FAST FERRY REPORT

Phase 1

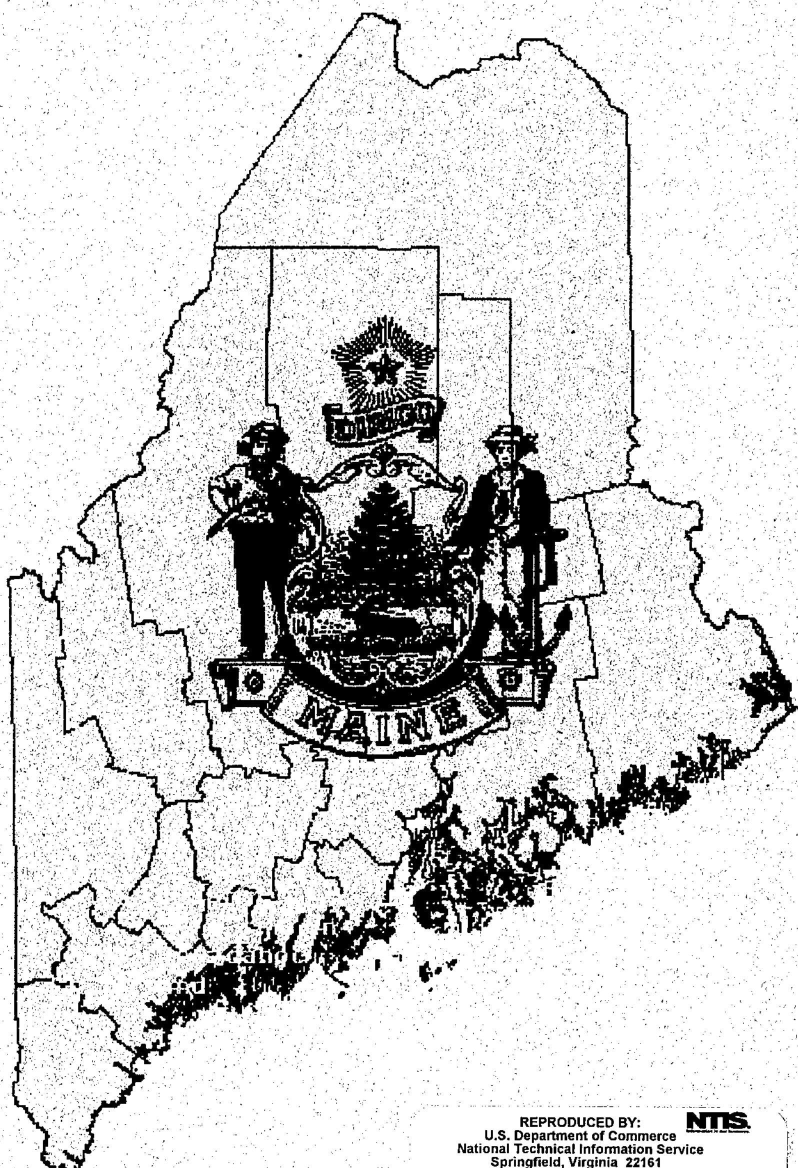
Maine Department of Transportation

FINAL REPORT

TECHNICAL REPORT ME 99-5

DECEMBER 1999

Research



Technical Report Documentation Page

1. Report No. ME 99-5	2	3. Recipient's Accession No.
4. Title and Subtitle Fast Ferry Report - Phase 1		5. Report Date December 1999
		6
7. Author(s) Mark S. Libby		8. Performing Organization Report No.
9. Performing Organization Name and Address Maine Maritime Academy Castine, Maine 04420		10. Project/Task/Work Unit No.
		11. Contract (C) or Grant (G) No.
12. Sponsoring Organization Name and Address Maine Department of Transportation 16 SHS Augusta, ME 04333-0016		13. Type of Report and Period Covered
		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract (limit 200 words)

The primary purpose of this report is to identify those vessel types that will be best suited for service in coastal Maine waters.

The high-speed craft that we are most likely to see operating on coastal Maine waters are standard and hybrid catamaran designs and monohull vessels. Propelled by power trains consisting of gas turbines or diesels coupled with waterjets or surface propellers, these vessels are all capable of producing speeds in the 30-50 knot range. With the use of computer controlled trim tabs these vessels can generated safe and comfortable rides in various sea conditions.

These catamarans and monohull vessels require very little infrastructure. Minimally, sufficient draft at various tide conditions and a floating platform at a height close to the vessel's main deck are required. Vessels in the size range that we are likely to see on the Maine coast, that is those capable of carrying 200 to 300 passengers, will have draft requirement less that 10 ft. The floating platform at main deck level affords the passengers easy access to the vessel.

17. Document Analysis/Descriptors Ferry, High Speed		18. Availability Statement	
19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages 21	22. Price

Executive Summary

All fast ferry types depend upon the reduction of surface tension and resistance by either reducing hull drag or by creating dynamic lift. There are four main types of fast ferries, each achieves lift or reduces drag in distinct ways:

- Monohull vessels, which are able to reach high speeds with planing hulls.
- Catamarans, which depend upon the hydrodynamic advantage gained by narrow efficient hulls. Wavepiercers and surface effect ships (SES) are hybrid catamaran designs. SES hulls create dynamic lift with air cushions. Wavepiercers are hull designs that cut through short waves efficiently.
- Hydrofoils, which operate with the hull clear of the water using dynamic lift provided by submerged or surface piercing foils at speed.
- Hovercraft, in which the hull is lifted clear of the water by an air cushion.

