LOW EMISSION HIGH SPEED FERRY

" *THE GREEN MACHINE*"

Designed for

San Francisco Bay Area Water Transit Authority (WTA)

By

Seaworthy Systems, Inc.

Jan 7, 2003 Presentation by

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BACKGROUND

- The San Francisco Bay Area Water Transit Authority (WTA) was formed by the California State Legislature to create and build a ferry system that was cost-effective, convenient and environmentally responsible
- The proposed regional system (if funded) would add 21 new 149 passenger 25 knot ferries and 10 new 350 passenger 35 knot ferries to the existing 14 boat fleet
- Seaworthy, as a consultant to WTA's contractor Glosten-Herbert LLC, was tasked to prepare a futuristic ferry concept design for the large 350 passenger 35-knot ferry

- WTA's primary goals for the ferry were:
  - Safe reliable commuter passenger service
  - Passenger capacity — 350 seated
  - Service speed — 35 knots
  - Range — 250 nm
  - USCG certification — Sub K - Lakes, bays & sounds
  - Emissions baseline — EPA 2004/2007 (Tier II) standards for N0x+HC, CO and PM
  - Emissions goal — As low as possible consistent with year 2010 technology

- Other requirements included; low wake wash, low internal and external noise, ADA compliance, convenient storage for bicycles and a 25 year service life

- The ferry design was to incorporate Seaworthy's best judgement of how to achieve the WTA's goals

- Seaworthy decided that it must not only use projected emission reduction technologies but, that a drastic reduction in the hull power requirements would also be necessary to meet the emissions goals

HULL FORM

- High speed displacement and planing hull form improvements in the next 8 years are not expected to result in any significant power reductions
- Air supported hull forms seem to offer the best possibility for drastic reductions in power
- One technology that exists today is the air assisted catamaran developed by Air Ride Craft and incorporated into the Seacoaster type hull
- One such vessel was built, tested and then was converted into a passenger ferry now in operation on Lake Erie (this vessel, in its test form and as a ferry, is shown in the accompanying film clip)

- The WTA design utilizing an air assisted catamaran hull has a 21% lower power requirement (including lift fans) at the design speed of 35 knots than a conventional high speed catamaran ferry of the same capacity, size and speed

- At higher speeds the power advantage of the air assisted ferry increases but, below 25 knots the power is slightly greater than the conventional ferry

- The 21% lower power at the design speed means a 21% reduction in fuel burned and an “off the top” 21% reduction in emissions per passenger mile

- The lower power requirements and the dynamic air lift will, in general, also lower the wake energy signature compared to an equivalent conventional catamaran

