFT. At, near or towards the rear of the craft.

AIR CUSHION VEHICLE. A vehicle capable of being operated so that its weight including its payload, is wholly or significantly supported on a continously generated cushion of air.

AIR GAP. Distance between the lowest part of an ACV's understructure and the surface when riding on its cushion.

ANGLE OF ATTACK. The angle made by the mean chord line of a hydrofoil with the flow.

ANGLE OF INCIDENCE. The angle mode by the mean chord line of foil in relation to the struts or hull.

AXIAL-FLOW LIFT FAN. A fan generating an airflow for lift that is parallel to the axis of rotation.

B.H.P.. Brake horse power.

BASE VENTILATED FOIL. A system of forced ventilation designed to overcome the reduction in lift/drag ratio of a foil at supercavitating speed.

BEAM. Measurement across a hull at a given point.

BEAUFORT SCALE. A scale of wind forces described by name and range of velocity from force 0 to frocel2 with hurrican classed seperately as force 17.

BOATING. Expression used to describe an ACV operating as a displacement vessel.

BOW. Forward part of a craft.

BREAST, TO. To take waves at 90° to their crests.

BRIDGE. Elevated part of a craft superstructure from which it is navigated or steered.

BROACH, TO. Nautical expression meaning to swing sideways in following seas under wave action.

CAMBER. (1). a convexity on the upper surface of a craft deck for increased strength and to facilitate draining. (2). the convex form on the upper surface of a foil. The high speed flow over the top surface causes a decrease in pressure and about two thirds of the lift is related to this.

CANARD FOIL SYSTEM. A foil arrangement in which the main foil of a craft is located at the stern, aft of the center of gravity bearing about 65% of the weight while the remainder is borne by the small central bow foil.

CAPTURED AIR BUBBLE (CAB) CRAFT. Vessel in which the cushion (or air bubble) is contained by rigid sidewalls and flexible bow and stern skirts.

CAVITATION. Cavitation is the formation of vapor bubbles due to pressure decrease on the upper surface of a foil or the back of a propellor blades at high speeds, and falls into two categories stable and unstable. Non-stable cavities or cavitation bubbles form near the foils leading edge and extend down stream before collapsing. At the points of collapse, positive pressure may be as high as 20,000 PSI.

CENTRIFUGAL LIFT FAN. A cushion lift fan which generates an airflow at right angles to the axis of rotation.

CHORD. The distance between the leading and trailing edges of a foil section measured along the chord line.

CHORD-LINE. A straight line joining the leading and trailing edges of a foil or propellor blade section.

CONTOUR, TO. The motion of ACV or hydrofoil when more or less following a wave profile.

C.P.. Center of pressure.

C.W.L.. Calm water line.

CRAFT. Boats, ships, ACV's and hydrofoils of all types, regardless of size.

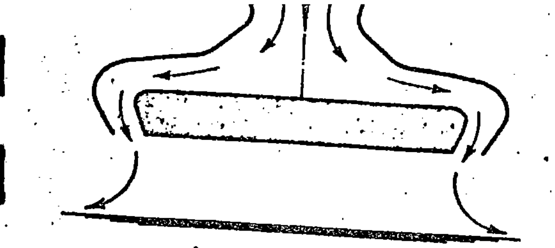
CUSHION. A volume of higher than ambient pressure air trapped beneath the structure of a vehicle and its supporting surface causing the vehicle to be supported at some distance above.

D.W.L.. Displacement water line.

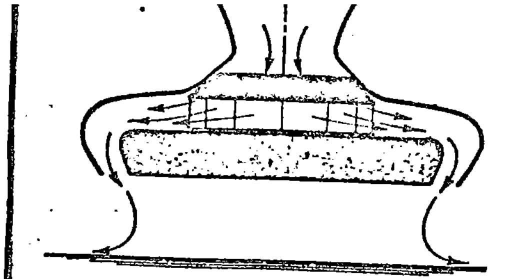
Displacement. The weight in tons of water displaced by a floating vessel.

DRAG. (1). ACV's-aerodynamic and hydrodynamic resistances encountered by an ACV resulting from aerodynamic profile, gain of momentum of air required for cushion generation, wave making, wetting or skirt contact. (2). Hydrofoils-hydrodynamic resistances encountered by hydrofoils result from wave making, which is dependent on craft shape and displacement, frictional drag from the foils and transmission shafts, supporting struts and structures, due to their motion through the water.

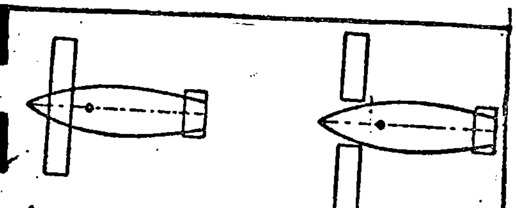
DRAUGHT. Depth between the water surface and the bottom of a craft.



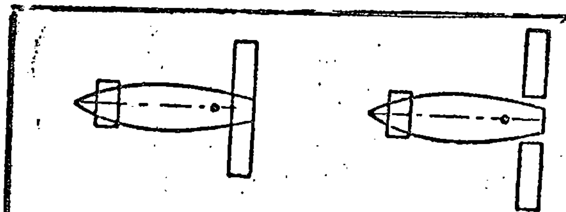
Axial flow lift fan



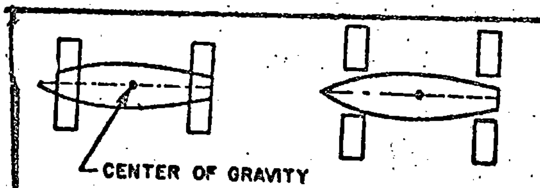
Centrifugal flow lift fan



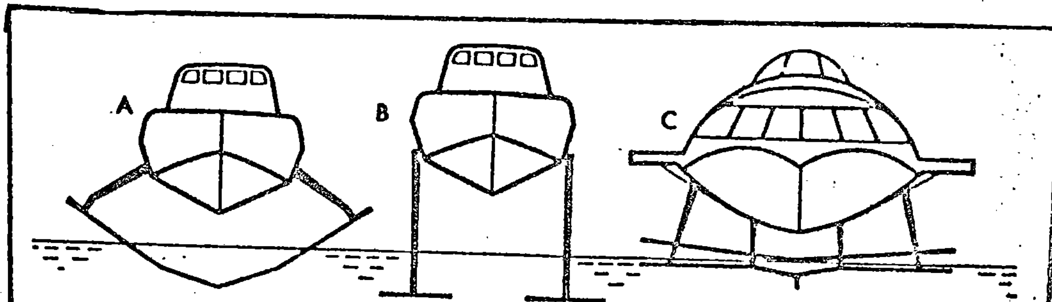
Aeroplane or conventional foil systems. The main foil may be divided into two to facilitate retraction



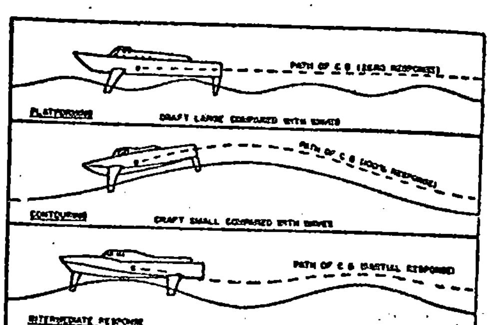
Canard foil configuration. The main foil area may be divided into two to facilitate retraction



Tandem foil system. The foil areas can be "split" into two to facilitate retraction



Foil systems in current use. A surface piercing: B submerged and C shallow draught submerged



Comparison of platforming and contouring modes, and the intermediate response of a craft equipped with fully submerged, automatically controlled foil system

F.W.L.. Foilborne water line.

FATHOM. Depth of 6 feet.

FENCES. Small partitions placed at short intervals down the upper and lower surfaces of a foil to prevent air ventilation from passing down and destroying lift.

FOILBORNE. A hydrofoil is said to be foilborne when the hull is raised completely out of the water and wholly supported by lift from the foil system (also called "flying").

FOIL SYSTEMS. Foil systems in current use are generally either: Surface-Piercing, Submerged or Semi-Submerged.

Surface Piercing Foils are more often than not vee shaped, the upper parts of the foil forming the tips of the vee and piercing the surface on either side of the craft.

Ladder Foils also come under the heading of surface piercing, but are rarely used except on a few sailing craft.

Shallow Draught Submerged Foils, employed exclusively on hydrofoils designed and built in the Soviet Union. Also known as the immersion depth effect system.

Submerged Foils, have a greater seakeeping potential than any other but are not inherently stable to any degree thus requiring auto stabilization.

FOLLOWING SEA. A sea following the same or similar course to that of the craft.

HEAD SEA. A sea approaching from the direction steered.

HEEL. To incline or list in a transverse direction while underway.

HEAVE. Vertical motion of a craft in response to waves.

HULL CRESTING. The contact of a hydrofoils hull with the waves in a high sea. The term slamming is used if the contact is preceded by foil broaching.

HUMP. The hmp formed on the graph of resistance against the speed of a displacement vessel or ACV.

KNOT. Nautical mile per hour.

LAND, TO. At the end of a run, ACV's and hydrofoils are said to "settle down or land".

NAUTICAL MILE. A distance of 6,080 feet (one minute of latitude at the equator).

PITCH. (1). rotation or oscillation of the hull about a transverse axis in a seaway. (2). the angle of air or water propellor blades.

PLATFORM, TO. Approximately level flight of a hydrofoil over waves of a height less than the calm water hull clearance.

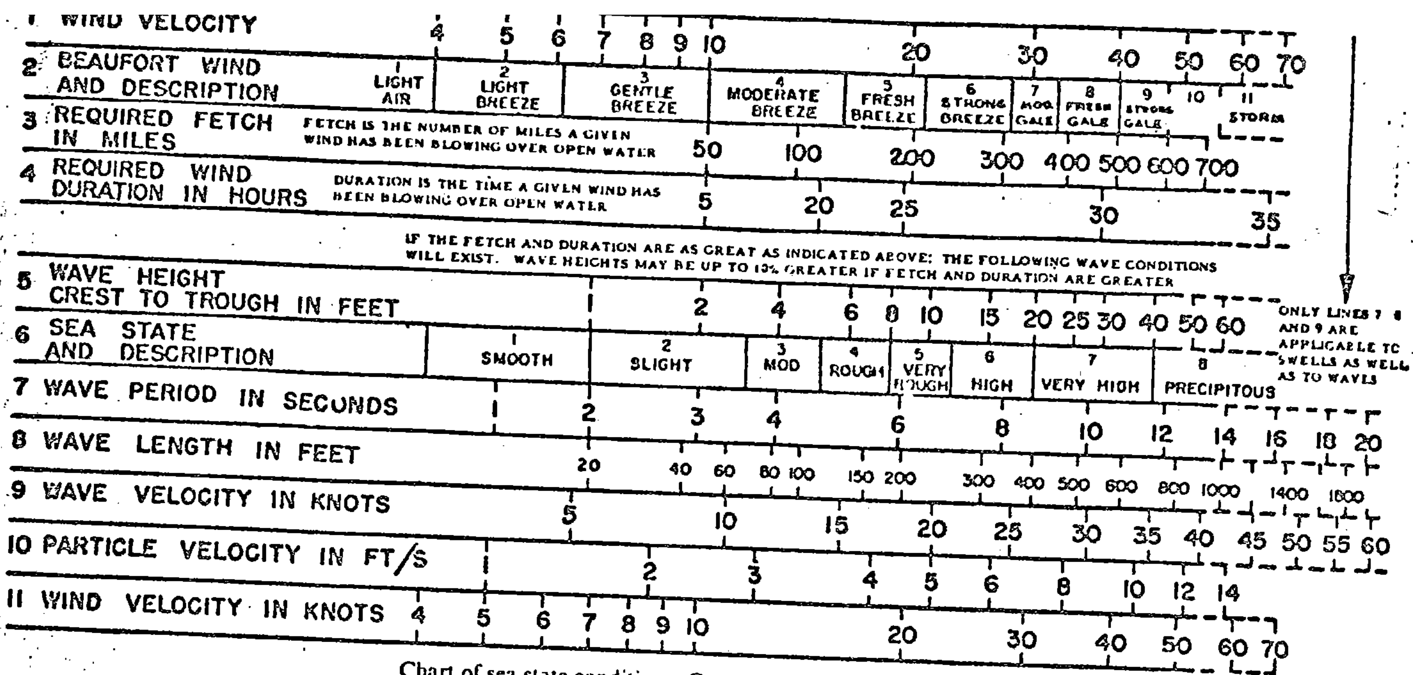


Chart of sea state conditions. Corresponding values lie on a vertical line.

Beaufort Scale. A scale of wind forces described by name and range of velocity and classified as from force 0 to force 12, or in the case of strong hurricanes to force 17. Named after Admiral Sir Francis Beaufort, 1774-1857 who was responsible for preparing the scale.

Beaufort Force Number	*State of Air*	*Description*	*Wind Velocity in Knots*
0	calm	Smoke ascends vertically. Sea mirror-like	Less than 1
1	light air	Wind direction shown by smoke. Scale-like ripples on surface but no crests	1-3
2	slight breeze	As Force 1, but wavelets more pronounced	4-6
3	gentle breeze	Flags extended. Short pronounced wavelets; crests start to break, scattered white horses	7-10
4	moderate breeze	Small waves, lengthening. Frequent white horses	11-16
5	fresh breeze	Waves more pronounced and longer form. More white horses some spray	17-21
6	strong breeze	Larger waves and extensive white foam crests. Sea breaks with dull rolling noise. Spray	22-27
7	moderate gale	White foam blown in streaks in direction of wind. Spindrift appears. Noise increases	28-33
8	fresh gale	Moderately high waves breaking into spindrift; well marked foam	34-40
9	strong gale	High waves and dense streaks of foam along direction of wind. Sea begins to roll	41-47
10	whole gale	Sea surface becomes white. Very high waves with overhanging crests. Rolling of sea heavy. Visibility affected	48-55
11	storm	Waves exceptionally high, visibility affected	56-65

ROLL. Oscillation or rotation of a hull about longitudinal axis.

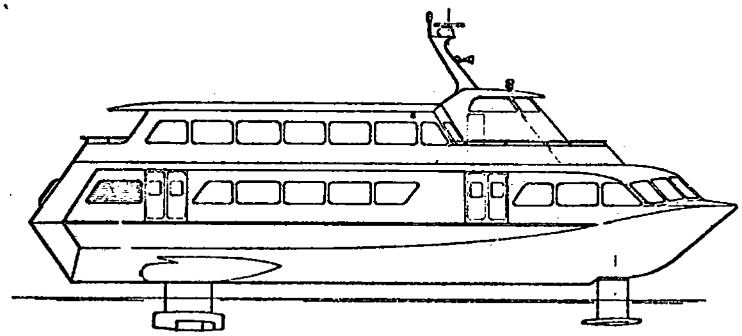
SES. Surface effect ship (another name for ACV's).

SEA STATE. A scale of sea conditions classified from state 1, smooth to state 8, precipitous.

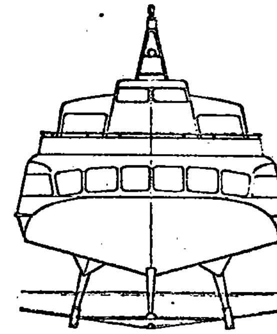
SKIRT. A flexible fabric extension hung between an ACV's structure and the surface to give increased height clearance for a small air gap clearance and thereby reduce power requirements.