The high-speed craft that we are most likely to see operating on coastal Maine waters are standard and hybrid catamaran designs and monohull vessels. Propelled by power trains consisting of gas turbines or diesels coupled with waterjets or surface propellers, these vessels are all capable of producing speeds in the 30-50 knot range. With the use of computer controlled trim tabs these vessels can generate safe and comfortable rides in various sea conditions.

These catamarans and monohull vessels require very little infrastructure. Minimally, sufficient draft at various tide conditions and a floating platform at a height close to the vessel's main deck are required. Vessels in the size range that we are likely to see on the Maine coast, that is those capable of carrying 200 to 300 passengers, will have draft requirement less that 10 ft. The floating platform at main deck level affords the passengers easy access to the vessel.

Introduction

Fast ferries have only really come to prominence in the 1990s with the development of larger car-carrying catamarans and monohulls, but have in fact been in existence for more than forty years. The features that distinguish this new breed of fast ferries are their speed, light construction, and design characteristics. With the evolution of the fast ferry, new methods of control have come into being. Management, operation, and safety are all issues that are being dealt with on national and international levels.[Fast Ferries:9]

This report will identify fast vessels that are likely to operate in Maine waters. Only vessels capable of carrying 200-300 passengers and maintaining speeds of 28 knots or better when fully loaded will be considered. All vessel types considered must conform to the current Jones Act laws, that is; they must be built in the U.S., and manned by crews licensed by the U.S. Coast Guard. The report will also look at the current International Maritime Organization's (IMO) High-speed Craft Codes (HSC CODE).

Basic Service Considerations

The fast ferry market is most notable for its diversity. Fast ferry craft may be found operating in many capacities, such as commuter service in large cities and for leisure purposes in tourist areas. By their very nature, all ferry services form part of a continuous transport system. In its many varying roles, the fast ferry can be an alternative or a supplement to highway and railroad options.

The notion that a particular fast ferry is suited for routes with closely defined characteristics has been proven wrong. A number of vessels that have failed in one service have found success in another, often with totally different operating conditions. Before a high-speed ferry is put on a new service, though, the following factors should be considered:

- Ability to meet the current regulatory requirements. (The vessel may have to be reclassed.)
- Knowledge of the route.
- Frequency of the service requirements. In Maine's case, this includes seasonal variations.
- Sustainable speed at sea, seakeeping and comfort.

- Maximum allowable speeds in close waters and port entrances.
- Maneuverability requirements when navigating and when docking and undocking.
- Vessel maintenance and overhaul considerations.
- Manning and management considerations.
- Wake/wash effects.
- Air and noise pollution considerations.

Infrastructure-Berthing Requirements

In general, most vessels of the same class will have similar berthing requirements. About 85% of the fast ferries in service today are side loading. The remaining vessels load from the front or rear and were designed for specific applications. Most of the vessels are adaptable to existing berthing arrangements with little or no modifications.

Ideally, the loading platform would be floating and at a height close to the main deck, so that the passengers can embark and disembark with relative ease. The main deck is usually between 2 and 4 meters above water level. Some other issues that must be addressed when considering berthing are:

- The number and location of the mooring lines.
- The requirement for utility connections.
- Vessel draft requirements.
- Suitable space for maneuvering the vessel.

Most fast ferries are highly maneuverable and need very little space to approach or leave a berthing area.

Ride Quality

Passenger comfort is of prime importance. The ability of a vessel to cope with bad weather from the point of view of strength is not always matched by an acceptable level of comfort. Although a standard exists on motion sickness, the minimum standard alone would probably not be enough to overcome passenger reluctance to use a service if the discomfort extends beyond a limited period.[Ryle:23] Most operators will curtail operations with seas in the 10 to 12-foot ranges. As one operator's representative said, "It's better to cancel a trip than to risk passenger dissatisfaction."

Motion sickness can be influenced by physical and psychological factors such as those listed below and should be taken into consideration when choosing a design:

- Confined spaces.
- The snowball effect of exposure to sick passengers.
- Consumption of inappropriate food and drink.
- Anxiety at the possibility of experiencing motion sickness.

Ride quality in various sea conditions can be improved by the addition of computer controlled trim tabs and/or inverted t-foils.[Hynds:37] These fixtures are designed to reduce vertical acceleration caused by vessel pitch, heave and roll which are instrumental in causing passenger discomfort and motion sickness. The use of computer simulation and tank testing can accurately predict the reduction in vertical acceleration by the use of different combinations of either trim tabs or t-foils. T-foils can be designed to be retractable so that they do not increase the vessel's draft for maneuvering.

A quiet environment, free from machinery noise and vibration, ranks right after ride quality and safety for passenger comfort. Mounts that effectively isolate inherent engine rumble, gear boxes that don't whine, propellers that don't sing or cavitate, exhaust systems that muffle effectively, and ventilation systems that lessen air flow noise are all essential to achieve the low noise levels that are expected today.

Internal noise levels will depend on where the measurements are taken. In almost all classes of vessels, when noise level measurements are taken, the results will be the same. The forward and interior areas are inherently less noisy than the after areas and outer areas. Noise levels in the 60-75dBA range are achievable in properly designed passenger spaces.

