RESEARCH ON A LARGE SES FOR THE TRANSATLANTIC RECORD

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This work was performed while I was employed by Art Anderson Asscoiates, Inc., in Bremerton Washington. This paper was published in 1996, at the Society of Logistics Engineers (SOLE) Advanced Marine Vehicles Symposium in Silverdale, Washington. It has been slightly edited for this website version.

Introduction & Background

In 1989 Mr. Tom Gentry set the transatlantic speed record with the V-bottom monohull *Gentry Eagle*. Then in 1992 the record fell to the Italian *Destriero*. Like the competitor that he is Gentry took *Destriero*'s success as a direct personal challenge and set out to retake the record.

Tom Gentry and Project Manager John Connor established Gentry Transatlantic Inc. in Fort Lauderdale Florida, for the express purpose of developing a new high speed boat. The project team studied several hull forms before encountering Washington Naval Architect Chris McKesson. McKesson convinced the group to model test a large SES designed for an unrefueled record-breaking crossing.

The model tests were successful, and McKesson's concept became the starting point for the Transatlantic development program.

The Fort Lauderdale based team have decades of high speed boating experience. The team members have an incredible number of hours of on-the-water experience at speeds over 100 MPH. Connor is typical of the team members, being himself a six-time world champion powerboat racer.

This team brought to the table technology developed in the world of powerboat racing. McKesson brought to the table a world of SES development work dating back to the USN 3KSES program. The result was a marriage of two communities, and a very interesting new boat design.

The Transatlantic team applied their lessons learned to McKesson's basic concept. They also engaged M. J. Plackett & Associates of Corvallis OR. to develop an improved lift and skirt system.

In this paper I wish to present an overview of the boat and the project. I will follow a chronological approach, stepping through the evolution of the program. It is my belief that this project is equally interesting from the viewpoint of the unique relationships and coincidences that took place, as well as from a purely technical viewpoint. I shall attempt to address both of these viewpoints in the pages that follow.

First Discussion - Presentation of the concept

The marine industry is well known to be a small, close knit community. And yet within this community there exist intriguing subcommunities, who may be unaware of one another’s existence.

Thus, in 1992, the communities of “high-speed boat racing” and “advanced naval vehicles” had little contact. At this time I was under contract to Textron Lycoming to provide technical support to their sales of the TF-40 gas turbine. My client Mr. Les Gingell and I embarked on a tour of the Patrol Craft industry as part of this contract.

Our intended route was a two day stop in the Miami area, followed by a visit to the New Orleans / Gulfport axis. We watched with a certain dismay as another traveler followed our exact route, one day ahead of us: Hurricane Andrew.

Hurricane Andrew tore through South Florida. Our hotel was closed to us, since there was a foot of standing water in the lobby. One prospect was unable to receive our visit, since the rooftop of his manufacturing facility was lying in the parking lot.

We eventually made our way to the offices of Gentry TransAtlantic. The *Gentry Eagle* had a single Lycoming TF-40 in it, which made them a legitimate visit, and we knew that John Connor was a pleasant fellow to spend some time with. We spent an intriguing several hours moving one of John’s friends out of a sinking houseboat before the water level rose to the height of the furniture. Our repayment was to be invited to the one bar in town that still had refrigeration, and thus cold drinks.

I dwell on this travelogue just to emphasize how big a role is played by happenstance. I do not believe that this is unique to the present project, but is in fact a major factor in most business affairs.

Over beer and oysters the discussion naturally turned to the trans-Atlantic target. John asked what hull form I would use to break the record. I immediately suggested an SES. On a cocktail napkin I explained the SES concept. I like to keep in my head a collection of simplified equations for craft performance [Ref 1]. Cocktail napkin calculations using these formulas showed that a SES could easily do the job. After all, wasn't the 3K SES feasible, and wouldn't it have clearly been a record breaker? The only real question was how much smaller than 3,000 tons could one be to still be a record breaker.

First Negotiations with the Client: Why an SES?

Our cocktail napkin discussion caught John's interest. He had, up to this point, tested many interesting variations on the planing hull. The result of these tests were that all concepts needed a 10% boost. In John's expression what he needed was "lightweight fuel". He and his team had even followed this thought path to the point of investigating the feasibility of hydrogen-fueling a vessel.

By contrast the SES appeared to offer a 20% improvement, easily surpassing the existing record. This realization became a keystone in the subsequent feasibility design phase.