APPENDIX III (B)

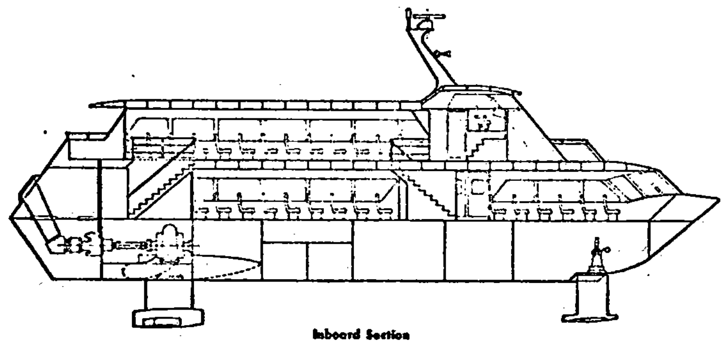
Illustrative List of Available Marine Vessels
Illustrations courtesy of Hoverprojects
England and the National Research Council
of Canada



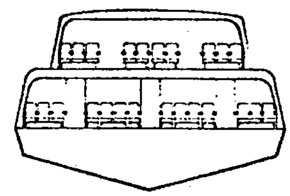
Outboard Profile



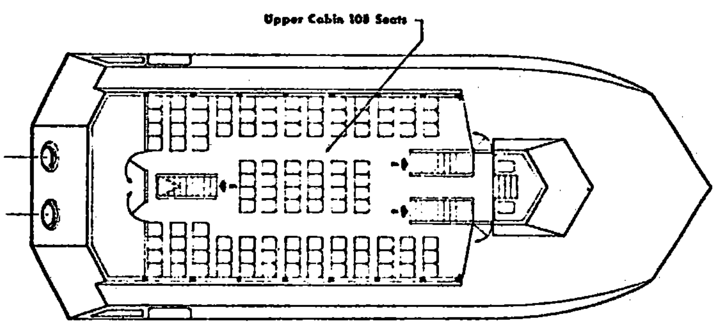
Bow Profile



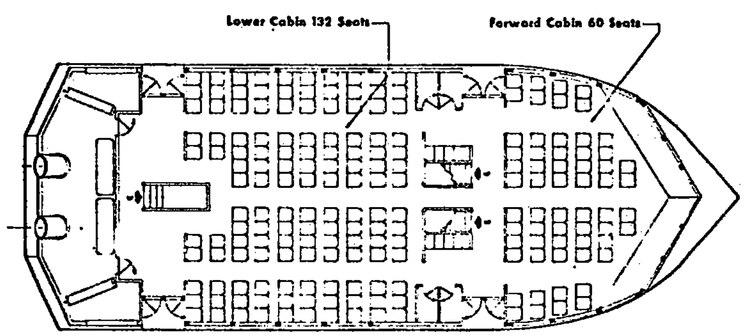
Inboard Section



Midship Section



Upper Deck Plan



Lower Deck Plan

BOEING MODEL 929-110

Passenger Capacity = 300

Length = 93 Feet

Beam = 35 Feet

Draft:

Foilborne 4.5 Feet

Hullborne 10.5 Feet

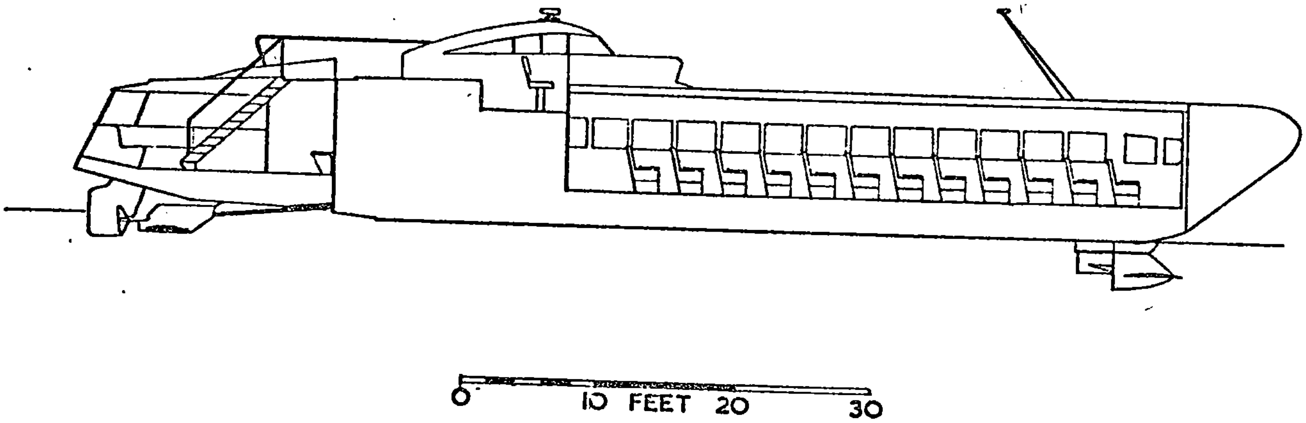
Propulsion:

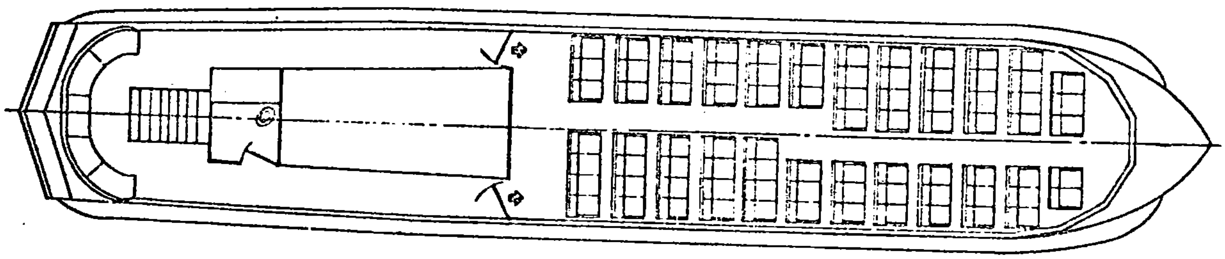
Two 2,500 hp Gas Turbine-Waterjets

Service Speed: 40 Knots

BOEING "929"

Waterjet Hydrofoil Boat

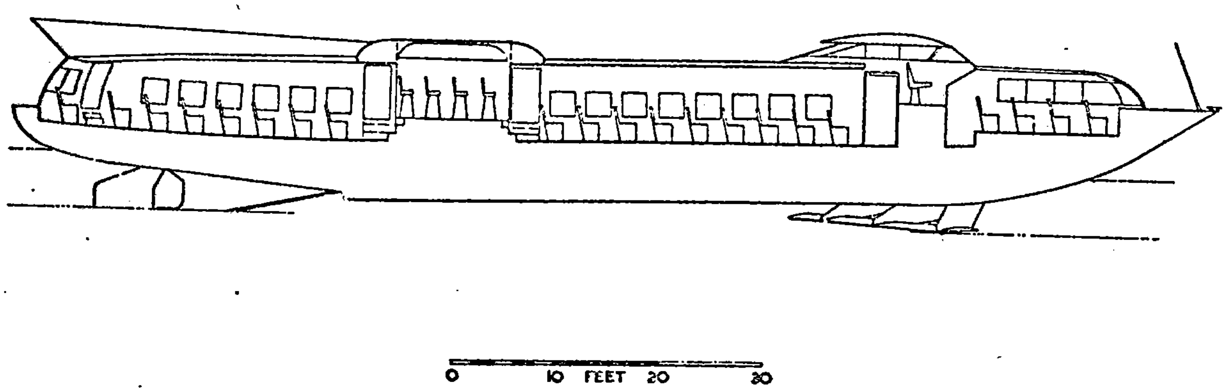


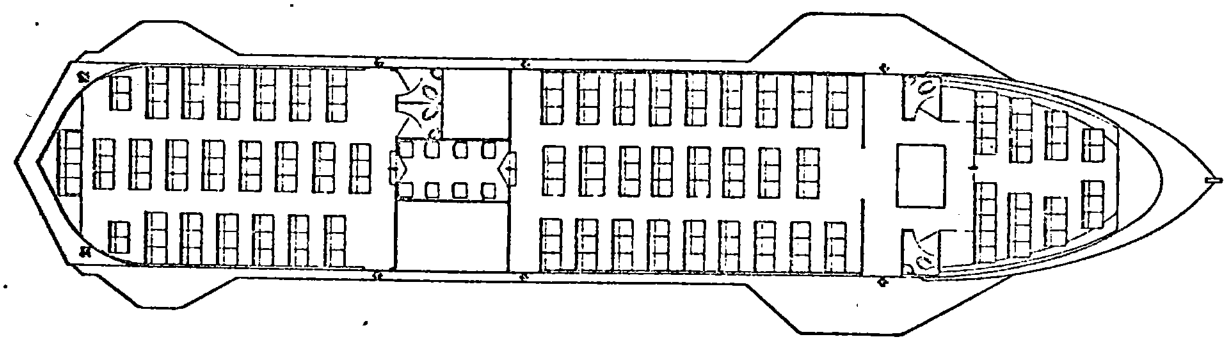


SORMOVO RAKETA

PASSENGER CAPACITY	80 Nominal
LENGTH OVERALL	88.5 ft.
BREADTH OVERALL	16.5 ft.
DRAUGHT FOILBORNE	3.6 ft.
DRAUGHT FLOATING	5.9 ft.
HEIGHT TO TOP OF STRUCTURE, FOILBORNE	16 ft.
HEIGHT TO TOP OF STRUCTURE, FLOATING	13.8 ft.
NORMAL OPERATING WEIGHT	25.2 tons
ENGINE TYPE	V–12 diesel
TOTAL INSTALLED POWER	1,100 h.p.
POWER AT MAXIMUM CONTINUOUS OPERATION	890 h.p.
SERVICE SPEED (WITH WATER JETS) IN UP TO 2 FT. SEA (AVERAGE FOR THAMES CONDITIONS)	32 kt.
FUEL CONSUMPTION AT MAXIMUM CONTINUOUS POWER	44 gals/hr.
ENDURANCE	9 hours

Cabin Layout by Hoverprojects Ltd.

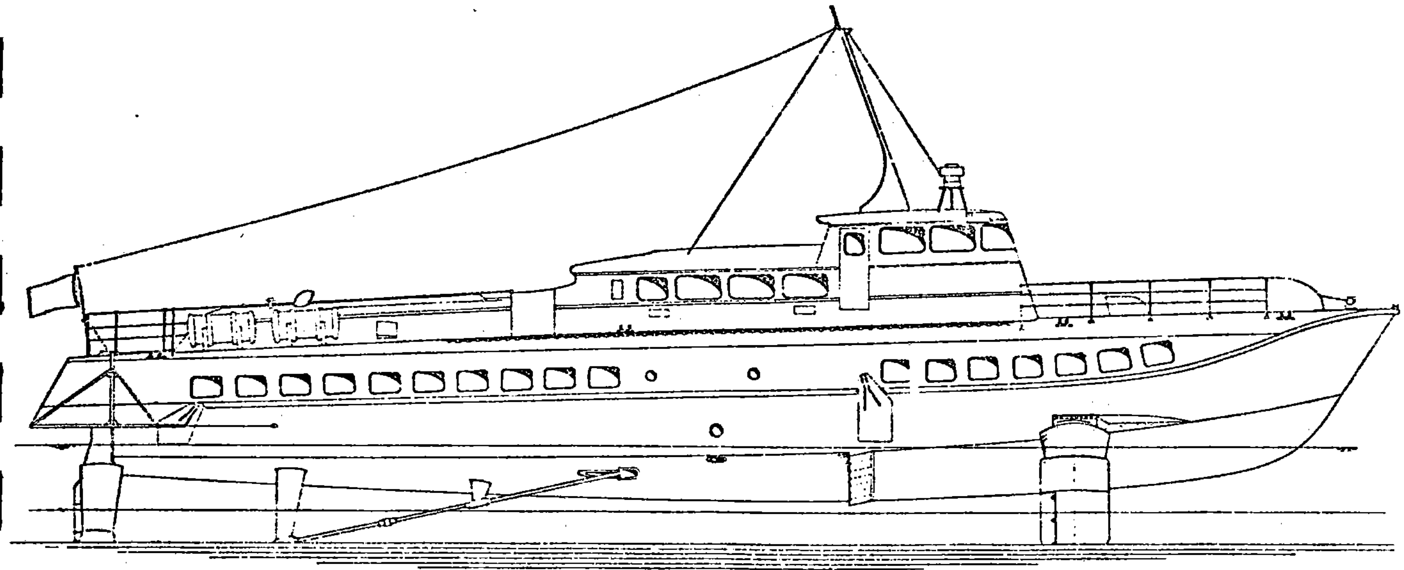


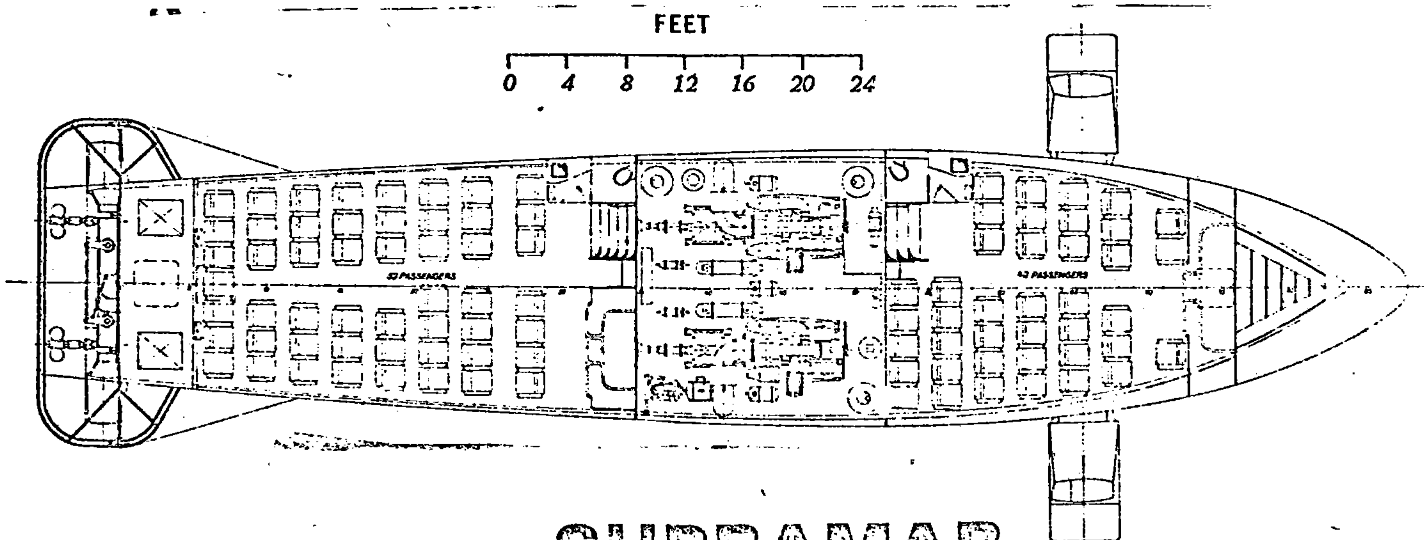


SORMOVO METEOR

PASSENGER CAPACITY	180 nominal
LENGTH OVERALL	113 ft.
BREADTH OVERALL	31.2 ft.
DRAUGHT FOILBORNE	3.9 ft.
DRAUGHT FLOATING	7.5 ft.
HEIGHT TO TOP OF STRUCTURE, FOILBORNE	22 ft.
HEIGHT TO TOP OF STRUCTURE, FLOATING	16.8 ft.
NORMAL OPERATING WEIGHT	53.3 tons
ENGINE TYPE	V–12 diesel
TOTAL INSTALLED POWER	2,200 h.p.
POWER AT MAXIMUM CONTINUOUS OPERATION	1,780 h.p.
SERVICE SPEED (WITH WATER JETS) IN UP TO 2 FT. SEA (AVERAGE THAMES CONDITIONS)	35 kt.
FUEL CONSUMPTION AT MAXIMUM CONTINUOUS POWER	80 gals/hr.
ENDURANCE	9 hours