Hull Types

There are many different types of high-speed craft, but these can conveniently be categorized within four main types. The four types are:

- Catamarans
- Monohulls
- Hydrofoils
- Hovercraft and Surface Effect Ships (SES)

Many hybrid designs exist within these basic categories, but all fast ferries depend upon the reduction of the surface tension and hull resistance by achieving dynamic lift and/or minimizing drag. Reducing hull resistance is accomplished by the use of lightweight materials to ultimately reduce the hull's wetted area and by the effective use of coatings. Coatings not only serve to reduce hull resistance, but will also help reduce hull deterioration. Dynamic lift is created by hull geometry or lifting the hulls out of the water with air cushions.[Fast Ferries:45]

The different types of hull forms can be seen in Figure 1. A brief description of each follows, with Table 1 describing the main advantages and disadvantages. For the purpose

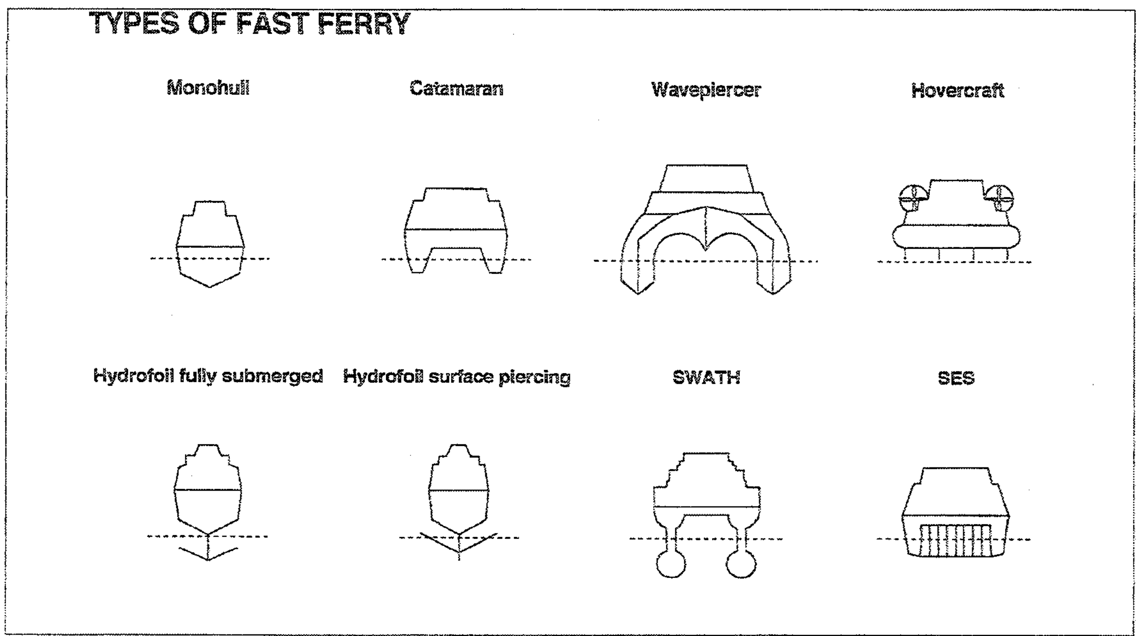


Figure 1 (Source: Drewry Shipping Consultants Ltd.)

of this report, their basic shape categorizes the vessels. It should be remembered, though, that each category contains a range of designs with varying performance characteristics and capabilities, rather than a single, standard type.

Monohull

Monohull fast ferries are long, deep veed craft, usually with very narrow beams. Monohulls are much longer than other vessels of the same capacity, which can create a docking problem in some ports. The narrowness of the hull creates an inherently smaller deck area.

Table 1 High Speed Vessel Types: Advantages and Disadvantages

Type	Advantages	Disadvantages
Catamaran	•Large deck area •Shallow draft •Modest technology •Good stability	•Moderate seakeeping(without ride control) •Aluminum structure restricts size to 120-130 meters at present
Wavepiercer Catamaran	•Spacious •Modest technology •Shallow draft •Improved seakeeping	•Structurally complex •High windage
SWATH	•Good seakeeping •Spacious	•Structurally complex •Deep draft for size •Power penalty at high speed •Deep draft at slow speed
Hydrofoil	•Well proven •Efficient at high speed	•Risk of foil damage •Limited seakeeping
Monohulls	•Simple construction •Traditional materials and building methods •Good seakeeping •Diesel propulsion	•High power required at high speeds •Restricted deck area •Length can be a problem in ports •Deep drafts
Hovercraft	•Amphibious •Simple structure •Well proven on some routes	•Complex technology •Skirt wear •Unusual handling characteristics

In order for monohulls to reach high-speed they will usually have planing or semi-planing hulls. Planing refers to hull shapes that allow the vessel to have dynamic lift as the vessel speed increases. A full planing hull might have 2-3 feet of hull in the water at full speed. At maneuvering speeds they have approximately the same or slightly deeper draft than a comparable catamaran, 4-6 feet.[Fast Ferries:10]

Chine is a term that refers to a monohull's shape in the area of the bilge. This refers to the area of the vessel around the bilge turn, side plating to bottom plating. A hard chine vessel has a distinction between side plating and bottom plating. It will look as if the vessel has a sharp edge at the bilge turn. This is in contrast to other monohulls that are rounded in this area. Hard chine vessels generally have better seakeeping ability.

Catamarans

Catamarans refer to vessels with two hulls which, in one form or another, depends on the hydrodynamic advantage gained by narrow efficient hulls and the cushion of air that is naturally generated between the hulls. Figure 2 shows two variations in hull shapes.