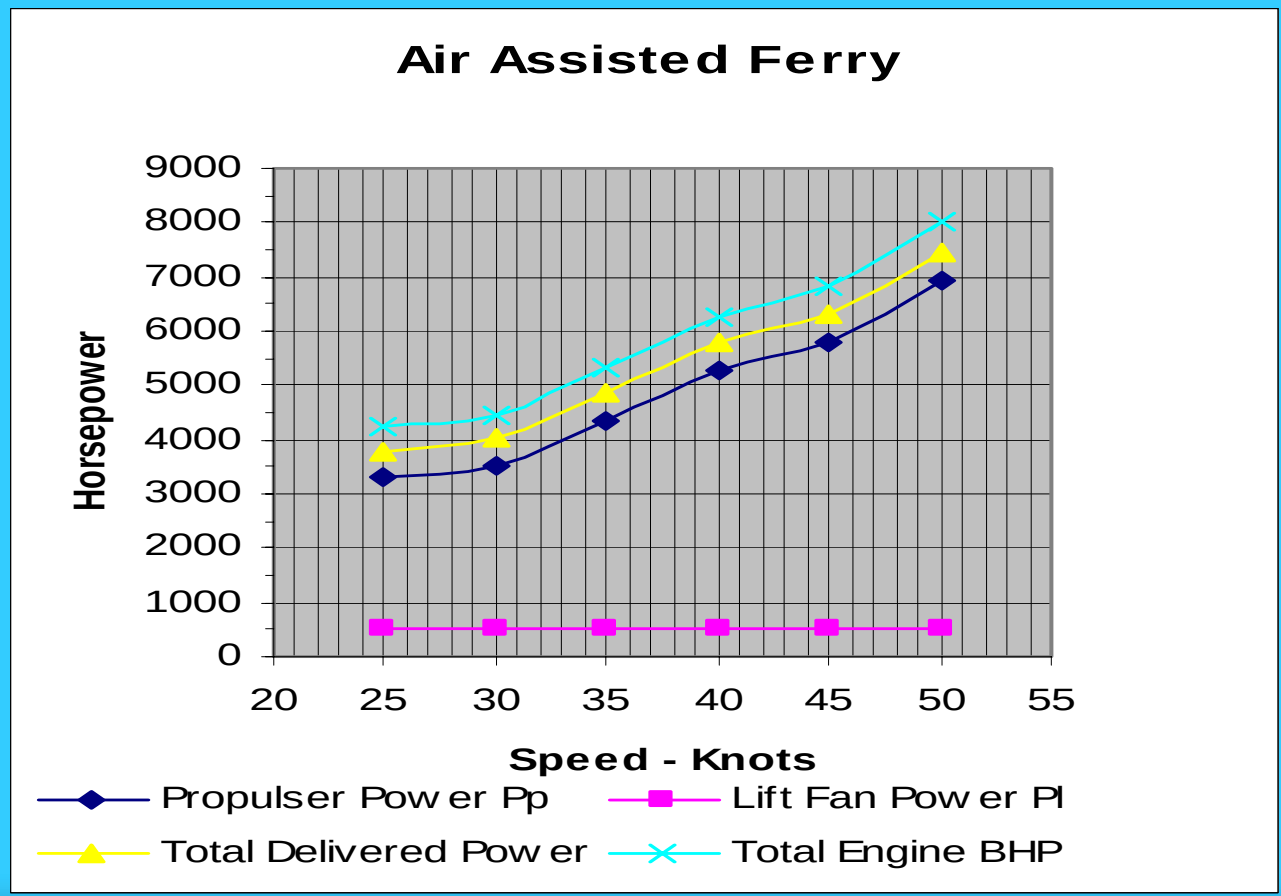
FERRY SIZE AND ARRANGEMENT

- Features incorporated into the design include:
  - Bow loading and all passenger accommodations on the main deck; speeds load/discharge, reduces wind resistance, lowers structural weight and VCG, lowers construction cost and reduces crew size by one person
  - Seating arranged fore and aft with wide access aisles; speeds passenger load/unload (no airliner stand and wait exits) and makes security sweeps and cleaning easier
  - Access to and from the passenger cabin is through wide bow doors and bow gates
  - During operation no passenger access is allowed to the foredeck or to the upper deck (access to upper deck is in emergencies only as a QAR)
  - There is sheltered storage for 14 to 20 bicycles on the foredeck
  - Reverse sloping pilot house windows provide superior visibility to the bow for docking and for observation of passenger during load/unload
  - Shrouded surface piercing propellers (Hydro Air Drives) take advantage of the air escaping past transom bottom forming an air-water interface
  - Adjustable depth dagger board type rudders reduce high speed resistance