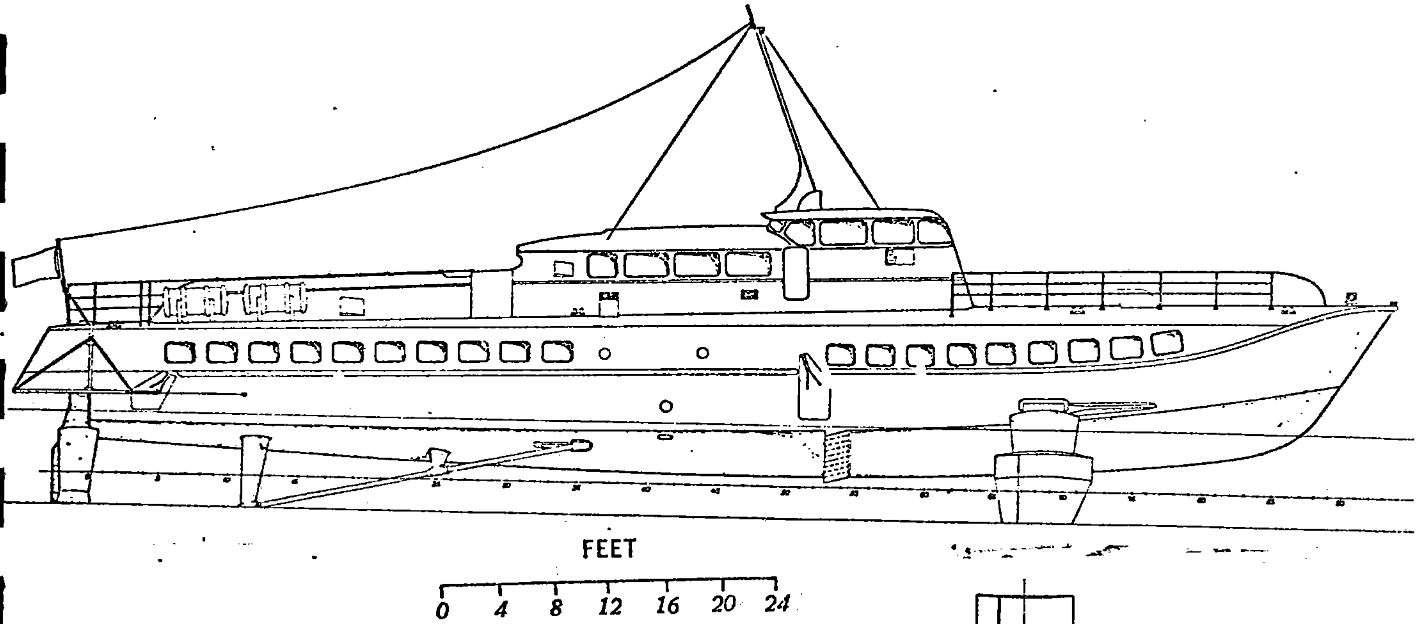
Cabin layout by Hoverprojects Ltd.

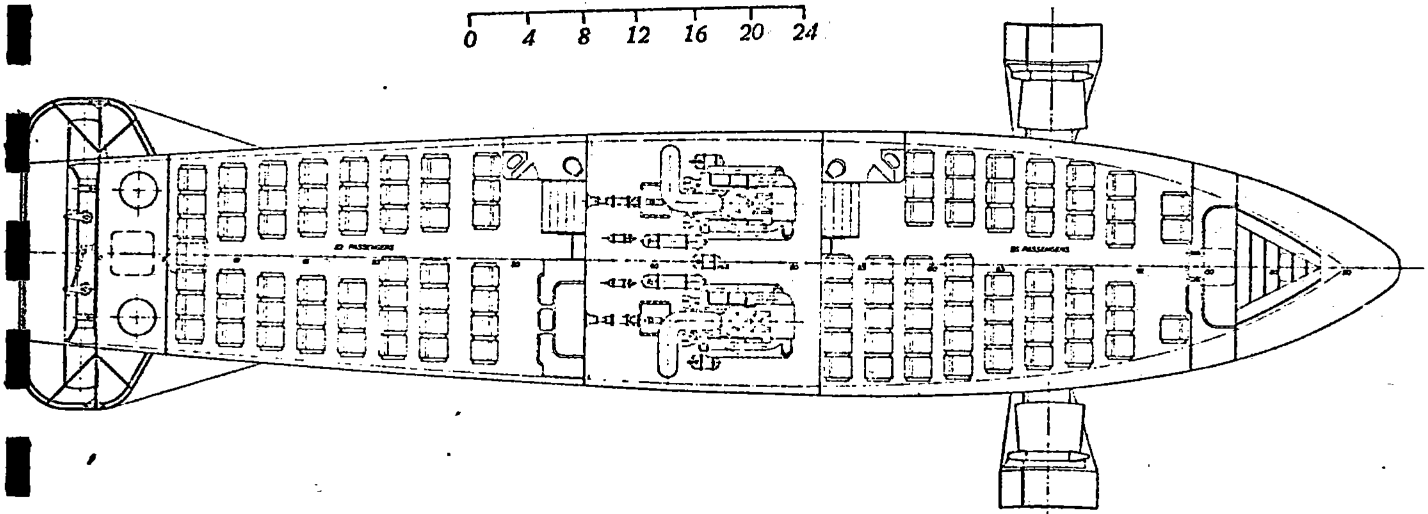




SUPRAMAR PT 50

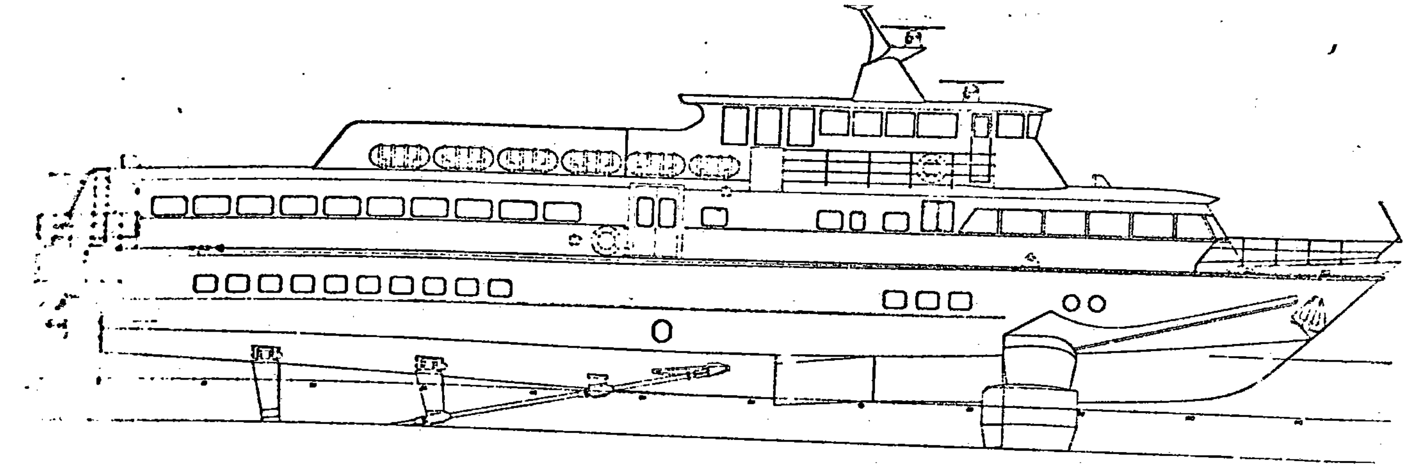
LENGTH OVERALL	91′ 6″
LENGTH OVER DECK	89′ 6″
BEAM MAX.	20′ 0″
WIDTH OVER FOILS	35′ 0″
DRAUGHT HULLBORNE	11′ 6″
DRAUGHT FOILBORNE	4′ 8″
DISPLACEMENT FULLY LOADED	62·6 ts
ENGINE PERFORMANCE MAX.	2 x 1330 HP
CRUISING SPEED	34 kt
RANGE	300 nm
PASSENGER CAPACITY	105–140 Pass.

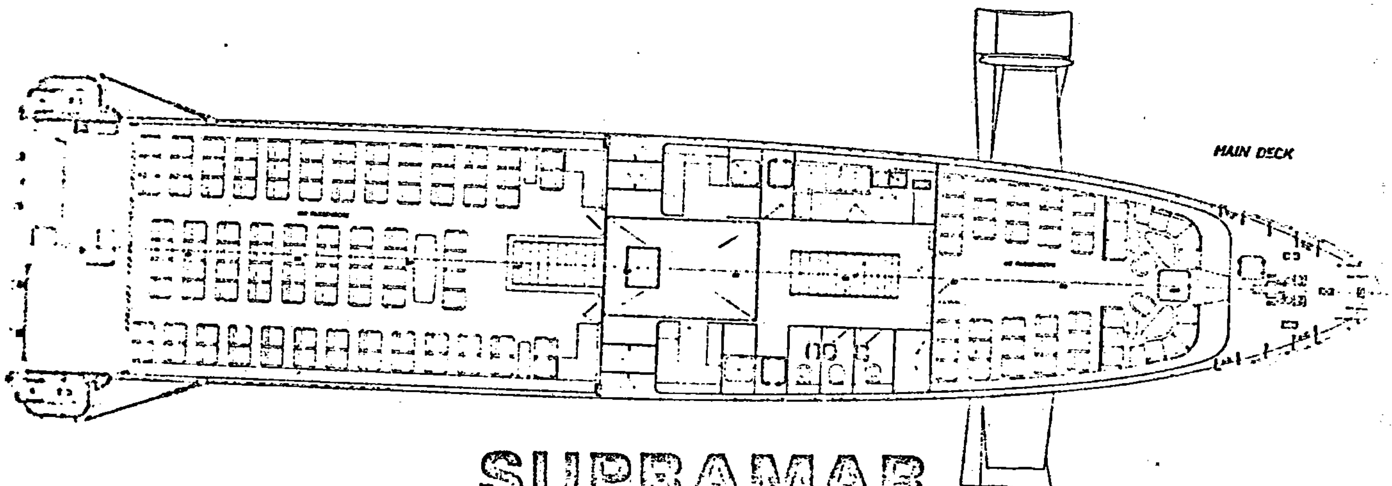




SUPRAMAR PT 70

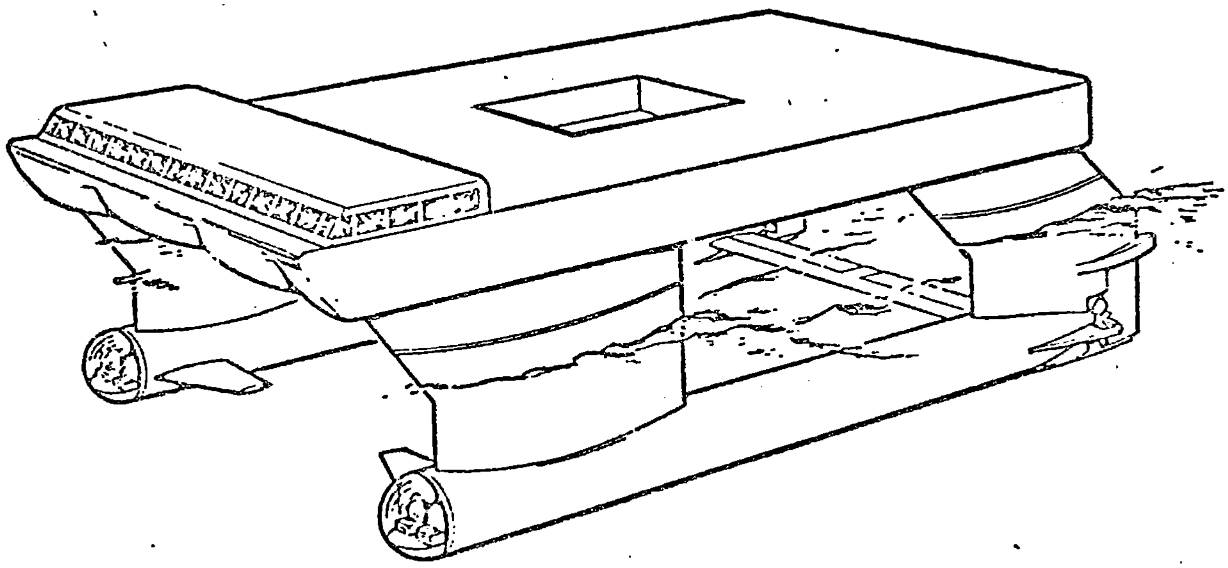
LENGTH OVER ALL	96' 9"
LENGTH OVER DECK	95' 0"
BEAM MAX.	19' 10"
WIDTH OVER FOILS	35' 0"
DRAUGHT HULLBORNE	12' 4"
DRAUGHT FOILBORNE	5' 3"
DISPLACEMENT FULLY LOADED	70.00 ts
ENGINE PERFORMANCE MAX.	2x1650 HP
CRUISING SPEED	35 kt
RANGE	260 nm
PASSENGER CAPACITY	120—155 Pass.





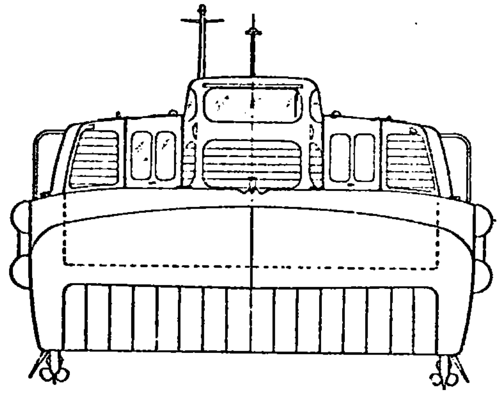
SUPRAMAR
PT 150

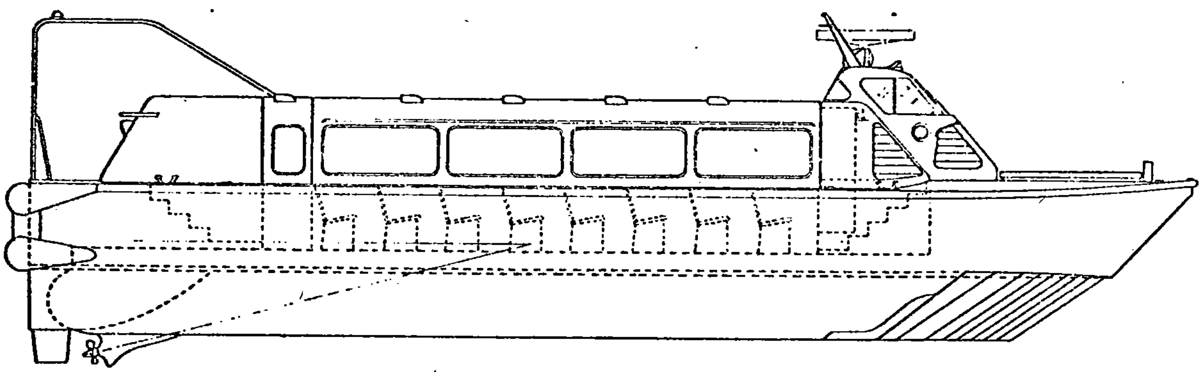
LENGTH OVERALL	123' 0"
LENGTH OVER DECK	122' 0"
BEAM MAX.	24' 7"
WIDTH OVER FOILS	52' 6"
DRAUGHT HULLBORNE	18' 0"
DRAUGHT FOILBORNE	8' 10"
DISPLACEMENT FULLY LOADED	148.00 ts
ENGINE PERFORMANCE MAX.	2 x 3400 HP
CRUISING SPEED AT 6880 HP	39 kt
RANGE	300 nm
PASSENGER CAPACITY	250 Pass. or 8 Autos and 150 Pass.