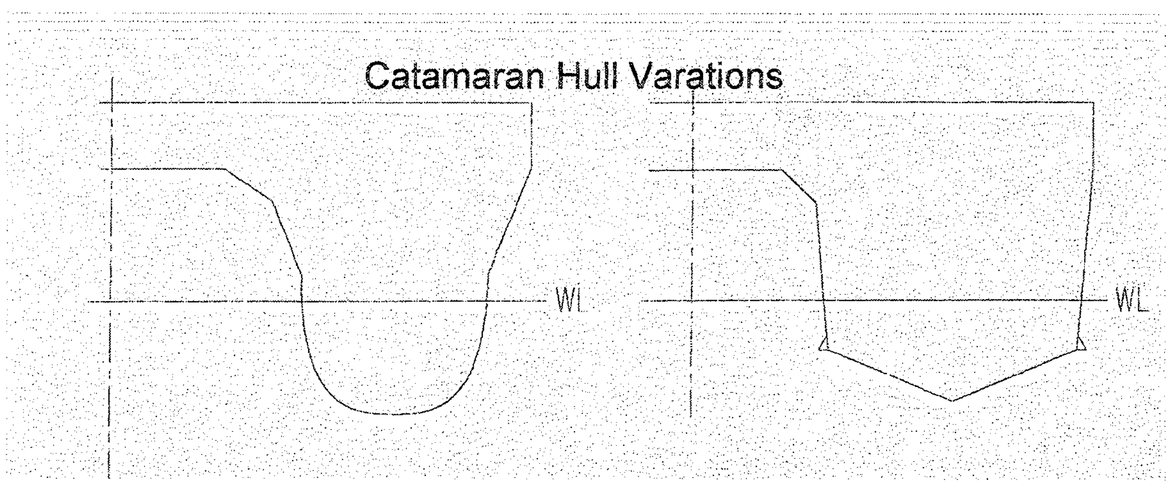


Figure 2 (Source: Nigel Gee Associates LTD)

The design on the right will give the vessel more hydrodynamic lift and has better seakeeping ability. Because of the wide vessel design catamarans have large, stable deck areas.

A hybrid catamaran hull form is the wavepiercers. This design came into prominence in the 1990s and is distinguished by a longer more efficient waterline hull length that gives the vessel the ability to pierce short waves. Wavepiercers offer improved stability and seakeeping ability. Conversely, they are structurally complex which makes them difficult to manufacture. Because of their high profile and shallow draft they will be more difficult to handle in high wind situations.

Another catamaran variation is dynamically supported by air. With this vessel, the forward portion of the hull is shaped like the standard catamaran. Approximately 2/3 of the hull bottom is indented, which provides a pocket for a cushion of air. Fans maintain the air cushion, and this in turn gives the vessel a tremendous dynamic lift. These hull forms offer the same advantages as the conventional catamarans with improved fuel efficiency. There are several smaller vessels with this technology; however, it is unproven with larger vessels.

A SWATH (Small Waterplane Area, Twin Hull) really falls into the catamaran category. SWATH vessels have two submarine-like lower hulls completely submerged below the water line. Above water, a SWATH resembles a catamaran. One or two relatively thin vertical members or struts connect its haunch areas to each submerged hull, which gives the SWATH vessels an extremely small water plane area. The longitudinal cross-section of each strut is somewhat streamlined to decrease wave making resistance.

Although the propulsion equipment of SWATH vessels can be located in the pods, this means that they are limited to submerged type propellers. The SWATH has excellent seakeeping, but consumes excessive power at high-speeds. To date, the SWATH technology is limited to speeds of 28 knots or less. Another disadvantage of SWATH vessels is its draft. For vessels in the 200 to 300 passenger range, the increase in draft over catamarans or monohulls is 1 to 3 feet.

Hydrofoil

Hydrofoils refer to a class of vessel that operates with its hull clear of the water, using dynamic lift provided by the foils at high-speed. The foils may be fully submerged or, more usually, surface piercing. The foils give these vessels a big draft disadvantage when the vessel's hull is in the water, although, some hydrofoils are built with retractable foils. Another disadvantage of the hydrofoil is their limited seakeeping ability.

Hovercraft

Hovercraft and SES type vessels can be broadly put together in the same category. Both of these vessels rely on air cushions to dynamically support the vessel and reduce drag. The difference is the means of keeping the air cushion contained and the method of propulsion. A hovercraft has a flexible containment system that extends 8-10 inches into the water and uses large air fans for propulsion. The SES has solid hull like sidewalls and a flexible skirt fore and aft. The hulls provide an area that can be utilized for more conventional types of propulsors.

It is widely believed that because of the aging nature of the existing worldwide hydrofoil and hovercraft fleets a considerable replacement demand should be created. It is also believed that most of this replacement demand will be with monohull and catamaran designs.

Structural Design

The USCG has final design approval of vessels produced in the United States. If a vessel is also classed by one of the major Classification Societies, it will have to meet their design approval. A Classification Society, in very basic terms, provides owner/operators with insurance protection. Each society has its own design criteria for high-speed craft. For example, a vessel classed by the American Bureau of Shipping (ABS) must conform to their design criteria. The USCG will generally work with the societies on structural design matters and in some cases will defer to their design requirements.

As previously stated, part of a high-speed ferry's ability to obtain high-speed is the reduction of vessel weight. Major parts of the weight reduction come from the use of less and lighter scantlings. A scantling is the dimensions of the frame, girders, and plating that go into a vessel's structure. Classification Societies and the USCG permit the reductions in the scantlings of these craft by limiting the sea and weather conditions in which the vessel can operate. A craft that was originally designed for certain conditions may not be allowed, or suitable, for operation in another service.

Materials

Three main material types are used in the construction of fast ferries. Each material has strengths and weaknesses; however, they are all excellent in certain applications. The three materials are marine grade aluminum alloys, fiber-reinforced plastics/composites (FRP), and high tensile steels.