The Pareto Principle states that 80% of the consequences result from 20% of the causes. In our case the critical breakthrough was the use of an SES hull form. This resulted in 80% of our success. Most of the other subsequent decisions (L/B ratio, choice of propulsor, etc.) would be shown to be on 20% important.

Baseline Design

The cocktail napkin conversation was sufficiently convincing that the Gentry team contracted for a concept design. We were still not full partners: Gentry TransAtlantic contracted for a feasibility from which they would build a model. Model tests would be conducted by Gentry TransAtlantic to establish our credibility. If we passed this test then we might expect to enter into a more collaborative relationship with the owner.

This approach clearly established our guiding principle: Be right. In 1993 we (Art Anderson Associates) were funded to develop a concept design. The resulting vessel is depicted in Figures 1 & 2.

The development of this design followed a set of design guidelines selected according to the 80/20 rule mentioned above: We believe that the SES concept is the critical variable for success. In the other areas, propulsion system for example, we avoided innovation. "Innovate where it's necessary, be low risk where it's not." Our goal was to be undeniably correct and conservative in the test phase, while still maintaining high enough performance break the record.

In practical terms this meant that we simply used two-thirds of *Destriero*'s propulsion plant: A pair of LM-1600's coupled to KaMeWa waterjets. After all this was a proven non-developmental system.

Similarly the geometries selected were simple. Systems design followed a principle of *reductio ad absurdium*. In a similar approach we used DNV rules for structural design, rather than proposing a structural loads R&D program. Remember throughout this that we were designing a vessel for one 48 hour trip. We were not designing a commercial craft with a 20 year economic life, nor a warship intended to sail into harm's way.

There was one unique constraint imposed by the client: Beam. For an 80 knot service speed pure hydrodynamic consideration would drive an SES to an L:B ratio of about 2:1. In order to moor in a yacht harbor, a Mega-Yacht should have a beam not over 40 feet. We performed a parametric design study to look at the interrelationship of Length, Beam, Displacement, and Required power. The results of this parametric study are shown in Figure 3.

As may be seen, increasing the beam would reduce the total required power. However the penalty was not tremendous, and the selected design was 145-feet to 165-feet with a 40-foot beam.

The ship is summarized in Table 1.

First Model Tests

The TransAtlantic team have their own model construction and testing facility in Fort Lauderdale

Florida. The facility is not a towing tank, but rather an innovative use of the south Florida canals.

The model is towed alongside a tow boat. The tow boat for our tests was a 20-foot tunnel-hull boat designed and built by Mr. Connor. The tow boat is propelled by a 250 hp Mercury Black Max outboard. Without a tow attached the tow boat will exceed 50 mph.

An outrigger boom extends to the side of the towboat. The model is towed from the end of this boom. The tow tether is attached via a strain gage, which is calibrated to read pounds of drag directly. The tow gage is recalibrated at the start of each day's testing to ensure that the calibration doesn't "drift."

Tow speed is measured by various speedometers on the tow boat, including a handheld GPS.

Unlike a planing hull the SES requires that power be carried out to the model (the model fans were electrically powered.) A second outrigger was installed on the tow boat which dropped an electrical umbilical on top of the model. The umbilical descended vertically to ensure that it did not contribute to tow force or drag.

A view of the tow rig is given in Figure 4.

The model was made of epoxy impregnated plywood. Figure 5 shows the model on it's trailer in the fitting-out shop. Figure 6 shows the model being lifted and launched in the marina.

I was concerned that the team tow the model from the model's center of gravity. Visible in Figures 5 & 6 is an aluminum frame which attaches to the model on a pivot joint acting through the CG.

This first model was successfully tested over a period of many months. Eventually the model was destroyed by continued use. Figure 7 is typical of the many photographs of the model underway.

The biggest lessons learned during the first phase of model testing were three:

- We encountered significant bow plunging problems at scaled speeds above 65 knots.
- We proved the importance of fitting spray rails both inside the cushion and outside.
- We convinced the client that the SES truly offered the performance claimed.

Model test series one was begun with the intent of seeing, on the part of a skeptical client, whether the SES concept really had the performance potential we claimed. We developed a conservative feasibility design with a 65knot speed target. We overwhelmingly succeeded in making our case, and the project entered an exciting second phase.