NAVAL UNDERSEA CENTER
Semi-Submersible Ship

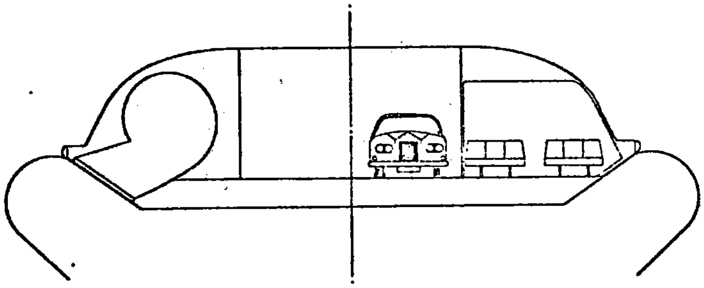
DISPLACEMENT	190 tons
LENGTH	87 feet
BEAM	47 feet
DRAFT	15 feet
POWER	4300 h.p.
SPEED	25 knots
RANGE	450 miles at 16 kts.
PAY LOAD	25 tons

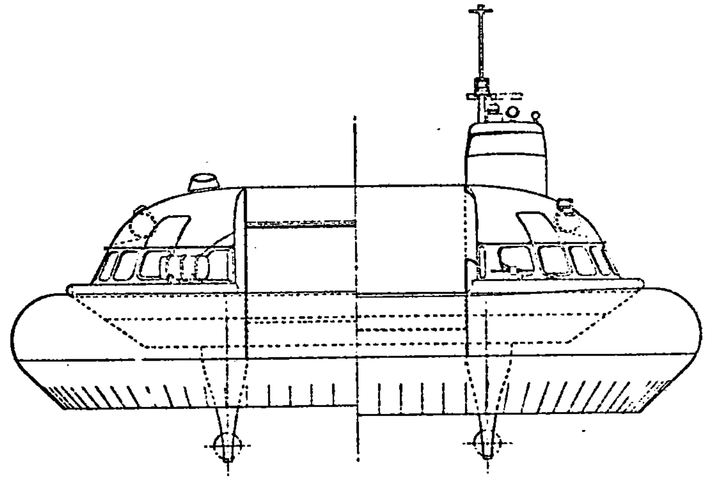


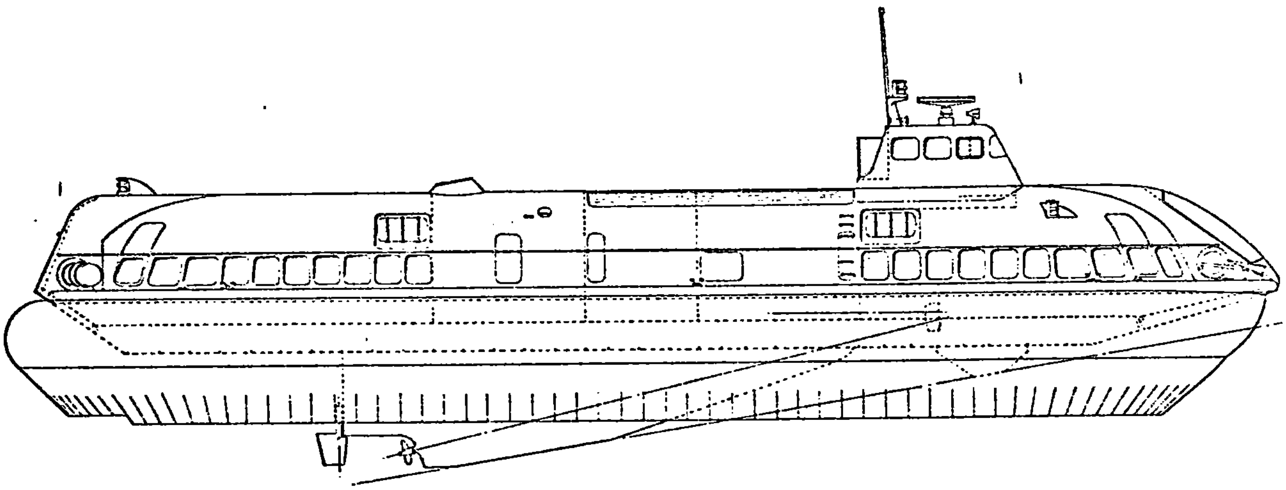


HOVERMARINE HM 2

LENGTH, OVERALL	51′ 0″
BEAM, OVERALL	20′ 0″
HEIGHT ABOVE HOVERING WATERLINE	12′ 0″
DRAUGHT, HOVERING	2′ 3″
DRAUGHT, FLOATING	4′ 10″
NORMAL GROSS WEIGHT	41,500 lbs
LIFT-ENGINE POWER (MAX. CONTINUOUS)	165 BHP
PROPULSION-ENGINE POWER (MAX. CONTINUOUS)	2x320 BHP
SERVICE SPEED	33·8 kt
RANGE	140 N. Miles
PASSENGER CAPACITY	60-65

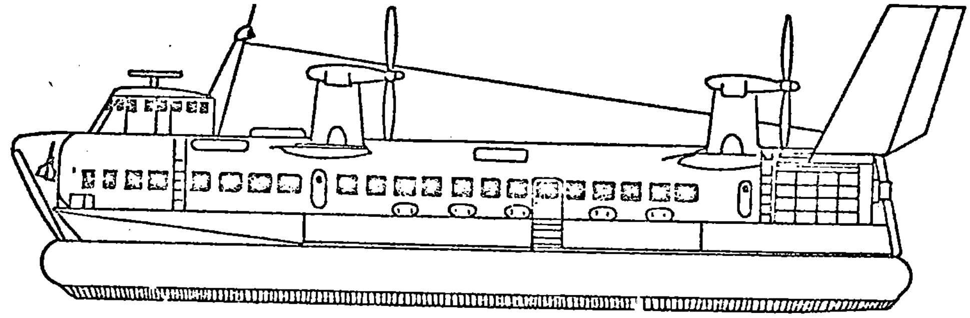


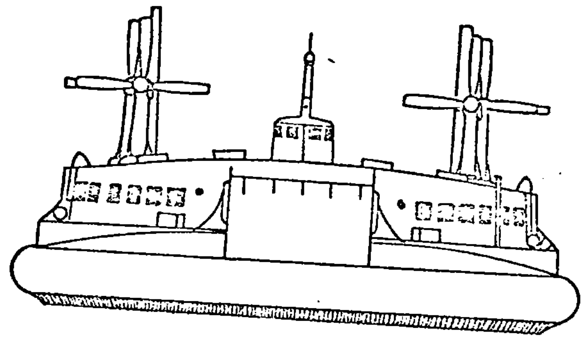




VOSPER THORNYCROFT VT 1

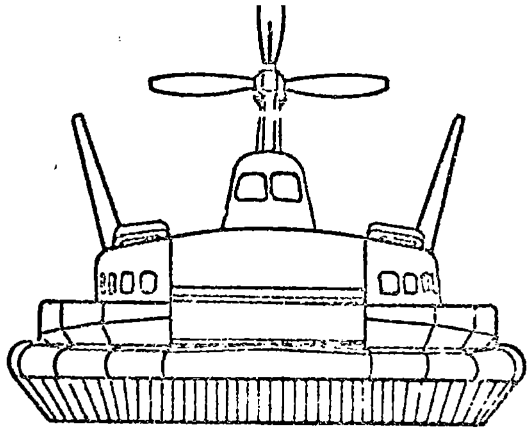
LENGTH OVERALL (STRUCTURE)	95′ 6″
BREADTH OVERALL (STRUCTURE)	44′ 6″
DRAUGHT TO BOTTOM OF SKEGS (HOVERING)	3′ 9″
DRAUGHT TO BOTTOM OF SKEGS (FLOATING)	9′ 9″
HEIGHT TO TOP OF MAST ABOVE WATERLINE (HOVERING)	32′ 0″
HEIGHT TO TOP OF MAST ABOVE WATERLINE (FLOATING)	26′ 0″
MAXIMUM OPERATING WEIGHT	85·0 ts
ENGINE PERFORMANCE MAX. CONTINUOUS	2 x 1850 HP
CRUISING SPEED AT 3700 HP	40 kt
RANGE	380 nm
PASSENGER MAXIMUM CAPACITY	322 Pass. or 148 Pass. and 10 Autos

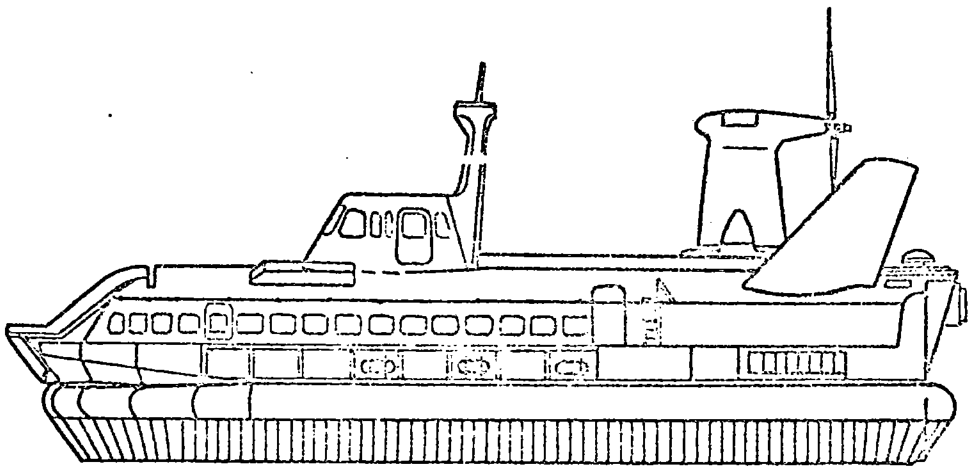




BRITISH HOVERCRAFT CORPORATION SR.N4

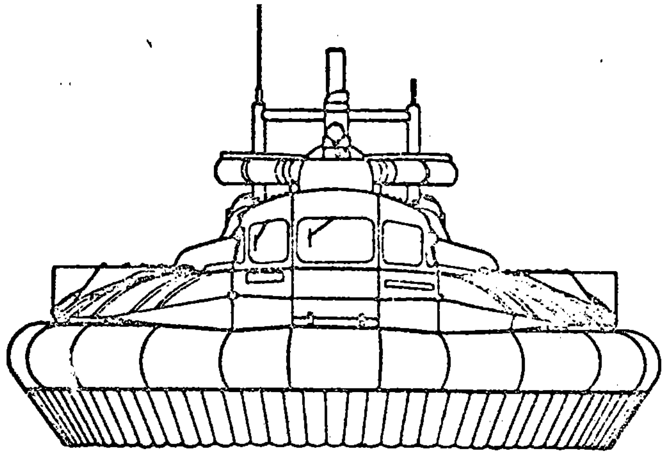
LENGTH,OVERALL (STRUCTURE)	130'2"
BREADTH,OVERALL (STRUCTURE)	76'10"
HEIGHT,OVERALL ON PADS	42'5"
HEIGHT,OBSTACLE CLEARANCE	5'9"
NORMAL GROSS WEIGHT	165 tons
MAXIMUM ENGINE POWER (CONTINUOUS)	13,600 hp
ERVICE SPEED	61 knots
ZERO WIND RANGE	175n.miles
PASSENGER CAPACITY	265

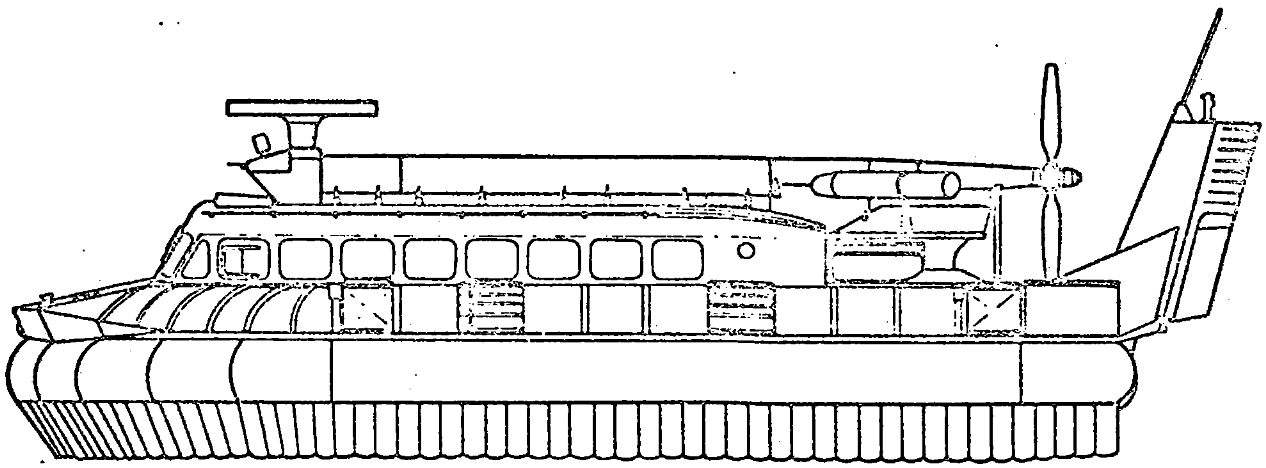




British Hovercraft Corporation
BH 7

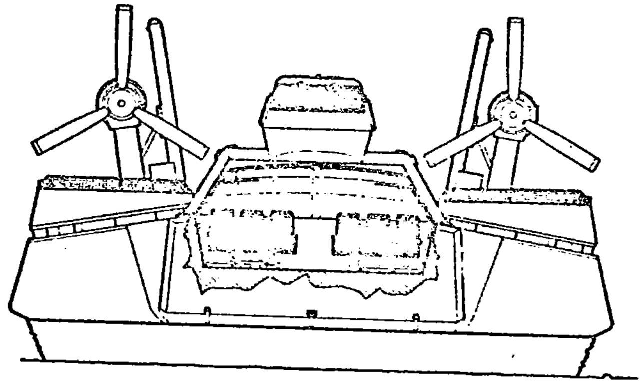
LENGTH, OVERALL	76′ 7″
BEAM, OVERALL	41′ 3″
HEIGHT, OVERALL	33′ 0″
DRAUGHT, HOVERING	Nil
DRAUGHT, FLOATING	2′ 0″
NORMAL GROSS WEIGHT	103,040 lb
LIFT/PROPULSION ENGINE POWER (MAX. CONTINUOUS)	3,400 HP
SERVICE SPEED	60 - 65 kt
RANGE	240 nm
PASSENGER CAPACITY	172
AUTO CAPACITY	Nil