Aluminum alloys are by far the most extensively used materials for high-speed craft, however, very few of the alloys can stand up to the rigors of marine use. 5000 and

6000 series alloys are commonly used for marine construction; 5000 series is used for hull plating and 6000 series is used for extrusions. Both use magnesium as an alloy, which gives it a high corrosion resistance quality. Aluminum is a more reactive material than steel or fiber reinforced materials when exposed to salt water. Because of this it is more susceptible to electrolytic corrosion. There have been improvements in material properties that have increased the welded strength and corrosion resistance. One such material, 5383, has increased the welded strength by 15% over the traditional hull plating, 5083 and 5086.

The use of marine grade aluminum has been on the increase because it is relativity inexpensive, lightweight, widely available, easy to fabricate in a broad range of climate conditions, and has low maintenance costs. As more demands are put on materials, due largely to higher operating speeds and harsher environmental conditions, greater attention must be given to the adequacy of the design and production detailing through improved workmanship. New methods of fusion welding and joining technology such as Friction Stir Welding (FSW) and adhesive bonding will help with these challenges.

FRPs have had a major impact on the marine industry in recent years. For years, they have been used successfully in small passenger vessels, where cost advantages are achieved through series production. By using these lightweight materials, operators of Sub-chapter T vessels have been successful at increasing the speed, lowering fuel consumption, and simplifying maintenance. The USCG is currently looking into the possibility of applying this technology to Sub-chapter K vessels which currently have to be built of steel or equivalent. Acceptance by the Classifications Societies has also been very slow due to their demand for margins of safety.

The glass fibers come in ranges of diameter and are woven into mats of different densities. It is the density of the mats which determines the load bearing qualities of the final product. Other manmade materials are used in a similar manner as glass fiber. Their use can result in an increase in cost but offers substantial improvements in strength. This manufacturing process allows the material to be easily formed into complex shapes that would be difficult to accomplish with aluminum plate. The strength of FRP can be enhanced by the use of core materials such as urethane forms. The core materials are sandwiched between layers of FRP to produce stiffened panels.[Kennel:126-128]

It is important to note that the laminates need to cure in controlled environments.

Humidity and temperature can affect the cure rate, thus the strength of the materials. Climate-controlled facilities are expensive to build and maintain, so this process can be cost prohibitive.

Although it is possible to use high tensile steels for high-speed ferries, the weight of the material is generally prohibitive for smaller vessels. Several large monohull car fast ferries have been constructed with high tensile steel.

Innovative composite panels for interior spaces are also used. Generally, the USCG has required interior panels to be lined with aluminum for fire retarding ability. However, there are other composite panels that meet all the requirements for fire restricting materials according to the HSC CODE rules for high-speed craft. One manufacturer uses a three dimensional glass fiber material that is impregnated with resin and then stretched before it cures. The result is an extremely light panel that is in service on several European fast ferries. The USCG may at some point approve the use of such panels for US built vessels.

Propulsion Methods

The speed, power, and fuel consumption of a craft are of prime interest to all parties involved in the development and operation of a marine craft. The initial cost of both the engines and propulsors must be considered along with reliability, maintenance, and operating expenses. In addition, environmental factors such as draft, vibration, noise, and emissions all influence the selection of both the engine and the propulsor.

A design-decision matrix for each craft design may have combinations of requirements that necessitate unique solutions. No engine-propulsor combination is likely to be the best solution for all marine applications. The combination the hydrodynamic characteristics of the hull and the propulsor results in a speed-thrust relationship suited for the environment in which the vessel operates.[Blount:276] The operating conditions, such as whether the vessel is at constant speed, accelerating, or decelerating, determine the power and RPM characteristics.

There are three popular propulsor types: submerged propellers, surface propellers, and flush inlet waterjets. Engine technology design has been rapidly changing in recent years and will continue to develop as the market for high-speed applications continues.

The current trend is to use medium or high-speed diesels, and/ or gas turbine engines geared to match optimal propulsor speed. Important powering considerations for high-speed fast ferries consist of the following:

- Competitive capital cost.
- Safety and social acceptance: fire, exhaust emissions, water pollution, noise, wash.
- High power to weight ratios.
- Compact size.
- Performance, durability and reliability.
- Fuel efficiency.
- Maintenance frequency and cost requirements.
- Ease of operation while in service.
- Economic flexibility across the range of speeds for the service that it is intended.

Engines

The diesel engine continues to dominate the small fast ferry market, except where very high speeds are demanded. That service generally requires the use of gas turbines. There are tradeoffs for the use of either type of propulsion. The initial cost of the gas turbine is more, as are its operational costs (it burns a higher grade of fuel). But savings can be realized on lubricating oil and maintenance costs, provided that a suitable program is followed. Significant revenue gains can be achieved from the reduced weight of the gas turbine, which can see a power to weight ratio of up to ten times that of a comparable diesel. The lifespan of a properly maintained gas turbine will exceed that of a diesel. Although service frequency is about the same for both, a more dedicated approach to care for the gas turbine is necessary.

In recent years there have been tremendous advances in the technology of both the diesel and the gas turbine. This is particularly true of the diesel, where advances have led to significant weight reductions while increasing the power output.

Propulsors

Current trends for design of the system are related to the vessel displacement and speed. Smaller vessels use fixed-pitch, submerged propellers. In smaller displacement vessels, submerged propellers can produce speeds up to 60 knots. Surface propellers are fitted to vessels designed for high-speeds or to those with draft restrictions. Waterjet propulsion methods are being used more frequently, and their applications are expected to increase. In general, waterjet propulsors are appropriate when the vessel's normal operating speeds exceed 25 knots and when vibration and noise must be kept to a minimum, or when there are operational draft considerations.