Design Improvements - Second Design

We now entered a stage where full collaboration took place between Art Anderson Associates and the TransAtlantic team. During this phase the TransAtlantic engineers added their unique high-speed boat skills to the SES design.

This collaboration made several design improvements which were incorporated into the second boat. We will briefly summarize these improvements.

Increased Sidehull Beam While the design sea state was quite modest, rough sea performance was of interest to the owner. Based on the team's tunnel boat design experience an increased beam sidehull was developed. A longitudinal strake was employed with the result that in calm water the sidehull beam is as narrow as the baseline. Only in extreme motions or seas does the increased beam come into play. This increased beam results in much greater sidehull planing forces and has yielded a very benignly behaved craft.

Reduced Wetted Surface Sidehulls Sidehull friction dominates the drag of the craft when at high speed. This characteristic is shared by other very fast craft such as offshore powerboats. It is common in "super boat" design to incorporate means of speed-dependently reducing the wetted surface of the hull. This was incorporated into model No.2 and was found to contribute a net 10% reduction in sidehull drag.

Pickle Fork Bow The baseline narrow-sidehull design showed a bow plunging problem in model tests. The team, again drawing on race boat experience, developed a pickle fork bow which resulted in increased pitch restoring force and completely eliminated the undesired behavior. Figure 8 shows Model No. 2 and depicts these three enhancements. Figure 9 shows the model under way

Change of Propulsor The baseline design used waterjet propulsion. The TransAtlantic team has years of experience with surface piercing propellers. The original Gentry Eagle is fitted with a surface piercing propeller and two waterjets, and they much prefer the propeller. Much of the research above is devoted to increasing the amount of air under the sidehulls, allow the cushion to leak and reduce friction by air-lubricating the sidehulls. This device, however, is incompatible with waterjet propulsion, as the air sheet would be ingested into the waterjet and cause thrust breakdown. Given this, and the team's preference for propellers, the design switched to a surface propeller baseline. The problem would be to fabricate a surface drive capable of handling the proposed 20,000 hp per side.

At the same time the team purchased seven 7,000 horsepower turbine engines at a "can't pass them by" price (Figure 10.) This quickly nudged us in the direction of a four-shaft design, with one turbine coupled to each propeller. We found that the propeller performance in this speed regime was compatible with off-the-shelf surface drives. All of a sudden the propeller driven approach seemed feasible. The remaining hurdle was propeller placement.

Drawing again on race boat experience the team selected an overlapping propeller arrangement. This is depicted in Figure 11. The model tests confirm the adequacy of the propeller inflow. We have not yet tested the performance of the overlapping props. This is an area of ongoing research.

Adjustable Skirts The team was concerned over predicted skirt wear during the trans-Atlantic run. Some predictions were as high as 48 inches of bow skirt wear during the crossing. In order to ensure that the skirt length would not be thus compromised during the run, MJPlackett & Associates developed an adjustable skirt system. The system would allow the skirts to be readjusted at various points during the crossing, so that finger tips would be consistently near the baseline. In addition the team built a flagellation test rig and qualified various seal materials for the craft.

The Future: What lies ahead for this project?

In November of 1994 Tom Gentry was rendered unconscious in a boating accident. Once again, happenstance took over the project's driver's seat. Tom has been comatose since the accident. His trustees have terminated funding to the project and have relinquished all the assets of Gentry TransAtlantic to Mr. John Connor.

The project is officially for sale. The team has made a few attempts to promote it and has gathered some interest. Will the boat ever be built? I don't know. I am confident however that we have learned several important things:

1. There is a tremendous body of knowledge in the race boat community. This knowledge is not held by the advanced vehicle community. There is at least an equal amount of knowledge held by the advanced vehicle community and not shared in the race boat community. Collaboration between these two communities can be very fruitful.
2. We believe we have made several significant improvements in the basic SES concept, particularly for very-high-speed applications. The combination of sidehull innovations in particular offer important advances over current SES designs.
3. We are convinced that the SES represents the "paradigm shift" that will be necessary to eclipse *Destriero*'s record.