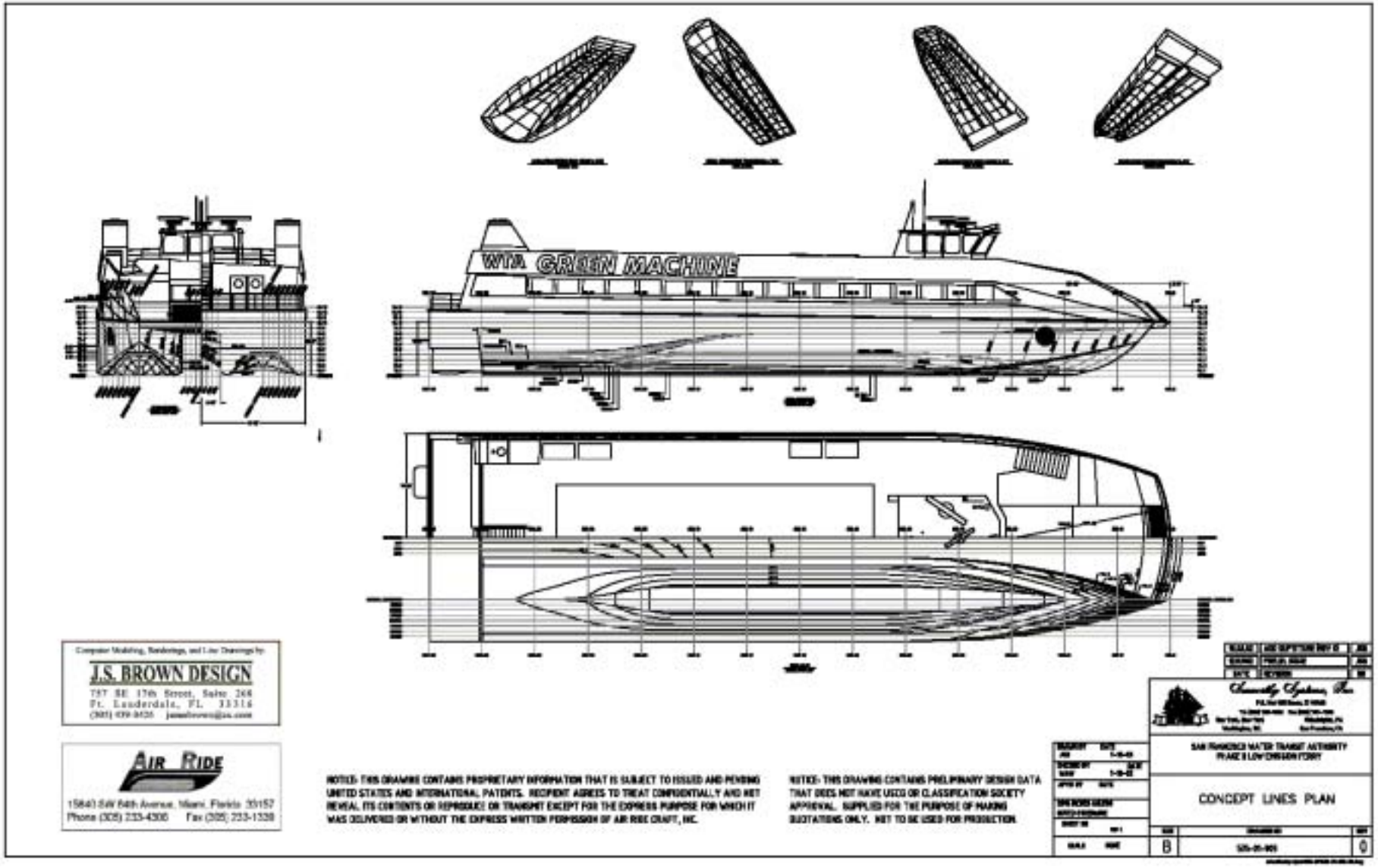
- Overall characteristics of the Seaworthy WTA ferry
  - Length 138.75’
  - Beam, max. 40.00’
  - Beam, demi-hull 15.93’
  - Max. Draft, lift fans off/on 5.50’/4.25’
  - Light ship weight 136 lt
  - Full load displacement (358 passengers+ crew) 184 lt
  - Freeboard, static, bow/stern 8.00’/7.00’
  - Passengers Max ~488 (350 seated + 8 wheel chairs + ~130 standing)
  - Crew 5
  - Service speed, full load @ 83% MCR 35 knots
    @ 100% MCR 41 knots

SPEED AND POWER

- At the full load displacement the total propulsion power required, including lift fans, is 5,347 bhp
  - The lift fans require a constant 514 bhp at full load and all speeds