Unless efficiency calculations are done on identical hull vessels, it is difficult to make assumptions on whether one propulsor type is better that another. However, at speeds above 25kts the waterjet is generally considered more fuel efficient than submerged and surface piercing propellers.

A waterjet consists of a duct formed by the hull's structure, which channels water to a rotating impeller that propels the water through a nozzle situated at the transom. (See Figures 3 and 4)

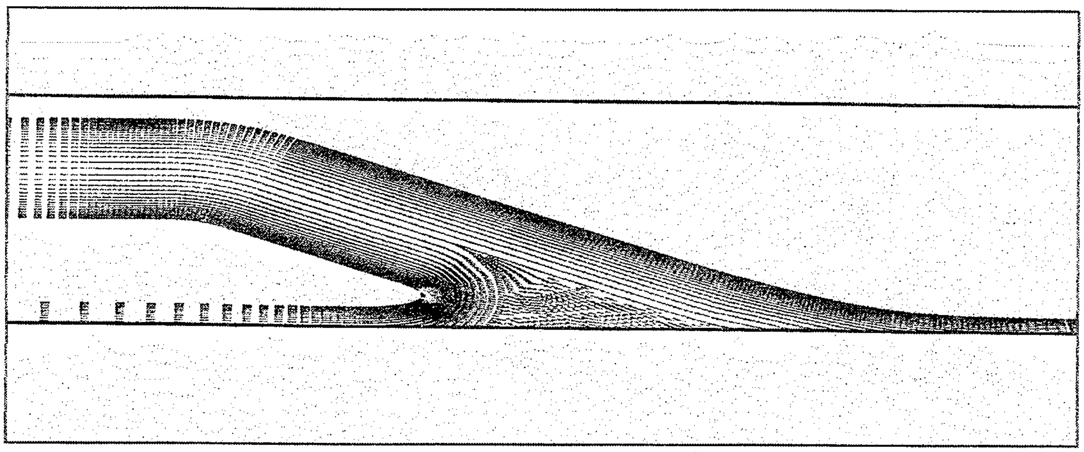


Figure 3: Model for a High-Speed Catamaran
Water Inlet Design (Source: Nigel Gee Associates LTD

A hydraulically actuated direction nozzle provides directional control over the water being discharged. Reversing is facilitated by means of a bucket flap, which reverses the water jet flow. The reversing bucket allows the vessel to be stopped from full ahead within a few boat lengths. Originally, waterjet propelled vessels were hard to maneuver at slower speeds. More recent designs have proven to have excellent maneuvering characteristics, particularly when used with twin hull type vessels. [Blount:227-228]

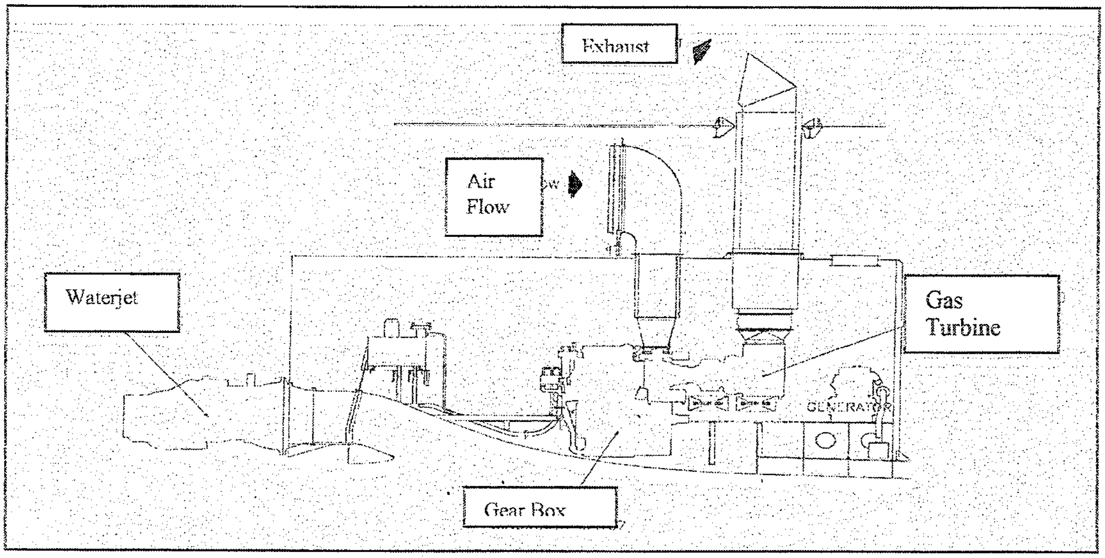


Figure 4: Machinery Arrangement
High-Speed Catamaran (Source: Nigel Gee Associates LTD)

Conventional submerged propeller types can be used on vessels up to about 60kts depending on the displacement. They do have an obvious drawback compared to either the surface propellers or waterjet; the propeller and the rudder are situated below the hull. Where draft is a consideration, this type of propulsion is not as practical as other options. All things being equal, submerged propellers are inherently more expensive to operate due to the increased resistance of the propeller and rudder. Cavitation becomes a major problem on fully submerged propellers as speeds increase. Even with increasingly efficient propeller designs, cavitation prevents speeds in excess of 35kts.