REFERENCES

1 "A Collection of Simplified Field Equations for SES Design" Chris B. McKesson, Intersociety High Performance Marine Vehicle Conference and Exhibit "HPMV '92", ASNE, June 1992

FIGURES

1. Art Anderson Associates Feasibility Design - Overview
2. Art Anderson Associates Feasibility Design - Overview
3. Parametric Study Results
4. View of Model Tow boat
5. Model in shop
6. Model being launched
7. Model Underway at 17 knots (Equivalent to 59 knots full scale.)
8. Model No. 2
9. Model No. 2 underway
10. Allison XT701 Turbine
11. Overlapping Props Model Test Rig

TABLES

1. Summary of Baseline Design

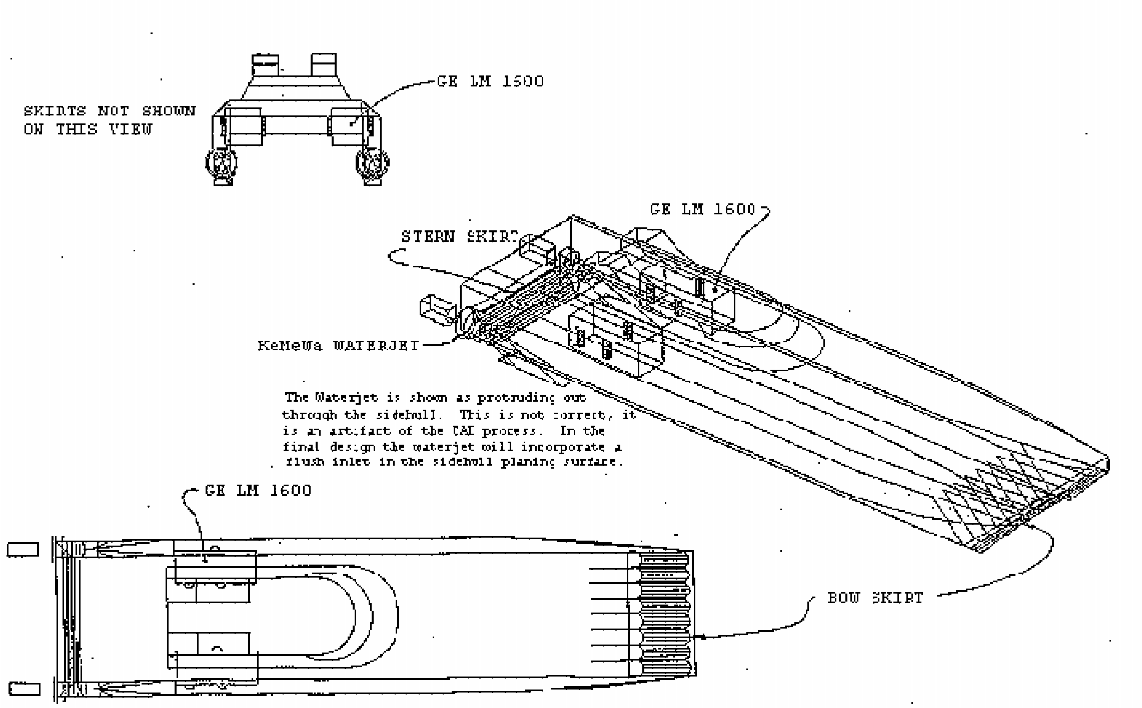

Figure 1 - Art Anderson Associates Feasibility Design - Overview

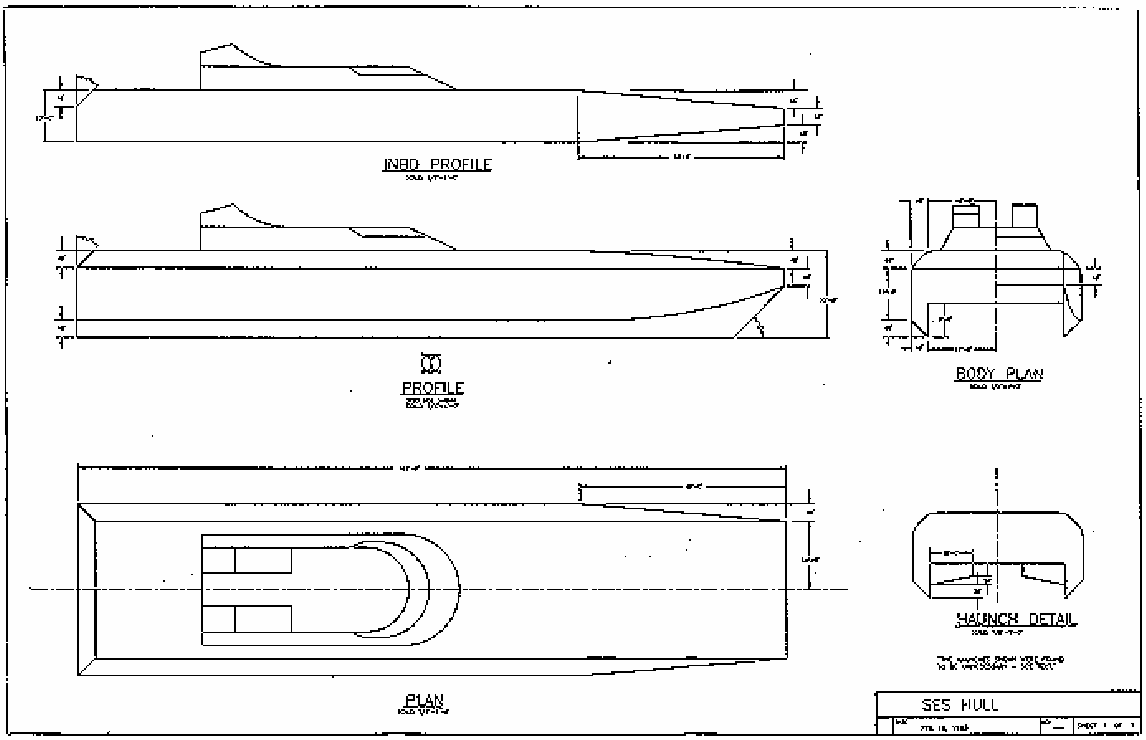