HULL LINES


WTA GREEN MACHINE
J.S. BROWN DESIGN
787 SE 17th Street, Suite 268
Ft. Lauderdale, FL 33316
AIR RIDE
15843 SW 84th Avenue, Miami, Florida 33157
Phone (305) 233-4300 Fax (305) 233-1338
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SAN FRANCISCO WATER TRANSIT AUTHORITY
PHASE II LOW EMISSION FERRY
CONCEPT LINES PLAN
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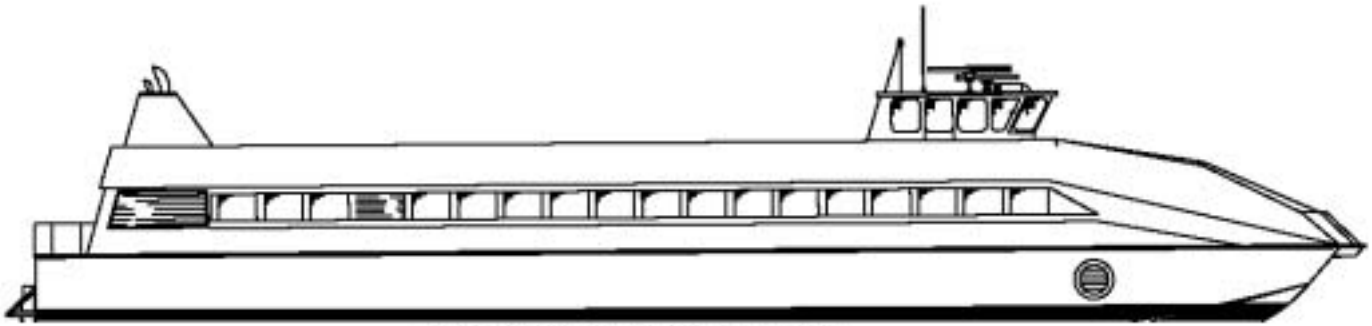
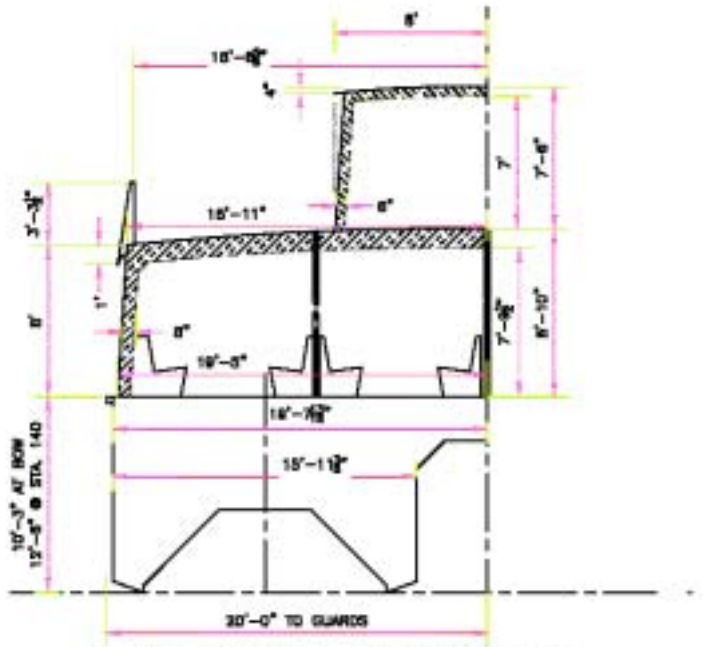
GENERAL ARRANGEMENT



OUTBOARD FLOATING PROFILE



STA. 70 LKG. TO PILOTHOUSE

PRINCIPAL CHARACTERISTICS

LENGTH ON DECK	138'-9"
BEAM OVER ALL	40'-0"
FREEBOARD AT REST: FWD:	8'-0"
AFT:	7'-0"
MAXIMUM DRAFT AT REST	5'-6"
INSTALLED PROPULSION POWER	5630 BHP
MAXIMUM SPEED AT FULL LOAD: 83% MCR	35 KNOTS
100% MCR	41 KNOTS
RANGE	250 N.MI
PASSENGERS	350
CREW	5