Surface-piercing propellers are popularly associated with the high-speed racing market, particularly where speeds in excess of 50 knots are required. The concept of a surface propeller is relatively simple. Instead of using a propeller that is fully immersed in the water, only the bottom blades are in the water and doing work. With surface drives, there is no drag from the propeller shaft or rudder, and the turbulence that is created around the submerged propeller hub is avoided.

A factor that has kept surface drives from expanding to commercial vessels such as fast ferries is the varying loads. They are most efficient at a single draft. New designs that adjust the shaft height according to the load may make this option more viable in the future.

Once the correct propulsion system is decided upon, it must be properly applied. This means the correct gear ratio, propeller or impeller size must be used. It should also be considered that the maximum efficiency is usually obtained with the minimum number of prime movers and propulsors. Four engines burn more fuel than two engines of equivalent power. Four propellers are less efficient than two if the right diameter, pitch and revolutions per minute are used. However, many operators believe that extra propulsion trains are necessary for purposes of redundancy. This gives the vessel opportunity to operate at speeds close to design speeds, should they have a failure in one of their propulsion trains. It should be noted also that vessels in the 200 to 300 passenger ranges have limited space and generally will not have the room for additional power trains.

Current Regulations

Developments in the design and operation of high-speed vessels in recent years have led to revamping of regulations for governing their construction and safety. The United States Coast Guard (USCG) is the government body responsible for insuring that all vessels operating in US waters are built and operated under current legislation. There are two sub-chapters of the Code of Federal Regulation (CFR) Part 46 that apply to the sizes of vessels capable of carrying 200-300 passengers. Sub-chapter K pertains to high-speed vessels with a passenger capacity greater than 150 and less than 100 gross tons displacement. Sub-chapter K also provides upper limits, above which vessels would be required to comply with specific sections of Sub-chapter H. They are:

- Vessels carrying > 600 passengers.
- 200 feet in length.

The international standard to which high-speed vessels must be built is the High-speed Craft Code (HSC Code), which has been adopted by the International Maritime Organization (IMO). Any high-speed passenger vessel operating on international voyages must conform to the rules detailed in the HSC Code. National administrators such as the USCG are responsible for vessels operating domestically, although many countries have chosen to apply the HSC Code to vessels operating in local waters. As part of a growing trend to harmonize maritime rules and regulations worldwide, the USCG now accepts the HSC Code as an equivalent design to Sub-chapter K vessels, as long as it is adopted in its entirety. In effect, if a design meets the HSC Code, even though it does not meet all of the USCG Sub-chapter K regulations, then the USCG will accept the international standard. At the present time, they have not done this for vessels that fall into the Sub-chapter H category. Because each flag state is responsible for administering the Code, it is subject to varying interpretations. Vessels that ostensibly meet all the Code provisions can still be required to undergo costly modifications before being allowed to operate in certain countries.

Traditional ships built of steel have been subject to a minimum of operational controls, but are also required to be completely self-contained as far as safety is concerned. New designs of fast ferries, however, demand a different regulatory approach, one that accounts for their lightweight construction and higher speeds. In recognition of the need for lightweight materials to attain high-speed, the HSC Code allows for the use of alternative hull materials such as aluminum and composites as long as the level of safety is comparable to that of conventional ships. In addition to the normal provisions for lifesaving, fire protection, and evacuation, the new regulations place a great deal of emphasis on the reduction of hazardous situations in the first place. These safety concepts were originally reflected in the Code of Safety for Dynamically Supported Craft, which was adopted by the IMO in 1977, as part of the Safety of Life at Sea Convention (SOLAS). The HSC Code was written to build upon these requirement, and applies to any high-speed craft built after January 1,1996. Deficiencies and ambiguities in the Code have already emerged and are currently being addressed. IMO's Marine Safety Committee is now at work to produce a revised version of the HSC Code in the near future.

An important aspect of the new High-Speed Craft Code is that it recognizes that a vessel's safety can be significantly increased by the infrastructure associated with regular routes. For example, the Code allows for two separate categories based on the route and passenger load. The division for the two categories, A and B, is based primarily on whether or not it can be demonstrated, in the event of an evacuation at any point on the route, that all passengers and crew can be rescued safely within certain time limits. For example, for a Category A vessel with a light passenger load and on a route where rescue assistance is readily available, the safety requirements may be relaxed. With Category B vessels on a route where rescue assistance is not available and the passenger load is high, additional passive and active protections are required. Increased stability and structural integrity are examples of the additional safety mechanisms that would be required for Category B vessels.

Addressing fire safety is a primary concern for regulatory bodies. The HSC Code devotes considerable space to this topic. The SOLAS philosophy pertaining to fire is to provide a safe refuge for those on board while a fire is attacked. This is accomplished with the use of zones protected by fire barriers. The need for zones is treated differently in the HSC Code. Category A vessels are not required to have zones because of their reliance on evacuation and rescue. Category B vessels are required to have at least two zones separated by non-combustible material. Each zone must have its own sprinkler and ventilation system. This is significant from a weight standpoint. Although dry systems will meet the code, depending on the size of the vessel, dedicated pumps capable of producing 600 to1000 gpm will add a tremendous amount of weight.

To insure that there is no misinterpretation of the meaning of high-speed, the Code specifies the following mathematical formula based on the volume of displacement at the design waterline:

$V = 3.7D^{0.1667}$

D= Maximum permissible displacement in cubic meters

V= Velocity in m/sec at the displacement D

For vessels of 100 gross tons, this works out to be 16 knots.[Fast Ferries:38]

The HSC CODE specifies that all public and crew spaces must be located and designed to protect their occupants under a design collision deceleration of 3.63 m/s2. Additionally, these spaces must be further than 7.4 meters from the vessel's stem. Baggage must also be stored in dedicated areas on the main deck forward so that it remains in the stowed position when exposed to a collision.