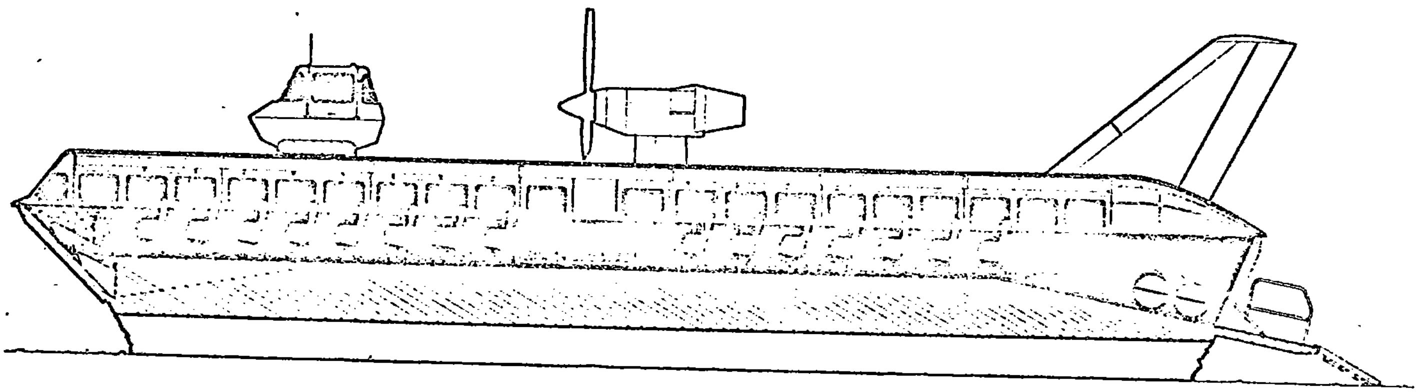




British Hovercraft Corporation
SRN 6

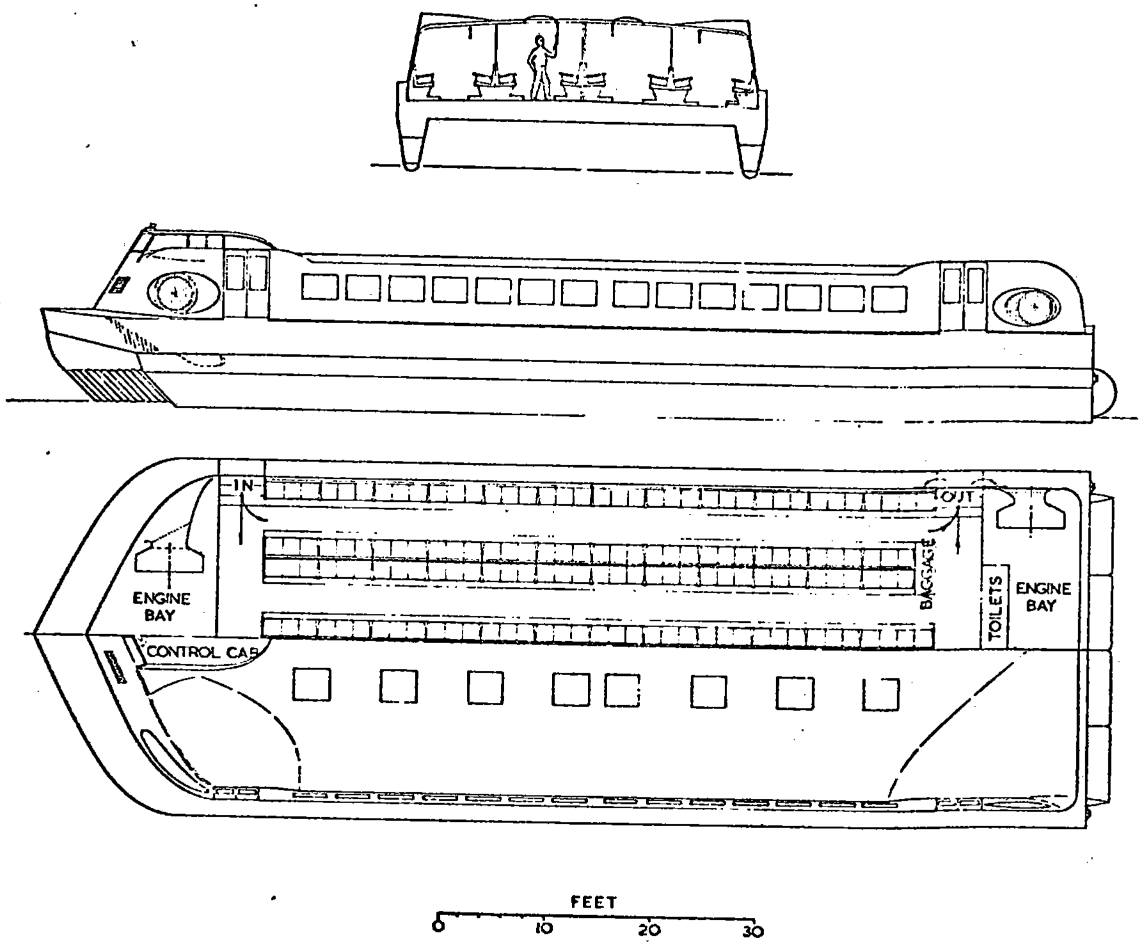
LENGTH, OVERALL	48′ 5″
BEAM, OVERALL	23′ 0″
HEIGHT, OVERALL	14′ 11″
DRAUGHT, HOVERING	Nil
DRAUGHT, FLOATING	1′ 0″
NORMAL GROSS WEIGHT	22,000 lb
LIFT/PROPULSION ENGINE POWER (MAX. CONTINUOUS)	900 HP
SERVICE SPEED	52 kt
RANGE	198 nm
PASSENGER CAPACITY	38
AUTO CAPACITY	Nil





SEDAM N-300

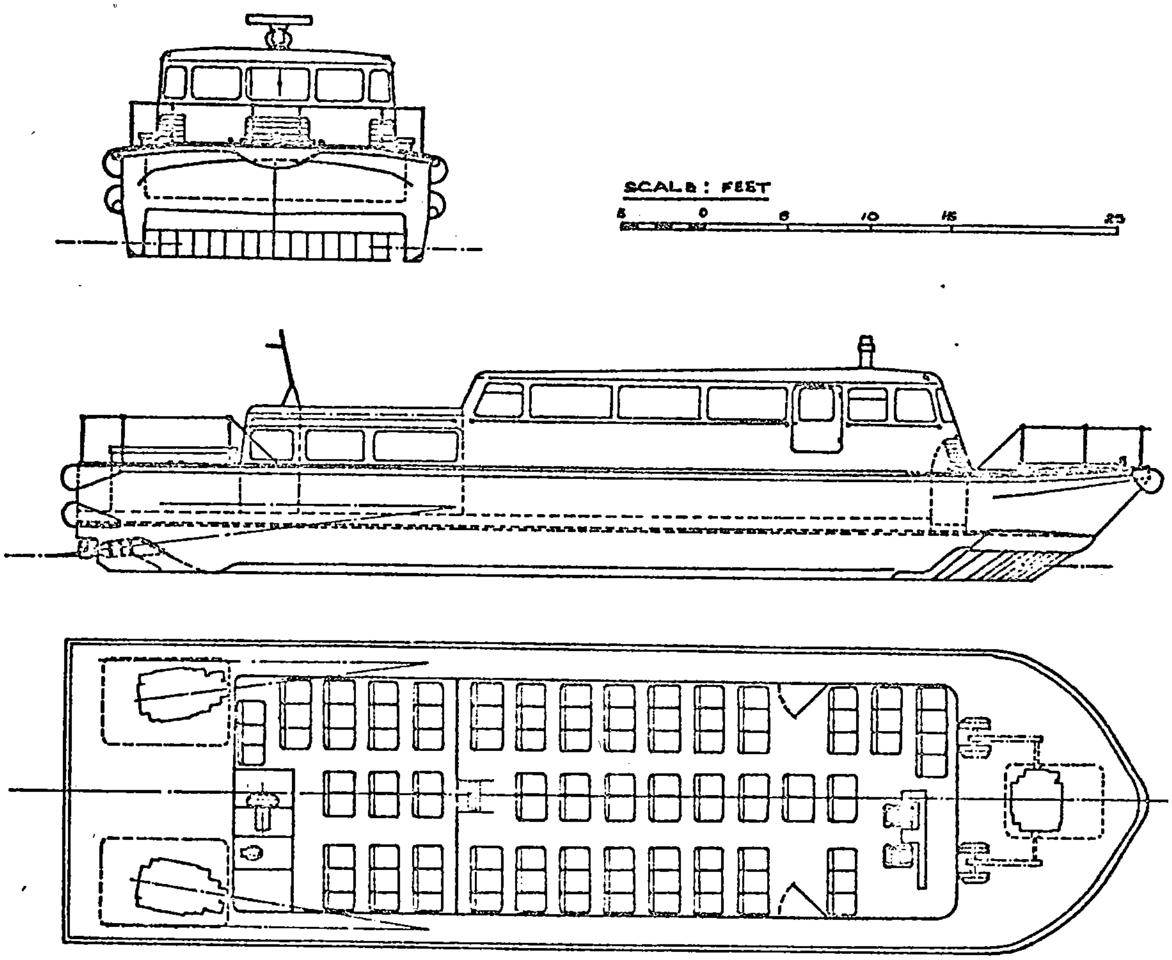
LENGTH OVERALL	76′ 5″
BEAM OVERALL	36′ 5″
HEIGHT, HOVERING	26′ 5″
DRAUGHT FLOATING	3′ 3″
NORMAL GROSS WEIGHT	66,150 lbs
ENGINE POWER, MAX. CONTINUOUS	2 x 1320 BHP
SERVICE SPEED	50 kt
RANGE	130 N. Miles
LOAD CAPACITY	90 Pass. or 8 Autos



HOVERPROJECTS LTD.

Proposed Thames Commuter Craft

PASSENGER CAPACITY	300
LENGTH OVERALL	102 ft.
BREADTH OVERALL	35 ft.
DRAUGHT HOVERING	1 ft.
DRAUGHT FLOATING	5 ft.
HEIGHT TO TOP OF STRUCTURE (HOVERING)	17.5 ft.
HEIGHT TO TOP OF STRUCTURE (FLOATING)	13 ft.
NORMAL OPERATING WEIGHT	60 tons
ENGINE TYPE	Probably rotary
TOTAL INSTALLED POWER	3,000 h.p.
POWER AT MAXIMUM CONTINUOUS OPERATING	2,700 h.p.
SERVICE SPEED (WITH WATER JETS) IN UP TO 2 FT. SEA (AVERAGE THAMES CONDITIONS)	35 kt.
FUEL CONSUMPTION AT MAXIMUM CONTINUOUS POWER	175 gals/hr. approx.
ENDURANCE	4 hours



HOVERMARINE TRANSPORT

Proposed HM.5 River Craft

PASSENGER CAPACITY	100
LENGTH OVERALL	66 ft.
BREADTH OVERALL	20 ft.
DRAUGHT HOVERING	2.2 ft.
DRAUGHT FLOATING	5 ft.
HEIGHT TO TOP OF STRUCTURE (HOVERING)	15 ft.
HEIGHT TO TOP OF STRUCTURE (FLOATING)	12.5 ft.
NORMAL OPERATING WEIGHT	26 tons
ENGINE TYPE	D esel
TOTAL INSTALLED POWER	985 h.p.
POWER AT MAXIMUM CONTINUOUS OPERATING	840 h.p.
SERVICE SPEED (WITH WATER JETS) IN UP TO 2 FT. SEA (AVERAGE THAMES CONDITIONS)	25 kt.
FUEL CONSUMPTION AT MAXIMUM CONTINUOUS POWER	35 gals/hr.
ENDURANCE	5 hours

APPENDIX III (C)

Hydrofoil and Hovercraft Usage At Present

Hydrofoil and Hovercraft Usage in the World

Roger A. Peterson

July 25, 1972

Whenever hydrofoils and/or hovercraft are mentioned, the usual reaction is to treat them as if they were a new experimental development. This is not the case and can be easily demonstrated.

The hydrofoil dates back to 1907 with the successful demonstrations by the Italians and the hovercraft to the late 50's with the English.

A complete list of hovercraft(or as they are more properly called Air Cushion Vehicle) and hydrofoil operators will be found as an attachment to this paper. In the main paper, we shall make a quick survey of the areas of major usuage of these vehicles. For ease and simplicity, the use of the two vehicles will be looked at individually.

Hydrofoils

Far East: Hydrofoil service can be found operating routes in Indonesia, Australia, New Zealand, and a dozen different routes in Japan. The heaviest concentration is the Hong Kong to Macao service which has proven sufficient to support a dozen vessels in year round service.

North and South America: Surprisingly, South America has more hydrofoils than does North America. Argentina, Bolivia and Venezuela and the West Indies are the main areas of service. The services provided in the U.S. and Canada have been limited primarily to areas of high tourism - Sea World in San Diego and Florida Hydrofoils in Miami. There are, however, signs of change. The advanced Boeing hydrofoil design has aroused serious interest in Hawaii, Washington State and San Francisco.

Mediterranean: Numerous services are to be found here. Coastal services are found in Italy, Greece, France, Spain and Morocco while oceanic operations cross the straits of Messina and operate between Italy and Yugoslavia while inland operations are conducted in Italy.

North and Central Europe: (except USSR)
Coastal services are found in England, the Channel Islands, Norway, Sweden and Finland. Inland lake and river service is provided in Bugaria, Finland, Hungary, Poland and Switzerland.

USSR: The Soviet Union has been treated separately because it has the greatest concentration of hydrofoil vessels in the world. The Ministry of the River operates over 1000 vessels on 150 plus scheduled routes over the canals, rivers, lakes and seas of the Soviet Union. The vessels range in size from the 30 seat Byelorus water bus to the sea going 100 ton, 300 passenger Vikhr with the fully submerged foil, turbune powered typhoon class due to enter service soon.

In 1968 the system carried in excess of 3 million passengers in contrast to the ten thousand it carried at its inception in 1958.[1] Statements by the Ministry of the River indicate that the hydrofoils provide significant advantages in time and cost over comparable forms of transport on water or land. Train service from Gorky to Kazan

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[1]James Surface Skimmers, 1971-72.

takes 20 hours while hydrofoils transit the same distance (516 M) in 12 hours at the same fare. On the Moscow to Sormovo trip (559 M) the time is 13 hours 40 minutes, while a conventional ship takes 3 days.

The above survey is based on worldwide usage of what can be called first generation hydrofoils with all of their faults. It can be reasonably anticipated that the advent of the second generation of improved vessels such as the Russian Typhoon and the American Boeing and Grumman boats will prove to be a great incentive to increased usage, especially when one compares their increase in seakeeping and passenger comfort.

Air Cushion Vehicles (ACV's)

Although Japan has initiated several routes using Air Cushion Vehicles, the primary area of use has been Europe.

The Ministry of the River in the Soviet Union has a fleet of approximately 50-60 Air Cushion Vehicles in scheduled service in the eastern Soviet Union. Forty of these are Zarya 66 passenger vehicles and the majority of the remainder are 50 passenger Sormovich craft.