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SHEET NO	1 OF 1
SCALE: NONE	

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PHASE II LOW EMISSION FERRY

GENERAL ARRANGEMENT

SIZE	DRAWING NO	REV
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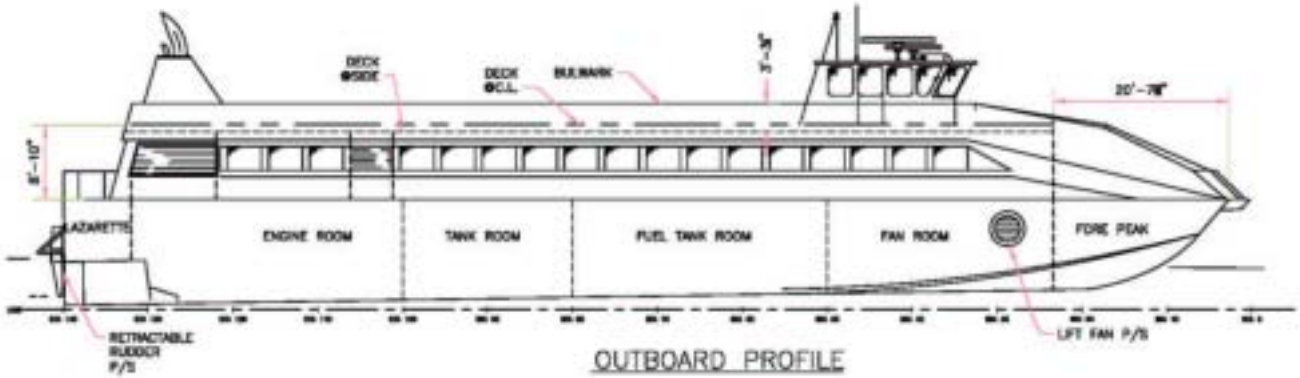
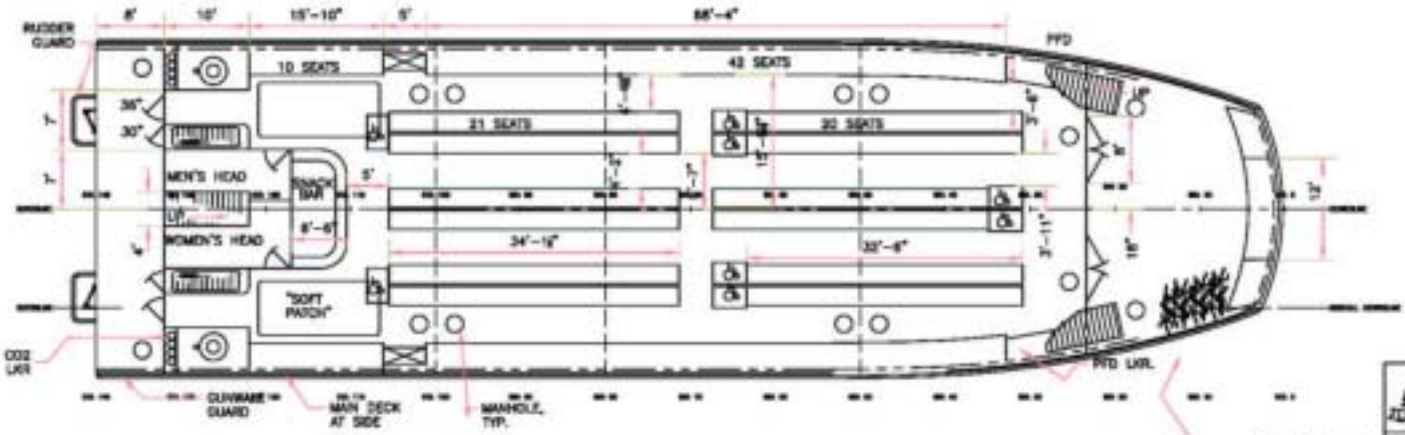


OUTBOARD PROFILE



PLAN VIEW, MAIN DECK

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SAN FRANCISCO WATER TRANSIT AUTHORITY
PHASE 3 LOW EMISSION FERRY

GENERAL ARRANGEMENT

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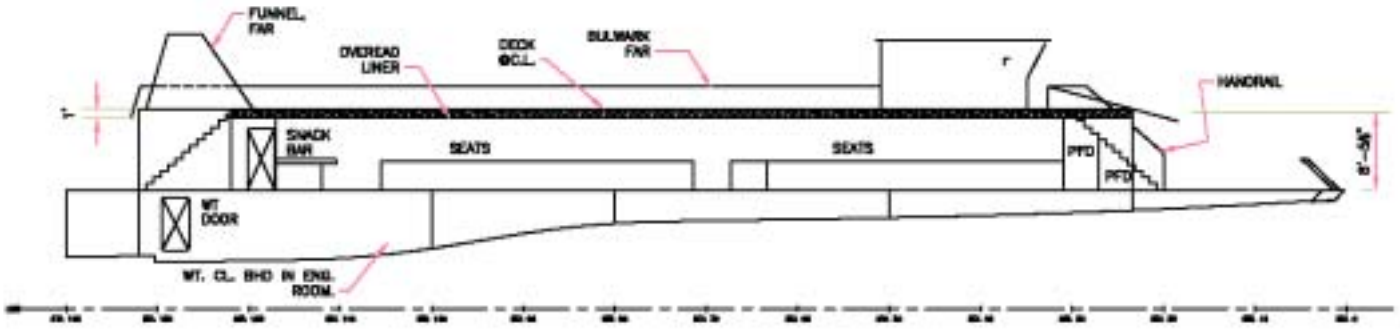
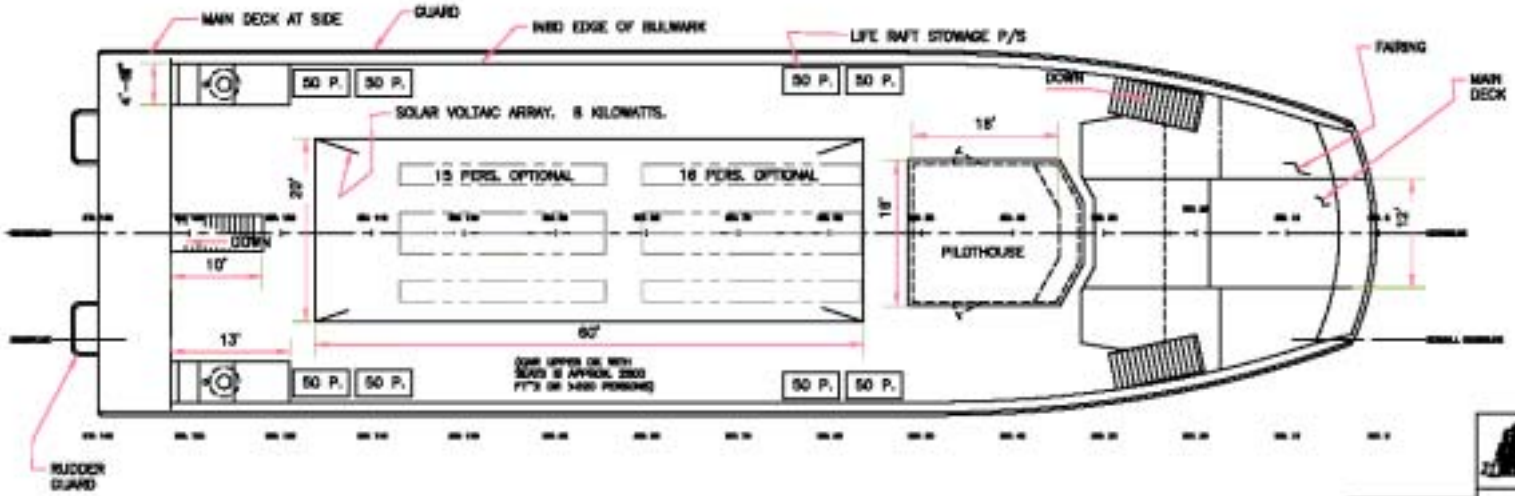