The HSC CODE also requires that the design of passenger and crew seating be capable of withstanding collision acceleration forces. Tests similar to those used to test jet aircraft seating are used. These include static and dynamic seat tests with an instrumented test dummy. In addition, the seats must have high backs with protective padding. Seat belts are required on all seats where there are no protective structures, such as another seat, forward of the seat in question. All passengers and crew must be provided with seats and no enclosed sleeping berths are permitted for either.

Another major area that the HSC CODE addresses is the training of operators. Each member of the crew is required to be type rated for the specific vessel and route. This is not a requirement of the USCG at this time. The USCG does, however, reserve the right to specify how many crewmembers are on each vessel. This is usually based on vessel type and route. [Lantz:128]

The USCG, the Classification Societies, and the IMO are all working diligently to keep up with this rapidly changing industry. The rules pertaining to their construction and operation will be continuously upgraded in the coming years.

Conclusion

The primary purpose of the report is to identify those vessel types that will be best suited for service in coastal Maine waters. Based on the information provided, either the monohull or any of the catamaran hull styles would be appropriate for the intended service. The catamaran fast ferries offer a wide stable platform that provides passengers with space and comfort. Although a comparable monohull is not as spacious, with ride control systems they can provide an equally comfortable ride. Both hulls, when constructed of aluminum, are lightweight and have shallow draft. Composite materials for hulls are not at a stage of development to be considered at this time. High tensile steels are too heavy for smaller high-speed passenger vessels.

Hovercraft and hydrofoils both have proven track records of successful service. However, both have limited seakeeping ability and are not suitable for coastal waters.

Either of the main engines, diesels or gas turbines, would be suitable for the intended service. The gas turbine offers greater horsepower per weight, but is initially more expensive. If a vessel is constructed specifically for service in Maine, then it becomes a matter of owner preference.

Because draft is a consideration for coastal service, the waterjet or the surface propellers become the choice for propulsors. The waterjet is more expensive, but offers excellent maneuverability.

References

Blount, D.L. and R.J. Bartee, "Design of Propulsion Systems for High-Speed Craft" Marine Technology, 34(1997):276-290.

Blunden, A. "Fast Ferries- Forty Years of Developing Technology." Presented at Fast Ferries International Conference, Boston, 1999.

Bonafoux, J., "Patricia Olivia- Development of the First 50+ knot Ferry in North America." Presented at Fast Ferry International Conference, Boston, 1999.

Cagle, M. W. Flying Ships: Hovercraft and Hydrofoils. N.Y.: Dodd, Mead, 1970.

Crannell, P. "Innovations in Ferry Terminal Design." Presented at Fast Ferry International Conference, Boston, 1999.

Cummings, T. and P. Roden, "A Summary of the IMO High-Speed Craft (HSC CODE) Code and the Impact on the First U.S. Vessel Built to This Standard," Marine Technology, 35(1998):183-190.

Duffy, Joseph. "High-speed Ferries, a Discussion of Speed Limits." Presented at Fast Ferries International Conference, Boston, 1999.

"Fast Ferries: Shaping the Ferry Market for the 21st Century," Drewry Shipping Consultants, London Oct. 1997.

Graul, T. "Watch Your Wake! Environmental Considerations in Ferryboat Design," Presented at Ferries '94, Fort Lauderdale, 1994.

Guest, G. "Type Rating, Line Training, and Demonstrated Proficiency: Essential Elements for Passenger Safety Aboard High Speed Ferries." presented at Fast Ferries International Conference, Boston, 1999.

Harley, H. "Move Faster (Increase Speed)." Presented at Logistics Management Institute Conference, Florida, 1998.

Hynds, Paul "Ride Control Technology Advances Steadily" Speed at Sea, 4 Jan. 1999:36-38

Kennel, C. "Design Trends in High-Speed Transport." Marine Technology, 35(1998): 127-134.

Lantz, J. and P. J. Maguire. "Coast Guard Passenger Vessel Regulations and The IMO

High-Speed Craft Code." Presented at Ferries '98, Fort Lauderdale, 1998.

Larson, E. Hovercraft & Hydrofoils Work Like This. N.Y.: Roy, 1970.

Lokites, R., and C. McKesson."High-Speed Vessels in the USA-An Introduction to the United States' Regulatory Environment." Presented at Ferries '98, Fort Lauderdale, 1998.

Marchant, A."The Evolution of Structures for Fast Craft and Ships." Presented at Fast Ferries International Conference, Boston, 1999.

Pike, Dag. "Confidence Grows in Surface Drive Systems" Speed at Sea, 5 June 1999:28-30.

Popko, P. A. "New Coast Guard Rules for Small Passenger Vessels: Sub-chapter T and H " presented at Ferries '94, Fort Lauderdale, 1994.

Ratcliffe, T., and C. Kennett. "SWATH Golf Club Hull Flow Studies," Marine Technology, vol. 34, (1997): 125-135.

Ryle, M. "Smoothing out the Ride," The Motor Ship,(Jan.1998): 23-26.

Savitsky, D. and J. P. Breslin. "Motions of High-Speed Hydrofoil Craft in Irregular Seas," Presented at Hydrofoil Symposium, 1965.

Trillo, R. T. Main Hovercraft Technology. London: Leonard Hill, 1971.

Woodyard, Doug. "Ratings Rise to Meet Demands For Power" Speed at Sea, 5 June 1999:12-17.