Figure 2 - Art Anderson Associates Feasibility Design - Overview

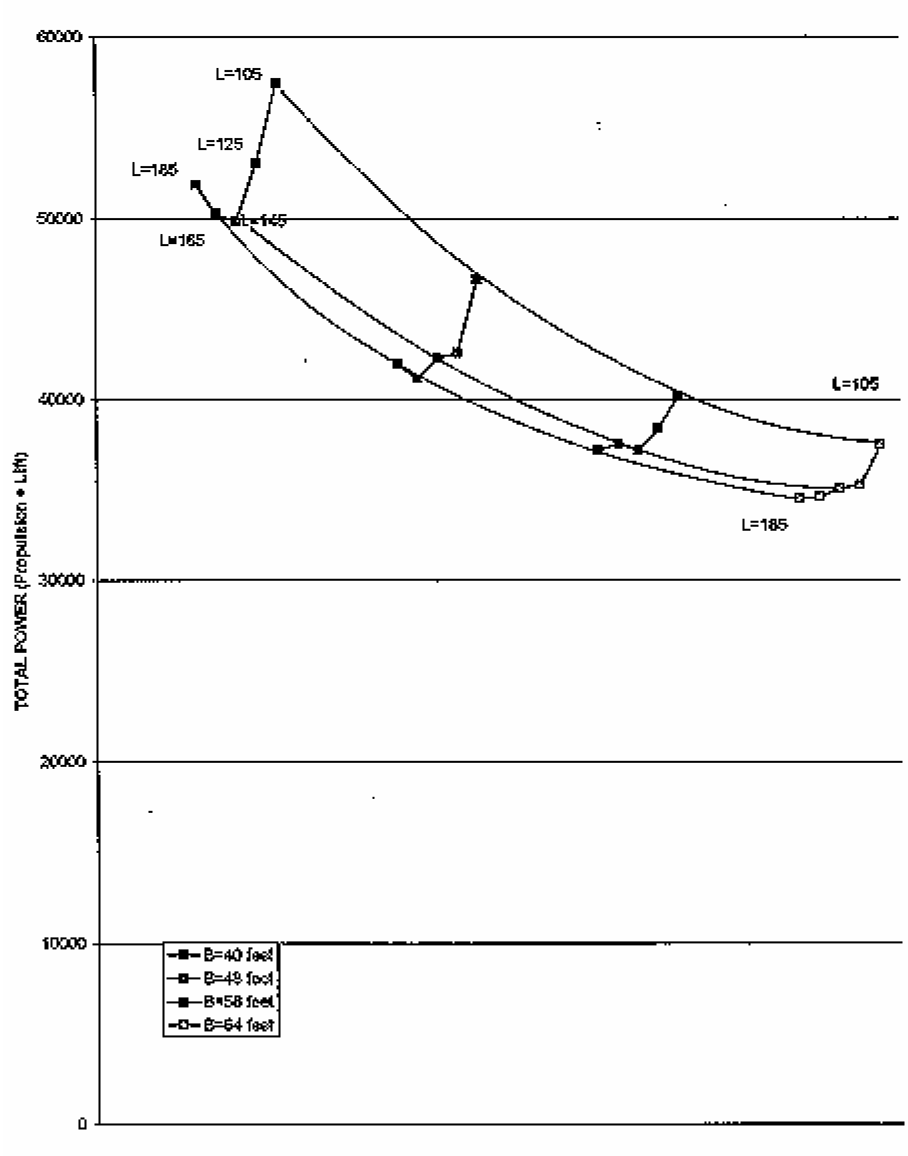

Figure 3 - Parametric Study Results

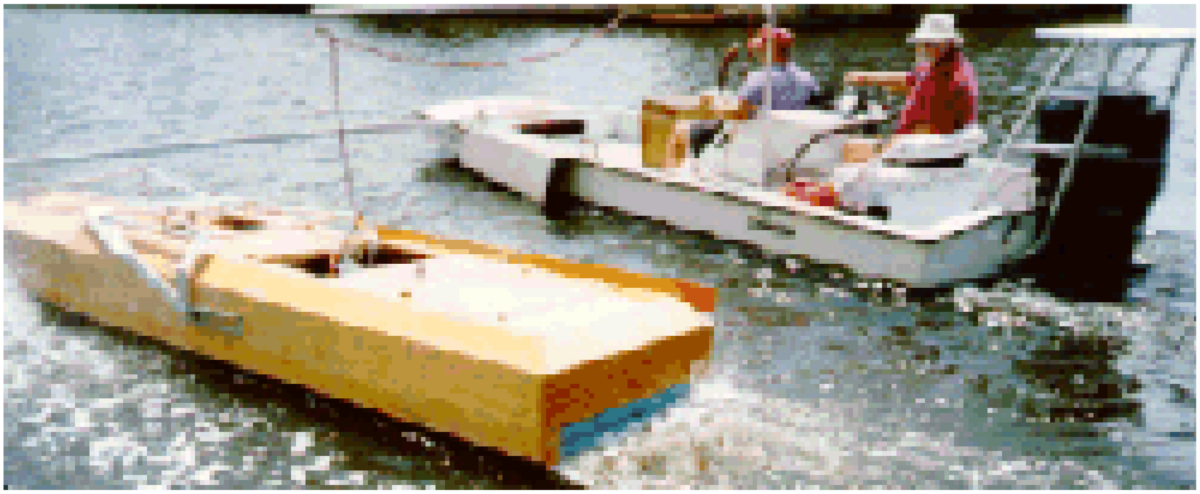

Figure 4 - View of Model Tow boat

Figure 5 - Model in shop

Figure 6 - Model being launched

Figure 7 - Model Underway at 17 knots (Equivalent to 59 knots full scale.)