CENTERLINE PROFILE



UPPER DECK

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PHASE II LOW EMISSION FERRY

GENERAL ARRANGEMENT

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PROPULSION MACHINERY

- Fuel cells were considered but, by 2010 their output and size will probably still not be suitable for use in a high speed ferry
- Gas turbines work well with high speed ferries and have emissions advantages over diesels but, they have very high initial, maintenance and fuel costs compared to diesels
- With the new EPA emissions regulations, diesel engines are expected to benefit more from near term emission reduction technologies (because of their sheer numbers) than are gas turbines
- Diesel engines were therefore selected for the WTA ferry design
- Our experience is that to be reliable, ferry diesel engines, regardless of their speed or route, need to be rated for Continuous Service

REDUCING EMISSIONS/KW-HR

- Only 1/2% of the diesel exhaust comprises harmful emissions; nitrogen oxides (NOx), unburned hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM) and sulfur oxides (SOx)
- Existing and advanced technology incorporated into the WTA ferry includes;
  - Direct water injection (DWI) – reduces N0x by 50 to 60% with no negative impact on engine performance, fuel rate or maintenance
  - Electronic control (EC) of fuel injection and valve timing – reduces fuel consumption by 5% and therefore reduces emissions by 5%
  - Exhaust oxidation (EO) catalytic converter – downstream of the turbocharger in the exhaust, reduces C0 and HC by 80 to 90% and PM by 50%
  - Selective catalytic reduction (SCR) - downstream of EO, reduces remaining N0x by 85 to 90%
  - Ultra-low sulfur fuel (ULS) – the only way to reduce S0x is to reduce sulfur in the fuel, using ULS diesel fuel @ 15 ppm sulfur instead of low sulfur (LS) fuel @100 ppm reduces S0x by 85% and prevents contamination and extends the life of the EO and SCR

MACHINERY SELECTION

- The engines selected for the WTA ferry are Wartsila 12V200's, one each hull, having the following characteristics;
  - 3217 bhp (2400 kW) maximum continuous rating @ 1500 rpm
  - 7.54 liter/cylinder
  - Specific fuel consumption @ 90% MCR 201 g/kW-hr
- These engines were selected for several reasons;
  - Today, with mechanical controls and without any emissions treatments, these engines meet EPA 2004/2007 (Tier II) emission standards for N0x+HC, CO and PM per kW-hr
  - DWI is available as an option today, the system is compact and relatively inexpensive, injectors have separate fuel and H2O passages with separate timing, operation with or without H2O is possible at any load, the ratio of water to fuel can range between 0.4 and 0.7 times the fuel rate
  - An SCR/silencer is already available for these engines using a 40% aqueous urea solution injection controlled by a N0x feedback sensor
  - EC for fuel injection (and H2O) and valve timing is expected to be available for these engines well before year 2010
- EO catalytic converter is not available from the manufacturer but will be commercially available in a few years