France operates 2 Sedam N300 90 passenger craft along the Cote d'Azur and one N300 across the Gironde Estuary. Two HM-2 craft serve Setubal, Troia Peninsula and Sesimbra in Portugal.

It is in the United Kingdom that ACV's have found their highest use. The world's largest ACV, the 390 passenger SRN has been acquired by two companies -- Hoverlloyd and Seaspeed. Their four craft have carried many thousands of passengers and cars, e.g. between April

1970 and March 1971, Seaspeed's two craft carried 372,260 passengers and 55,880 automobiles while the summer of 1971 saw Hoverlloyd carry 556,600 passengers and 77,691 automobiles.

The SRN4's operate cross-channel on routes of Dover-Calais, Ramsgate-Calais and Dover-Boulogne while smaller craft (HM-2 and SRN-6) operate on various routes such as Portsmouth-Ryde, Southampton-Cowes, and local services on the Clyde in Scotland and the Solent.

Though the ACV's, at present, are greatly restricted in their areas of use, it can be anticipated that we will see increasing use of ACV's in those areas where their unique abilities qualify them to be the best vehicle.

APPENDIX I (cont'd)

Hong Kong: Hong Kong - Macao

Indonesia: Coastal Services

Australia: Sydney Bay and Coastal Services

New Zealand: Auckland - Waiheke Island

Philippines: Manila - Corregidor Island

Mediterranean:

Egypt: Abu Simbel - Asswan

Italy: Messino - Reggio - Isole Lippare

Naples - Capri

Trapani - Egadi Islands

Tremoli - Isoledi Tremiti

Lake Garda

Lake Maggiore

Lake Como

Naples - Ischia

Palermo - Ustica

Piombino - R, Matina - P, Azzutto

Spain: Palma - Ibiza

Greece: Athens - Passalimini - Hydra

Yugoslavia: Italy - Yugoslavia

Pula - Dubrovnik

Europe:

Bulgaria: Bourgas - Nesetow - Varna

Canary Islands: Las Palmas - Tenerife

APPENDIX I

Commercial Hydrofoil Routes

North and South America:

Argentina:	Buenos Aires - Colonia-Montevideo
Bolivia:	Lake Titicaca area
Venezuela:	Lake Maricaibo area
	Maracaibo - Cabimas
West Indies:	St. Thomas - Tortula
USA:	San Diego Bay
	Ft. Lauderdale - Miami - Virginia Key
Canada:	Vancouver - Seattle

Far East:

Japan:	Yanai - Mitohama	Osaka - Takamatsu
	Biwa Lake	Kobe - Sumoto
	Misumi - Shimabara	Himeji - Takamatsu
	Kagoshima - Hakamakoshi	Matsuyama - Hiroshima
	Onomichi - Innoshima	Onomichi - Imabari
	Nagoya - Toba	Kobe - Naruto
	Gamagori - Toba	Onomichi - Matsuyama

APPENDIX I (cont'd)

Channel Islands:	Guernsey - Jersey - St. Malo
Denmark:	Copenhagen - Malmo
Finland:	Lahti - Jyvaskyla
France:	Brest Coastal area
Hungary:	Budapest - Vienna
Norway:	Oslofjord
	Savanget - Haugesund - Bergen
	Bergen - Tittlelsness
	Copenhagen - Malmo (different co. then Finnish)
	Trondheim Coastal Services
Poland:	Szcaecin - Swinoujscie
Switzerland:	Lake Leman
United Kingdom:	Southampton - Cowes
	Greenwich area
	Bournemouth area
USSR:	Too numerous to cover here - see text

APPENDIX II

ACV Commercial Routes

Japan:	Trans - Ise Bay
	Gamagoori - Toba, Ise Bay
	Oita Airport - Oipa - Beppu

Europe:

France:	Cote d'Azur Coast
	Trans Dironde Estuary
Portugal:	Setubal - Troia Peninsula - Sesimbra
USSR:	Gorky, Oka, Sura Rivers
	Eastern Soviet Union
United Kingdom:	Dover - Calais
	Dover - Boulogne
	Ramsgate - Calais
	Southampton - Cowes
	Portsmouth - Ryde
	Ryde - Southsea
	Bournemouth - Swanage
	Bournemouth - Poole
	Bournemouth - Yarmouth

PART IV

CONSTRUCTION AND CAPITAL COSTS

PART IV

CONSTRUCTION AND CAPITAL COSTS

This section will explore capital costs of the HEART system, dredging, terminals, vehicles and supporting equipment. It will be presented in the following layout:

A. Canal Construction
B. Bridge and Access Construction
C. Terminals and Support Facilities
D. Vehicles and Spares

Each in turn will be explored in as much detail as is available, parameters and costs listed.

A. Canals

Basically, the program involves utilization and improvement of existing drainage canals. By improvement we mean modification of these canals to meet the following criteria:

1. minimum width of 100'

2. minimum depth of 9'

3. modification and or installation of provisions as to prevent clogging and silting.

In a few instances, the plan calls for the lengthening of existing canals and in only one instance do we project the construction of an entirely new canal.

The following material will be a listing of the various canals and will include information on whether they are existing or new, length to be modified, number of cubic yards of dredging (both wet and dry), and lining requirements. Part X of the report contains a map visually portraying the canal system.

CANALS

NAME	COMMENT	LENGTH (ft.)	CU. YDS. DRDG. dry / wet	CU. YDS. LIN. req.
Wailupe Stream	Existing	5,070	2,420,000	43,000
Kapakahi Stream	Existing	2,850	117,000/17,200	19,000
Ala Wai Canal	Existing	10,170	/283,000	113,000
Ala Wai Extension	Length Increase	5,280	280,000	24,000
Manoa-Palolo	Existing	5,280	/123,000	27,400
Ala Moana Park	Existing	4,400	34,000	6,900
McCully Stream	Existing	2,100	110,000	18,000
Nuuanu Stream	Existing	3,300	/55,000	16,700
Kapalama Canal	Existing	4,330	/143,000	32,200
Moanalua Stream	Existing	5,000	1,490,000	48,000
Airport	New	7,600	420,000	36,000

Total length of dredging is 10.5 miles and estimated cost will be $25,500,000 for dredging. Lining requirements are estimated to run $35,000,000.

B. Bridges

To permit operation of the system, any bridges now extant will have to be demolished and rebuilt to provide 25' vertical clearnance, and 40' horizontal clearance between spans. New bridges will have to be erected where canals are lengthened or new canals constructed. In all cases, access roads will have to be modified to meet the new vertical clearance requirements.

BRIDGES

ROUTE	BRIDGE	COMMENT
Hawaii Kai	Hawaii Kai	Existing--No improvements
Wailupe	Wailupe Stream	Existing
	W. Hind Drive	Existing
Kapakahi	Wailae Beach Park	Existing
	Wailae Nui	Existing
Ala Wai	Ala Moana	Existing
	Kalakaua (two)	Existing
	Ala Wai Blvd.	Existing
	Kapahulu Ave.	New
	Monsarrat Ave.	New
	Paki Ave.	New
	Kalakaua Ave. (D.H.)	New
Manoa-Palolo	Date St.	Existing
	Kapiolani Blvd.	Existing
	King-Freeway	Existing
Ala Moana	None	
Nuuanu	Nimitz Hwy. (2)	Existing
	King St.	Existing
	Beretania St.	Existing
	Kukui St.	Existing
	Beretania St.	Existing
	Vineyard Blvd.	Existing
Kapalama	Nimitz Hwy. (2)	Existing
	Dillingham	Existing

ROUTE	BRIDGE	COMMENT
Kapalama	King St.	Existing
	Freeway (H-1)	Existing
Moanalua	Kam Hwy. (2)	Existing
	Nimitz Hwy. (2)	Existing
Airport	Lagoon Drive	New
	Access Roads (2)	New

Estimated cost of bridge demolition, erection and modification of access roads is $20,000,000.

C. Terminals

Terminals will be divided into two classes: local and oceanic transfer. Local terminals will consist of minimum facilities, being no more than an embarkation/debarkation point for passengers, providing minimum dockage, limited numbers of benches and shelter.

Oceanic transfer terminals will be much more extensive, provisions will have to include:

1. dockage for 2 or more vessels
2. rest rooms
3. refreshments
4. sales areas for passes and tickets
5. sheltered waiting areas and benches
6. limited parking
7. access for bus embarkation/debarkation

It is estimated that each of this class terminal will require approximately 8,000 sq. ft..

The system will require seven oceanic terminals and twenty-one local terminals. Estimated cost of these facilities with approach roads is $20,000,000.

D. Vehicles

This analysis will be limited to marine vehicles and will approach the subject from three viewpoints, vehicles for: express, semi-express and local usage.

1. Vehicles for the oceanic express routes wi-l be second generation hydrofoil vessels with fully submerged and retractable foils and auto-stabilization. Eighteen vessels will be required with supporting spares at a cost of $59,000,000.

2. Semi-express vessels will be either captured air bubble or smaller second generation hydrofoil craft. Eight of these vessels will be required with supporting spares at a cost of $9,000,000.

3. Inland vessels will be of the so called "Hydroski" design, fifteen in number with supporting spares at an estimated cost of $8,000,000.

All estimated costs do not include transportation costs to bring the vessels to Hawaii if they are manufactured elsewhere.

E. Support Facilities

Support facilities will include those required for maintenance, repair and parts storage. No administration provisions have been made under the assumption that the system will be operated by some governmental agency and incorporated into its administrative structure. Estimated cost of $5,000,000.

G. Summary

The capital costs herein provided are the best presently available and include some safety margins. However, it must be borne in mind that verification will have to come from detailed engineering studies. For instance, no provisions have been included for silt traps, replacement of or rerouting of storm drains or other items not within our scope of experience or knowledge. Bearing this in mind, total cost of the system is estimated at $181,500,000, broken down as follows:

Dredging	$25,500,000
Lining	35,000,000
Bridges	20,000,000
Terminals	20,000,000
Vessels & Spares	76,000,000
Support Facilities	5,000,000
Total	$181,500,000

PART V

FINANCE AND ECONOMICS

PART V

FINANCE AND ECONOMICS

I. FINANCE

Finance of the HEART system is a complex matter, due to the lack of organization of mass transit funds at the federal, state, and local levels. The amount and type of financing necessary will depend upon whether the system is to be self supported or subsidized.

More funds appear to be available for mass transit systems which are publicly operated. For instance, the Urban Mass Transit Act (1964) authorizes loans and grants only for transit systems operated by public agencies. It may be contended that private business may more efficiently run mass transit systems, due to the lack of "red Tape" and political concessions required. However, Honolulu's present bus system (MTL) is City owned and operated, and public ownership of the HEART system may permit harmonious interaction between the two systems. Greater availability of funds, and coordination with present mass transit may make public ownership and operation a necessity.

The immediate costs to be met by the HEART system are set out in Part IV, and total $181,500,000 as follows:

Dredging	$25,500,000
Lining	35,000,000
Bridge changes	20,000,000
Express Craft	59,000,000
Semi-express Craft	9,000,000
Local Craft	8,000,000
Support Facilities	5,000,000

The United States Maritime Association has provisions for loans covering 87.5% of the cost of craft. Total craft cost is $76,000,000. The Maritime Association loan would cover $66,500,000, leaving $9,500,000 to be financed.

Assuming usage of the Maritime administration's provisions, $115,000,000 will need to be financed elsewhere. This remainder may be financed by using anyone or combination of the following:

1. Urban Mass Transit Act of 1964: This act authorizes loans and grants for improvement and initiation of transit systems operated by public agencies. If finance of the HEART system should result from this act, full provisions must be made for the handicapped. It is believed that finance upward of 70% may be proveded by the Urban Mass Transit Administration. Such finance may possibly cover the entire $115,000,000.
2. Bond Issues: The most attractive form of bond issue is the municipal bond, which is tax exempt from interest received. These should be publicly offered at a favorable rate of interest at the time of issue. Bonds create a stable atmosphere among the investors (the public), thereby making such bonds feasible.
3. Loans: This method of finance is the least attractive, and is the most difficult to obtain. Loans are possible through banks, factors, underwriters, and several other channels. Many legal technicalities are involved in financing such a large venture through loans.
4. Fares: Some revenue may be produced by the assigning of fares. While annual costs must be covered, it may be possible to pay some percentage of loans back with passenger revenues.

5. Present Transportation Secretary John A. Volpe is advocating the allocation of some of the Federal Highway Trust funds for use in mass transit systems, and has proposed several programs. Such programs may be advantageous to the finance of the HEART system, although no specific bill has been written or passed at this time.

Assuming HEART system finance to be available through the above mentioned means, yearly, variable, and organizational costs must still be met. The only cost which need not be considered is that of canal maintenance. It is believed that, due to past precedent, such maintenance will be carried out by the Army Corps of Engineers. (See Part VI)

Those initial organizational costs which must be met are craft delivery cost, financing costs, and administrative initial costs. These costs are not yet ascertained. However, they may be added to the immediate necessary costs of the HEART system and financed accordingly, or they may be borrowed and repaid through passenger revenues.

Yearly operating costs are both fixed and variable. Those fixed costs consist of administration, depreciation, insurance and salaries. Variable costs include fuel, and maintenance of craft and terminals. Fixed costs will total approximately 3 million dollars. Variable costs are estimated at 9 million dollars annually, due mostly to the cost of vessel fuel ($7,766,000).

Additional scheduling of tours and excursions on the HEART system vehicles is not expected to be a financial burden. If sufficient fares are charged to cover the marginal cost, there will be no addition to yearly or total cost of the HEART system.

Fares: All or part of these costs may be met by the income resulting from passenger revenues. HEART system patronage has been estimated at 89,660,000 revenue passengers per year (See Part II for derivation). The following annual revenues will result (with the estimated 89,660,000 revenue passengers) yearly, when the following flat fares are charged:

$.20 per passenger ride	$17,932,000 yearly revenue
.25 " " "	22,415,000 " "
.30 " " "	26,848,000 " "
.35 " " "	31,381,000 " "
.40 " " "	35,864,000 " "

Although somewhat more complex, the institution of zone fares may increase both the number of passengers and the yearly revenue. Charging different rates for local, semi-express, express, and super express rides may accomplish this goal with relative ease. For instance, a fare of twenty cents may be charged on local and semi-express routes, while 35 cents is charged on express runs. Any commuter transferring would pay only once, but would pay the fare of the greatest cost ride. Zone fares may also be charged by trip length, etc., although this method requires greater sophistication in ticket routines.

A "no-fare" system (free system) has been advocated by some of this city's officials. Such a system is highly likely to attract the driving commuter to the HEART system. However, operating costs must be met by some means. Administrative costs may be lowered somewhat if the system is city and/or state operated.

Taxes: A heavy tax on car ownership or car operation (gasoline tax) or on second and third car ownership and operation may be self defeating. Such a tax may help pay for the system during its beginning period of operation. However, as commuters begin to switch from automobiles to the HEART system for reasons of economy, tax revenues will fall rather rapidly. A rise in state sales tax from the present rate of 4% to the advocated 5%

may be able to handle part or all of the yearly operating expenses. The proposed hotel room tax may possibly be able to handle yearly costs, although revenue of this nature often fluctuates.

II. ECONOMICS

The HEART system appears to be economically feasible at this time. The projected cost of such a system is far less than that projected for other modes of rapid mass transit. It is expected that a commuter who choses to travel by the HEART system (without the supplementary use of an automobile) will save a good deal of money in transportation expense. Because all costs are not yet computed, a precise cost differential cannot be given. However, it is known that an automobile costs approximately twelve cents per mile to run. Fares on the HEART system are expected to be far less, if computed by the mile, whether flat or zone fares are charged.