Figure 8 - Model No. 2

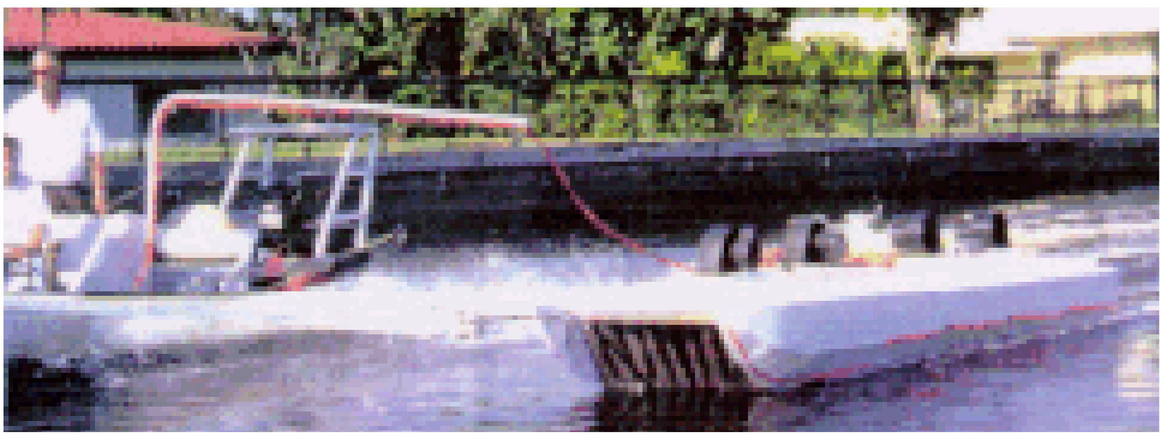

Figure 9 - Model No. 2 underway

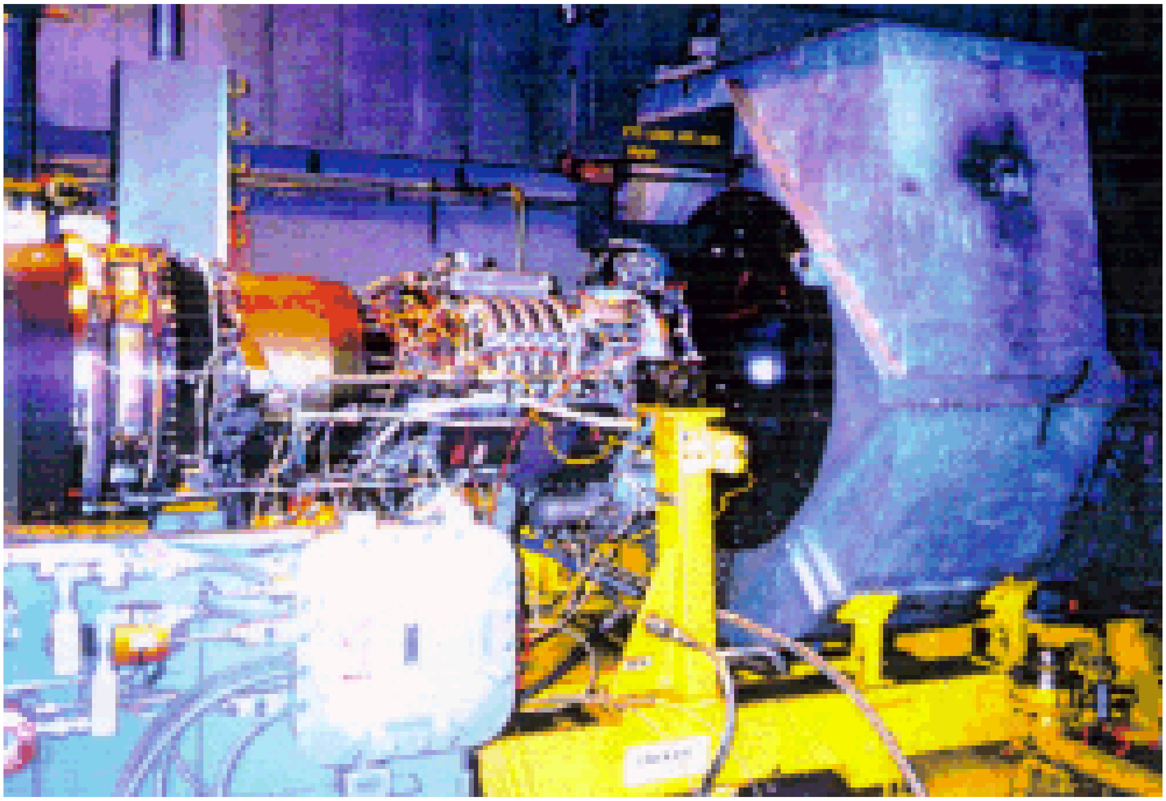

Figure 10 - Allison XT701 Turbine

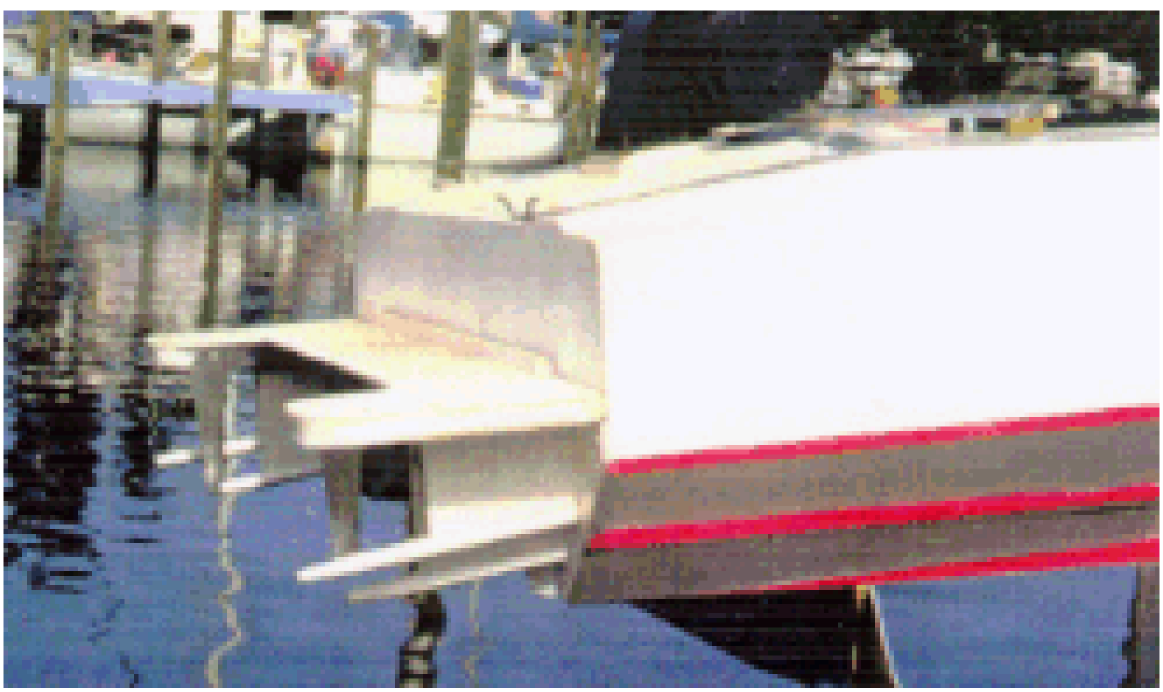

Figure 11 - Overlapping Props Model Test Rig

Table 1 - Baseline Design Summary of Characteristics

DIMENSIONS

LENGTH	
Overall	165'
Cushion	136'
BEAM	
Overall	40'
Cushion	32'
Side Hull (each)	4'
DEPTH	
Keel to Wet Deck	8'
Keel to Main Deck	12'
Keel to Weather Deck	20'
Keel to Deckhouse Top	25'

WEIGHTS (in long tons)

Structure	87.0
Propulsion	116.8
Electric Plant	8.0
Command & Control System	2.5
Auxiliary Systems	14.3
Outfit & Furnishings	10.0
MARGIN	15% = 35.8
LOADS	
Fuel (incl. 10% unburnable)	238.1
Other	5.0
Total Displacement	
Light	274.4
Mod-50	396.0
Heavy	517.5

SYSTEMS

STRUCTURE	
Welded aluminum designed in accordance with DNV rules for high speed light craft.	
PROPULSION	
Main Engines	2xGE/MTU LM 1600 Gas Turbines 20,000 shp each
Propulsors	2xKaMeWa 125 waterjets
ELECTRIC	

SYSTEMS (continued)

Not specifically designed. Weight estimate provides for simple system of 100 kW.

COMMAND & CONTROL

Components not selected. Weight estimate provides for yacht-type safety of navigation system.

AUXILIARY SYSTEMS

Minimal provisions for:

- Compartment HVAC
- Portable firefighting equipment
- Fresh water for engine cooling
- Fuel handling
- Turbine electric-hydraulic starting

OUTFIT & FURNISHINGS

Components not selected. Weight estimate provides 10 tons for spartan accommodation of racing crew.

PERFORMANCE

Max Speed, Calm Water, FLD	100+ Knots
Max Speed, Calm Water, Mod-50	100+ Knots
Max Speed, Calm Water, Light	100+ Knots
Speed @80% power, Calm Water, FLD	95 Knots
Speed @80% power, Calm Water, Mod-50	97 Knots
Speed @80% power, Calm Water, Light	100+ Knots
Max Speed, 6' seas, FLD	87 Knots
Max Speed, 6' seas, Mod-50	90 Knots
Max Speed, 6' seas, Light	93 Knots

STOPPING

At 400t. from 80 knots, at full reverse thrust: 24 seconds, 1600 feet

RANGE

3200 nm at 80 knots with 10% reserve