PROPELLERS, GEARS AND RUDDERS

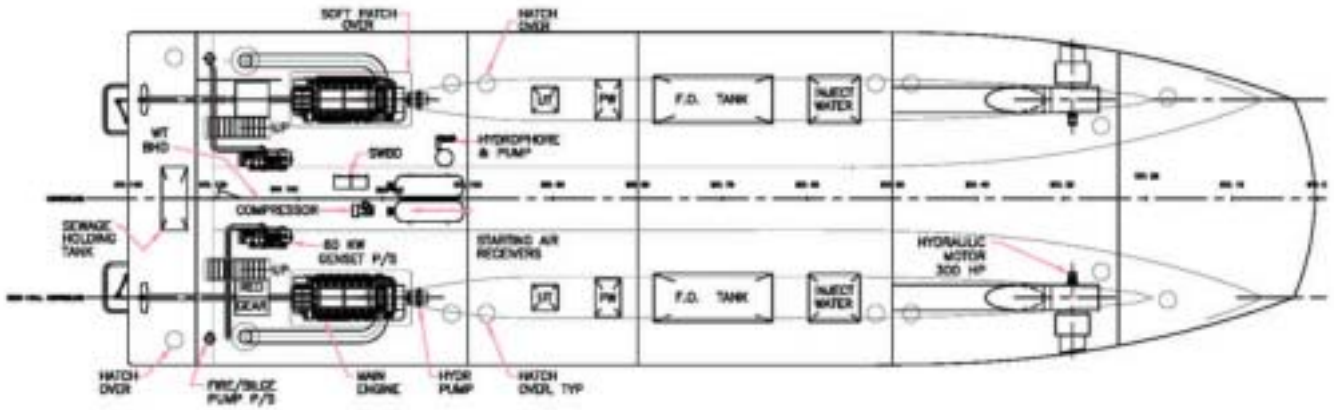
- Hydro Air Drive (HAD) units were selected instead of water jets because they are ideally matched to an air assisted hull (water jets are not) and will be commercially available within a few years;
  - The propeller rotor operates as a surface piercing propeller half above and half below the air cushion escaping under the transom
  - A fixed shroud around the propeller helps to stabilize the flow, recovers some rooster tail energy and provides some debris protection for the propeller
  - Surface piercing propellers potentially offer higher efficiencies than water jets and the propellers do not suffer cavitation damage
- At low speeds the HAD propellers are fully submerged increasing shaft torque; this is overcome by using 2-speed reversing reduction gears available today
- Behind the HAD units are high aspect ratio dagger board rudders, blade depth is controlled hydraulically so at high speeds depth (and resistance) is reduced and steering is accomplished by simply deflecting the rooster tail spray

LIFT FANS AND PTO'S

- Each hull of the ferry has a large centrifugal lift fan mounted forward requiring a 260 hp driver
- Options for driving these fans include independent diesel engines, electric motors and hydraulic motors
  - Independent diesels on each fan would require separate emission controls so were not considered
  - Electric motors driven by PTO generators on the main engines may be the best option once super conducting technology becomes commercially available after 2010 but,
  - The hydraulic drive option seemed to be the best solution until then
- Each main engine drives a separate hydraulic pump and with a cross over both fans can be driven at reduced capacity by one engine
- Advantages of this system are; reduced weight and space, operation on the very low emission main engines, convenience of construction and variable fan speed control; all at the expense of some efficiency
- When needed the hydraulic power is available to drive ship service fire pumps

ELECTRICAL

- Every effort has been made to reduce the electrical load because no emission control equipment will be added to the generator diesels
- The largest electric loads on a ferry of this type are air conditioning, heat and electric fire pump starting but; in San Francisco no air conditioning will be required (only forced fresh air) and heating is only required occasionally (so will use engine jacket water) and the fire pumps are hydraulically driven off the main engines
- Without these three main electric loads the two ship service diesel generators can be a very modest size, about 30 kW each, and only one needs to operate at a time so their emissions contribution is very small
- To further reduce the generator size and/or load, a flat solar electric array is installed on the “unused” upper deck and on a sunny day can provide up to 8 kW of power
- Combined with a large battery bank, the resulting DC power would be used to operate all navigation, communication, security, alarm and emergency lighting equipment as well as engine, emission and steering controls
- The battery bank can also be charged when on shore power or, when necessary, using the spare diesel generator



PLAN VIEW BLW MAIN DECK

NOTE:
THIS MACHINERY ARRANGEMENT PROVIDED BY HERNANDEZ ENGINEERING CORP. (HERNTECH).