Construction of the HEART system is projected for completion within two years, and will cause minimal disturbance on Honolulu's streets. Recent modes of rapid transit throughout the United States (including feeways) have taken much longer to complete, and have greatly disturbed traffic flows. If the present trend in automobile ownership and new residents on Leeward Oahu and the south shore is to continue, every major automobile throughway will have to be widened substantially, unless mass transit alleviates this situation.

"Speed of service has been found to be of particular concern to the consumer..."[1] Time, to the commuter, may often be given the same economical importance as cost. Fast transportation by the HEART system, combined with low cost, places it in a highly favorable economic position.

Finally, the cost now suffered by Honolulu in reference to traffic

1. Wilfred Owen, <u>The Metropolitan Transportation Problem,</u> p. 129.

congestion, automobile emissions, automobile accidents, and a skyline already dotted with parking garages cannot be measured, it can only be relieved.

PART VI

LEGAL AND POLITICAL

PART VI

LEGAL AND POLITICAL

Legal and political implications involved in construction and operation of the HEART system are many and diverse. There is no question that these areas will require continuing detailed research and resolution.

LEGAL:

Perhaps the most pressing and important of any of the existing or predicted legal problems is that of ownership of the canals. The present situation is cloudy and confusing to say the least. However, after research, both by this study group and by Chester Kaitoku, Administrative Intern for Dr. Craven, a series of tax and engineering maps (included in Part X of the original report) have been acquired and analyzed. The situation has been explored also in Part I of the report, "Topography and Population."

The problem here is that no one person, entity or government owns the entire system of canals but that they are owned by the State of Hawaii, City and County of Honolulu, Bishop Estate and perhaps a myriad of small private owners. In addition, because of the lack of formal agreements between the city and state governments, the exact ownership of many portions of the canals is clouded. This can be attributed to the following: Whenever a canal is improved and utilized as a major drain, the ownership (if privately owned) passes to the State or City depending on who instituted the program. Then as time passes, various informal agreements seem to have been worked out, that whoever has been doing the maintenance exercises practical, if not legal control of the canal. This question is now being queried by the Bishop Estate. Thus, if the canals are to be improved and utilized for the HEART system, these areas must be fully explored and clarified.

The Major problem will be in the area of nongovernment ownership. When dealing with estate owned portions (in particular, Bishop Estate) one immediately encounters the problem of leases and sub-leases. Individual ownership is even more difficult to determine, particularly in the case of three specific canals: Kapalama, Nuuanu and Manoa-Palolo. These two areas will require extensive research and up dating just to present a comprehensive picture of the potential problem. Though not difficult, it promises to be tedious and time consuming.

The true issue may lie in the future. This is the possibility of opposition to sale and the necessity for expensive time consuming condemnation procedures.

To acquire rights of way is that of jurisdiction and usage of the canals. The Coastwise Laws of the United States (commonly called "The Jones Act"), and the U.S. Coast Guard Regulations, Subpart 2.10 and Subparts 2.20 through 2.99 (title 33, chapter 1, Code of Federal Regulations 2.10, 2.20 through 2.99), indicate that the canals will be classed as navigable public waterways. Since the canals will have outlets to the sea they will fall under the Jones Act. The implications of this are twofold. One, can the usage of the canals be controlled so as to permit the operation of a scheduled transit system within a reasonable limit. Secondly, unless some form of exemption is obtained, the use of any vessel not built in the United States is prohibited. This in effect bars any consideration of use for shallow draft hydrofoils or captured air bubble craft unless there is some change in the policies of American vessel manufacturers.

The next area of legal concern is the possibility that the canals contain hidden usage not determinable at this time. Such hidden usage may be underwater sewage pipes, electrical and communication lines. What the extent of this usage and by whom will have to be carefully evaluated.

The last legal area to be discussed here is that of who is to operate the system. At the moment the legality of the City's take over of Honolulu Rapid Transit of the bus system is not yet settled. It appears to be moving in favor of the city, although the effects of an adverse decision on the HEART system should be considered.

POLITICAL:

This area seems to boil down to simply selling the system to the Federal State and City governments. This promises to be a very difficult proposition.

The Federal Government has embarked on a program of mass transit expansion, but the primary agency, the Department of Transportation is land oriented. The Maritime Administration, who have historically provided funds for marine systems has not in the past adopted any courses of action in the mass transit area with the exception of conventional ferry systems.

The historical development of waterways policy of the United States is such that it appears worthwhile to explore the feasibility of having the responsibility for canal maintenance to be assigned to the U.S. Army Corp of Engineers. The cornerstone of this policy is the Ordinance of 1787, for the government of the Northwest Territory and its navigation clause (Article IV). The Congressional Act of March 3, 1803 (2 STAT. At L. 229, 235) and the Congressional Act of May 24, 1824 (4 STAT. 32) reinforced, and for all purposes defined the policy that the development and control of waterways was a federal responsibility.

The Hawaii State Government is not presently committed to any specific transit system and seems willing to consider any alternatives. However money is tight at the state level and the availability of federal funding will have a great deal to do with the acceptance or rejection of any system. (SEE PART V)

The City and County of Honolulu Administration appears to be committed to a fixed rail-bus system on the advice of their Consultants, (Daniel, Mann, Johnson and Mendenhall). The City Council on the other hand appears to be still actively exploring all alternatives.

Therefore, it is recommended that the following action be taken:

1. Determine the interest and availability of funds by the Federal Government.

2. Actively explore the opinions of the State and City government officals and legislators.

3. Prepare informational packets and presentations for all three levels.

4. Initiate a legal study, utilizing qualified staff, into the various areas involved. The staff must include those experienced in maritime law.

Finally, any resolution of the political problems will involve a careful presentation involving cost/benefit ratios and a convincing demonstration of the HEART system advantages.

APPENDIX VI (A)

LISTING OF AGENCIES AND ORGANIZATIONS HAVING JURISDICTION AND/OR INTEREST IN THE HEART SYSTEM

APPENDIX VI (A)

I. FEDERAL AGENCIES

Department of Transportation

Highways Division

Urban Mass Transit Administration

Maritime Administration

Coast Guard

U.S. Army Hawaii

Army Corps of Engineers

II. STATE OF HAWAII

Department of Transportation

Harbors Division

Airports Division

Highways Division

Department of Land and Natural Resources

Department of Planning and Economic Development

Office of Enviromental Quality Control

Attorney General

Land Use Commission

Legislature

III. CITY AND COUNTY OF HONOLULU

Planning Department

Department of Public Works

Office of Mass Transit

III. CITY AND COUNTY OF HONOLULU(cont...)

City Council

IV. OTHER

Life of the Land

Save Our Surf

Bishop Estate

Kaiser-Aetna

Kalihi-Palama Community Association

Oahu Development Conference

PART VII

OPERATIONS

PART VII

OPERATIONS

I. ROUTES

The HEART system incorporates three separate types of routes. One connects all terminal stops via high speed express craft. Those points to be connected are Hawaii Kai, Waialae Beach Park (Kahala), Waikiki Nataorium, Ala Wai Yacht Harbor, Honolulu International Airport, Aloha Tower, Hickam Air Force Base, and Pearl City. These points are not definite and some changes may be considered:

1. The Ala Wai Yacht Harbor stop may best be located at either Magic Island or the City and County owned portion of Fort De Russy. These are the only known sizable parcels of land in this area to which the HEART system may possibly attain access.
2. It is proposed that the Airport stop be located next to the airport terminal. An express route would connect with the airport, utilizing an extension of the present canal. Relocation of the express stop at Keehi Lagoon Beach Park should be considered, using some type of local craft to transport passengers to the airport, using the proposed canal. This method would make passenger transfers to local points much simpler.
3. The proposed stop at Hickam Air Force Base might more suitably be located at Iroquois Point, due to population distribution. If this were done, one of the smaller local craft would need to stop at Hickam.

Semi-express routes connect pickup points with terminal stops, using craft moving at speeds somewhat lower than the express craft. Local routes are to be used to connect main terminal stops with various pickup points along the coastal and local routes. These routes are to use some type of shallow draft vessel or the Captured Air Bubble craft, which may be necessary on the semi-express runs. (See Part III) It is unlikely that channels will be cut through the existing reef line in Aina Haina and Niu Valley areas, and the Captured Air Bubble craft may be a necessity in this area.

Semi-express routes:

1. The Hawaii Kai--Kahala Mall semi-express connects Upper Hawaii Kai, Hawaii Kai, Niu Valley, Aina Haina, Waialae Beach Park, and Kahala Mall.
2. The Hickam - Pearl City run connects Hickam, the Shipyard, Aiea, Pearl Ridge, and Leeward Community College.

Local routes:

1. The Natatorium - Ala Wai run connects Waikiki Natatorium, Kapahulu - Ala Wai, Lewers-Ala Wai, Lewers-Date and Lewers-Kapiolani (on the Manoa-Palolo canal), McCully-Ala Wai, McCully Date and McCully=King (on the McCully Street canal), Ala Wai Yacht Harbor, and Kewalo Basin.
2. The Aloha Tower - Airport local connects Aloha Tower, Nuuanu
II Stream, Nuuanu Stream-Hotel St., Nuuanu Stream-Foster Gardens, Moanalua Stream-Keehi lagoon, Moanalua Stream-Ft. Shafter, and the Airport.

II. TERMINALS

All express-stops are to be equipped with terminals capable of holding 500 passengers. Both semi-express and local runs will treat stops as pick-up points, and a sheltered area will be provided. The size of the shelter will vary with the patronage of the various stops, but will be ample to shelter all waiting passengers.

Engineers at Look Labs have determined the necessary average terminal size to be 8,000 square feet, and each terminal is to measure 150 feet by 50 feet. Ample space for automobile parking should be provided for approximately 200 cars. These measurements will vary somewhat with the size and contour of the land available. Terminals will be served by express craft with a 250 passenger capacity.

1. The Hawaii Kai terminal is to be located at the Hawaii Kai Shopping Center, immediately adjacent to Chuck's Steak House using parking already available at the shopping center.
2. Waialae Beach Park has a large open space which is presently beach park exists on the Diamond Head - Makai (south) side of Kapakahi Stream's bridge, measuring approximately 70 yards by 130 yards. Space for the parking area and terminal exists.
3. Waikiki Natatorium's terminal can be located within the Natatorium structure, although remodeling will be necessary. Some of Kapiolani Park space may need to be converted for automobile parking stalls.
4. Ala Wai Yacht Harbor. Magic Island is now recreational park space, and offers a possible terminal site. More than sufficient area exists, although it appears that much wet dredging would be necessary. Fort De Russy offers an alternate site. The City and County of Honolulu owns land at the end of Fort De Russy Road. The actual land area measures approximately 75 feet by 150 feet, and the extending beach area perhaps 75 feet by 300 feet.
5. Aloha Tower. A terminal could easily be located within the building, with very little construction necessary. A City operated parking lot is located across from Aloha Tower, and

could potentially be converted to an eight hour parking lot.

6. Airport. HEART system terminal may be located either just mauka (north-east) of the airport terminal and main parking area, or at Keehi Lagoon Beach Park (and transfeerring airport-bound passengers to the airport via smaller craft). At the airport terminal there presently exists a water fountain and small pool, next to a flower garden. This area has sufficient space for a HEART system terminal. The area at Keehi Lagoon Beach Park has not yet been studied.

7. Pearl City. A potential terminal could be located at Pearl Ridge Shopping Center where the inner roadway crosses the canal. This is within walking distance, approximately 100 yards south of the main entrance to the shopping center.

III. SCHEDULES

A combination of express vessels, carrying a maximum of two hundred fifty passengers, and inland vessels (of two probable types) carrying approximately eighty to one hundred twenty passengers, is to be used. During peak hours, a minimum of eighteen express craft and twenty-three local craft (eight Captured Air Bubble type or size, and fifteen "hydroski" type or size), is recommended. Peak hours are believed to exist in Honolulu from 6:20 A.M. to 8:40 A.M. and from 3:20 P.M. to 5:40 P.M. Operation with this minimum number of craft can provide express service every nine to ten minutes. With twenty three express vessels and thirty local vessels, service can be increased to every six to seven minutes.

Due to the lapse of time during peak traffic (six and one-half hours), a number of express craft, and perhaps a few local craft, will be left idle. Various means may be employed to extract further revenue from the operation of these craft.

1. The concept of inter-island freight transportation should be explored.
2. Inter-island tourist excursions may be undertaken.
3. Transportation to the outer islands may be provided.
4. Transportation to various recreational areas on Oahu may be provided, and excursions for school children may be undertaken.

Express vehicles servicing eight terminals from Hawaii Kai to Pearl City will complete this run in an estimated seventy=four minutes. This service is to be complimented by two super-express routes:

1. Pearl City to Aloha Tower taking only eighteen minutes, including loading times.
2. Hawaii Kai to Waialae Beach Park to Aloha Tower in twenty-two minutes.

An Airport to Waikiki express (either to the Ala Wai Harbor, or to the Natatorium, or both) is recommended. Service to these destinations should be provided from approximately 5:00 A.M. until midnight, at a regular interval basis.

Schedules have been completed for the express run, and for each of the local runs:

ROUTE:	STOP:	ARRIVE:	DEPART:
A. Express:			
Hawaii Kai - Pearl City	Hawaii Kai		0.0 min
est. speed: 40 knots	Waialae Park	5.75 min	8.75 mine
total time: 74 min.	Natatorium	17.8 min	20.8 min
	Ala Wai Harbor	25.0 min	28.0 min
	Aloha Tower	34.0 min	37.0 min
	Airport	44.0 min	47.0 min
	Pearl City	74.0 min	
B. Local:			
Hawaii Kai - Kahala Mall	Upper Hi. Kai		0.0 min.
est. speed: 33 knots	Hawaii Kai	1.0 min.	3.0 min.
total time : 23 min.	Niu Valley	6.5 min.	8.5 min.

ROUTE:	STOP:	ARRIVE:	DEPART:
B. Local (cont.):			
	Aina Haina	13.0 min.	15.0 min.
	Kahala Mall	19.5 min.	21.5 min.
	Waialae Park	23.0 min.	
C. Local:			
Natatorium - Ala Wai	Natatorium		0.0 min.
est. speed: 20 knots	Kapahulu-Ala Wai	1.5 min.	3.5 min.
total time: 17 min.	Ala Wai-Lewers	8.0 min.	10.5 min.
	Ala Wai-McCully	12.5 min.	15.0 min.
	Ala Wai	17.0 min.	
Shuttles:			
1. Manoa Canal	Lewers		0.0 min.
est. speed: 20 kts.	Date	2.0 min.	4.0 min.
total time: 6 min.	Kapiolani	6.0 min.	
2. McCully	McCully		0.0 min.
est. speed: 20 kts.	Date	2.0 min.	4.0 min.
total time: 6 min.	King	6.0 min.	
3. Ala Wai-Kewalo	Ala Wai		0.0 min.
est. speed: 20 kts.	Kewalo	3.5 min.	
total time: 3.5 mon.			
D. Loacl:			
Aloha Tower - Airport	Aloha Tower		0.0 min.
est. speed: 20 knots	Nuuanu	1.5 min.	3.5 min.
total time: 29 min.	Kapalama Hts.	9.5 min.	12.5 min.
	Moanalua	18.5 min.	21.5 min.
	Airport	29.0 min.	
Shuttles:			
1. Nuuanu Stream	Nuuanu		0.0 min.
	Hotel St.	4.0 min.	6.0 min.
	Foster Gardens	8.0 min.	
2. Kapalama Stream	Kapalama		0.0 min.
	King St.	3.0 min.	
3. Moanalua Stream	Moanalua		0.0 min.
	Ft. Shafter	3.5 min.	
E. Local:			
Hickam - Pearl City	Hickam		0.0 min.
	Shipyard	5.0 min.	7.0 min.
	Aiea	12.0 min.	14.0 min.
	Pearl Ridge	17.0 min.	1910 min.
	Pearl City	22.o min.	
Shuttle:			
1. Pearl City-Leeward	Pearl City		0.0 min.
	Leeward	13.0 min.	15.0 min.