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APPROVED BY	DATE
SHEET NO	
SCALE	NONE

Chesapeake Systems, Inc.

SAN FRANCISCO WATER TRANSIT AUTHORITY
PHASE II LOW EMISSION FERRY

MACHINERY ARRANGEMENT

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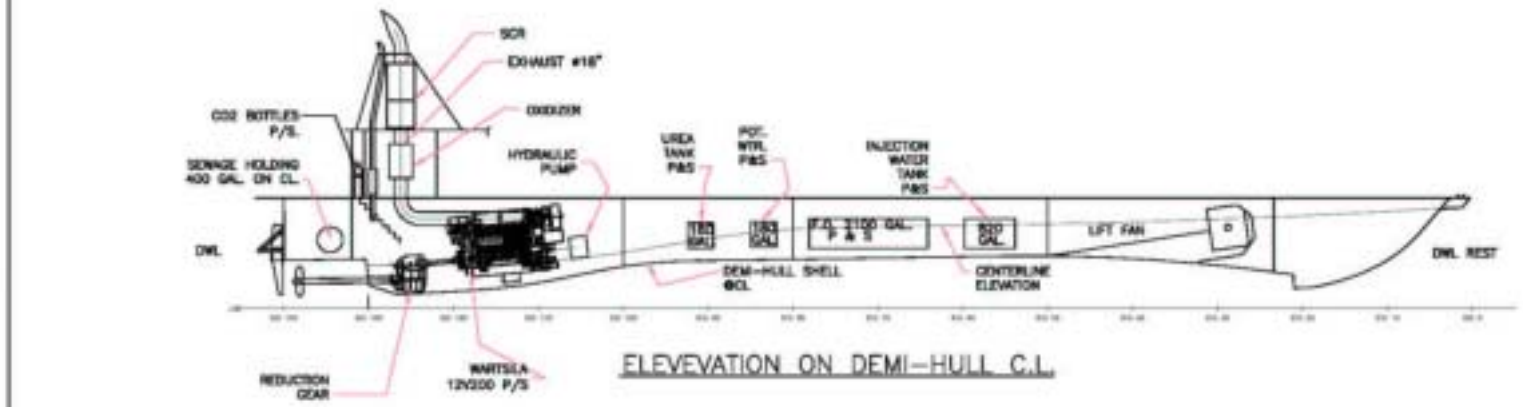
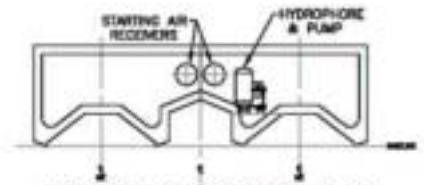
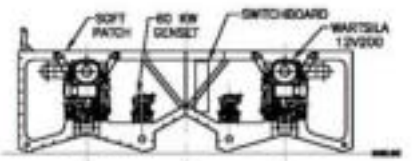


ELEVEVATION ON DEMI-HULL C.L.



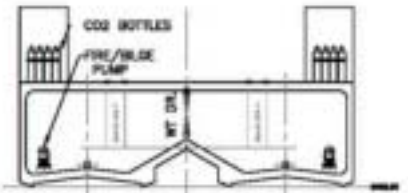
SECTION AT STATION 100

LOOKING AFT



SECTION AT STATION 110

LOOKING AFT



SECTION AT STATION 130

LOOKING AFT

San Francisco Water Transit Authority
Phase II Low Emission Ferry

MACHINERY ARRANGEMENT

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EMISSIONS/PASSENGER MILE

- What are the emissions/passenger mile at 35 knots compared to a conventional ferry

Pollutant	Conventional	Seaworthy WTA	% Reduction
N0x + HC	3.2165 g	0.1315 g	95.9
C0	2.0632 g	0.1677 g	91.9
PM	0.1118 g	0.0329 g	70.6
S0x	(Ratio of ppm S in fuel)		85.0

- Because of the very significant reduction in emissions (average 85.5%) the Seaworthy ferry has been dubbed

"THE GREEN MACHINE"

- And WTA has adopted an emissions reduction goal of 85% below EPA 2004/2007 (Tier II) standards for their ferries