IV. SYSTEM OPERATIONS

A. Personnel Costs

Each oceanic express vessel will need one captain (or pilot), and one mate. The equivalent will be necessary on board all local craft. Salary for the captain will run $17,000 per year, and the mate's pay will run $14,000 yearly. Cost per year for the entire crew of the HEART system will be $1,500,000. Costs for administrative personnel are estimated at $200,000 (maximum). Janitorial costs may run to $98,000. Costs for other supportive personnel are not available at this time.

B. Maintenance

1. Vessels: Craft maintenance will total approximately $1,500,000 yearly; fifty percent of this sum paying the cost of labor, and fifty percent necessary for the purchase of parts.
2. Canals: Dredging, debris and silt removal, and general cleaning will be needed in all canals on a regular basis. The cost of this maintenance is not yet known but should not prove to be a barrier on the local level. The Army Corps of Engineers will bear this responsibility if historical precedent is followed. This issue is explored in more detail in the legal and political section of this report.
3. Terminals: Terminals are to be designed in order to require minmum maintenance. However, janitorial service will be necessary on a regular basis.

C. Fuel Cost

Fuel consumption has been computed with all craft running an estimated twelve hours a day. Fuel costs will be $7,755,000 yearly, or $21,240 per day.

D. Insurance

It is advised that the HEART system be self-insured for hull damage, due to the high rates currently being charged for insurance coverage. Liability insurance will cost $43,500 per year, and will insure each craft for $30,000.

E. Fares

A survey sampling of seventy-eight persons from Ewa Beach to Hawaii Kai has shown that the average citizen prefers to be transported by automobile if the fares charged by mass transit operators exceed the 25¢ to 40¢ range. The rate on either the oceanic or the local run may prove to be the "ticket taker" or "fare taker". Zone fares, or fares charging differing amounts for local as compared to express runs may also be necessary. (See Part V)

PART VIII

ENVIRONMENT

PART VIII

ENVIRONMENT

The construction and operation of the HEART system, like any other undertaking of this magnitude, will have a large impact on the local environment. It is therefore important that a detailed environmental impact study be done at a time when system parameters are fully defined.

At this time only a limited number of areas of major concern will be explored and the absence of detailed solutions will be readily noticed. The areas to be covered are noise, water pollution, air pollution, and safety factors.

I. Noise: The projection of any new transportation system, particularly those involving operation in densely populated areas, necessarily involves concern over noise levels. The solution to this in the HEART system will be the use of gas turbine powerplants, coupled with waterjets for propulsion. The manufacturers of the new generation of power plants and vessels at this time are willing to adhere to specifications for levels of noise emission that are more stringent than those to be applied to automobiles in 1975. Possibly even these specifications will be bettered in the near future, while the waterjet units obviate the need for air propellors and their attendant high noise levels.

II. Water: The use of waterjet propulsion eliminates the need for externally mounted reciprocating machinery such as propellors, struts, etc. The elimination of this machinery also removes the need for lubrication and the risk of water pollution by petroleum products.

Proper engineering design of the system will include such provisions as silt traps, arrangements for debris prevention and collection. Careful design and selection of construction materials will insure flow and circulation of system waters, preventing stagnation and the creation of a gigantic cesspool.

Rigid standards must be set and enforced to minimize or prevent water pollution from such areas as debris or pollutants entering the water from transiting vessels or as the result of maintenance and cleaning operations. In addition, the increased size of the canals and the improved flow patterns should aid in reducing pollution below the present levels.

Engineering studies presently indicate that the cap rock is safely below the projected requisite levels of dredging and that the system will have no effect on Oahu's fresh water supply.

Since the system is designed to utilize existing canals, channels and harbors which are either dry or already connecting with the sea, there should be little or no effect on marine life and reefs, but this area must be explored in greater detail.

III. Air: The turbine power plants specified for the marine vessels have levels of exhaust emission well below the standards set as danger levels and changes in technology will in all probability further reduce those. In addition, the use of these vehicles throughout the metropolitan area will greatly reduce the requirements for the presently utilized buses. The substitution of mini buses for these diesel powered vehicles will rid the downtown area of a great deal of exhaust and odor.

IV. Safety: There has been a great amount of concern manifested by various groups as to the safety of the HEART system, in particular, the high speed express portions. Careful investigation has revealed that due to its inherent stability and maneuverability a hydrofoil of the second generation is safer at cruising speed than any conventional vessel. Its ability to avoid obstacles

Borders on the unbelievable, and one of these vessels travelling at forty-five knots can stop in less distance than a conventional vessel travelling at ten knots. To be more specific, an oceanic express vehicle of the type projected can stop in less than seven hundred feet under normal procedures, and less than three hundred feet under emergency conditions.

The design of the vessel incorporates multiple power plants for safety, and the vessel is structurally designed to suffer a head-on collision with a reef at foil level while retaining hull integrity and the capability to return on its own power.

Coast Guard design approval will be received for all vessels and all appropriate safety regulations and requirements will be either met or exceeded.

In conclusion, though a detailed environmental impact study will have to be made, no problems are presently anticipated that careful thought, design and preparation cannot cope with.

PART IX

CONCLUSION

PART IX

CONCLUSION

Use of the waters of Leeward Oahu and the canals of metropolitan Honolulu is possible and competitive block speeds can be attained. Careful analysis and design of an integrated water vessel/bus system can provide an efficient, reliable and comfortable mass transit system.

In addition the need for the service will increase as Honolulu continues in its pattern of expansion along the coastline.

The existing canal system is too narrow and too shallow while the existing bridges do not provide sufficient clearance. However, the costs and time to remedy this are not seen as prohibitive and are considerably less than competing modes.

Success of the system will depend on acceptance, first by commuters and later by tourists and others. They will expect reliability, convenience and a reasonable fare. In addition, with the prevailing attitude towards the private automobile, it is doubtful whether any mass transit system can succeed without some action to reduce its attractiveness. This, is not a problem unique to the HEART system but applies to any other mode as well.

A well run water based system could become an attractive part of the daily scene in Honolulu as well as a tourist attraction.

The capital outlay in launching the HEART system is calculated to be $181,500,000, with a construction time of two to three years. This is considerably less than any other system offering the same capability.

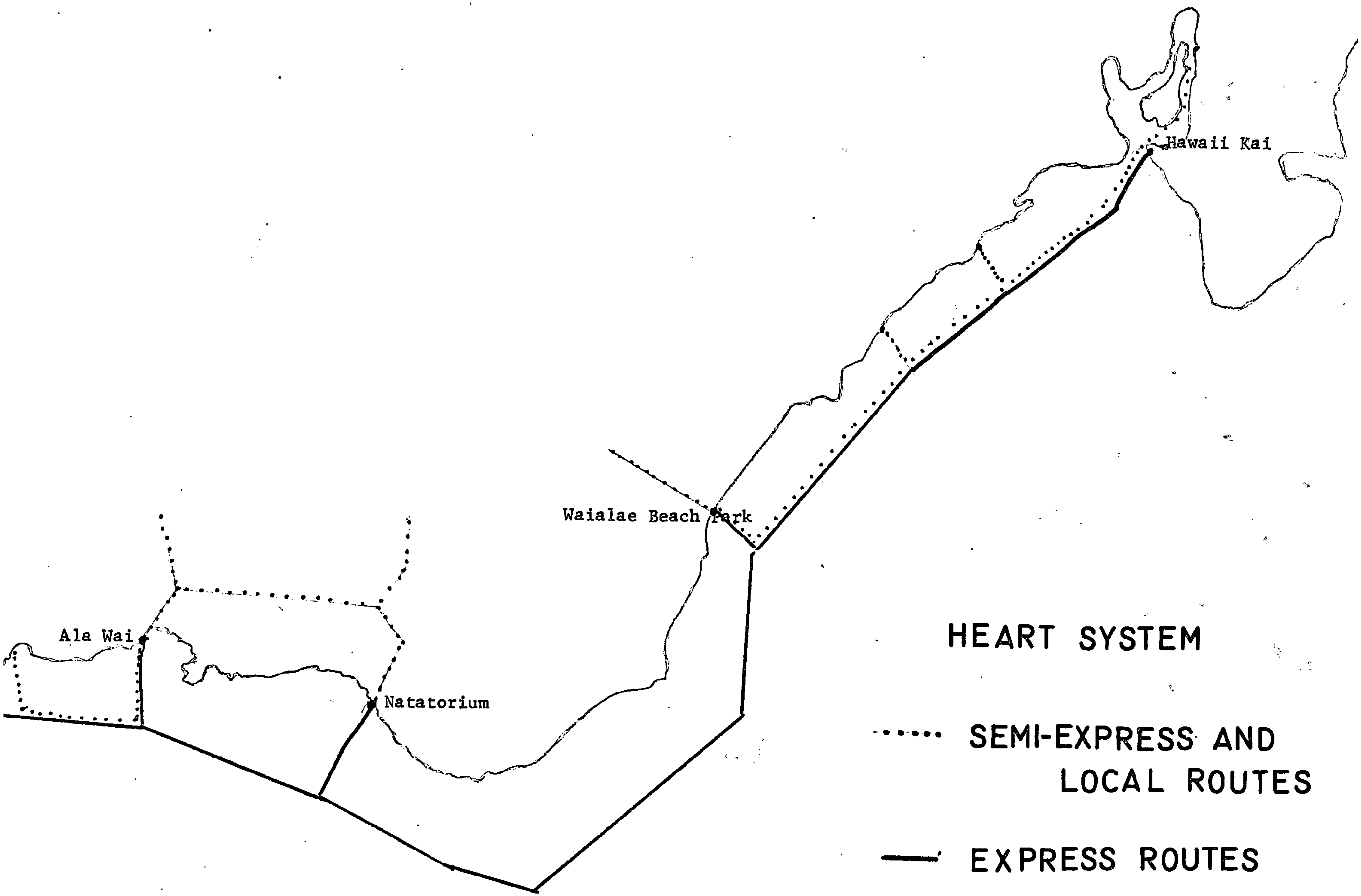
PART X

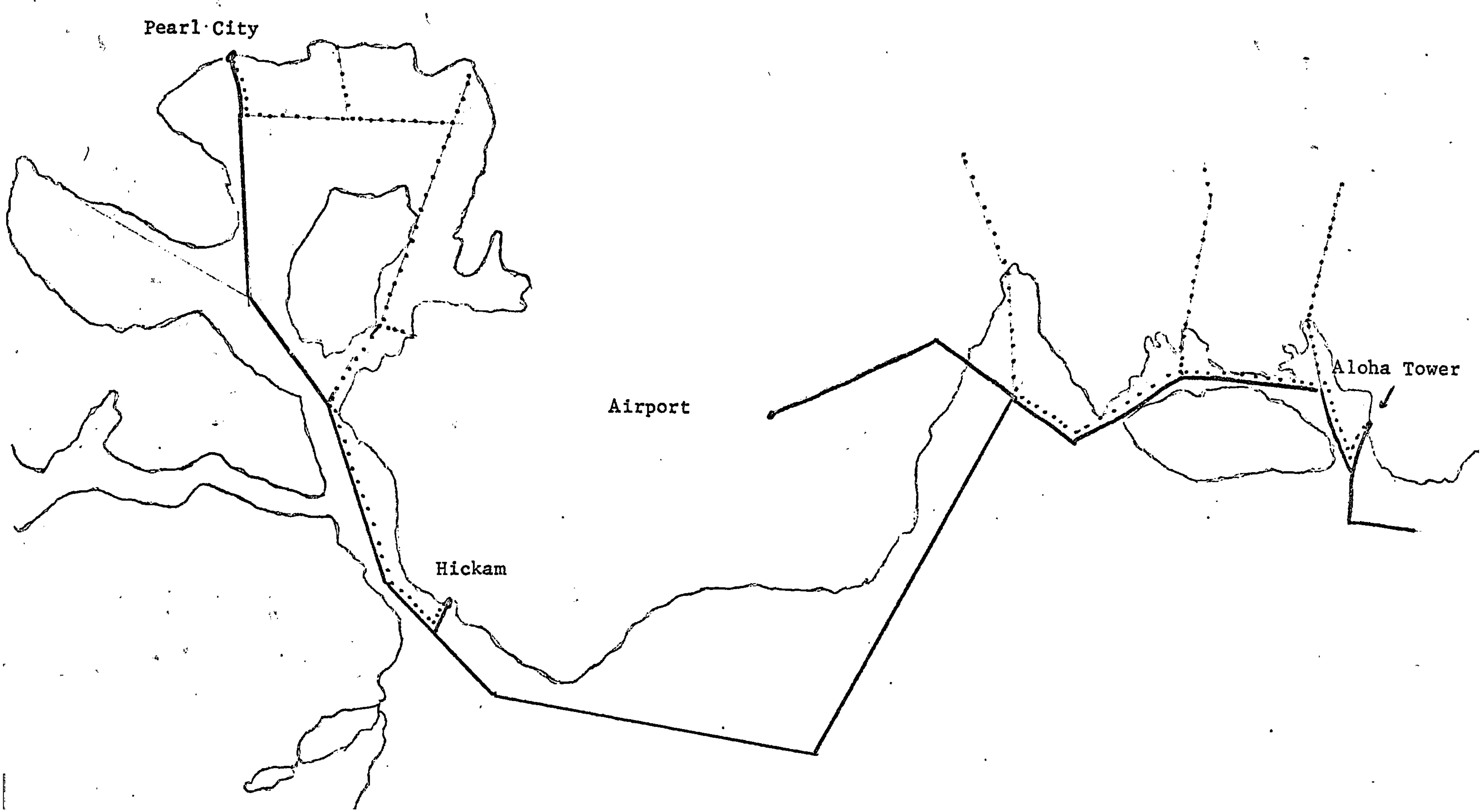
MAPS & ATTACHMENTS

ENGINEERING & TAX MAPS

INDEX

NAME	NO. ENGINEERING	NO. TAX
NIU	1	1
WAILUPE		3
KAPAKAHI	3	2
NATATORIUM		5
DE RUSSY		1
ALA WAI	4	
MANOA-PALOLO	2	9
NUUANU	3	11
KAPALAMA	5	11
MOANALUA & AIRPORT		5
KALAUAO SPRING	1	1
ALA MOANA DRAINAGE	2	2


Hawaii Kai
Waialae Beach Park
Ala Wai
Natatorium
HEART SYSTEM
SEMI-EXPRESS AND LOCAL ROUTES
EXPRESS ROUTES



Pearl City
Airport
Aloha Tower
Hickam

NOTE: ALL ENGINEERING AND TAX MAPS AND MASTER MAP OF HEART SYSTEM ARE PART OF THE ORIGINAL REPORT, AND ON FILE WITH MASTER COPY AT THE SEA GRANT OFFICE AT THE UNIVERSITY OF HAWAII.