UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
MARITIME ADMINISTRATION
PROJECT NO. DTMA 1HO1003

REPORT ON

PROPOSED CONVERSION OF

M.V. "HARBOR QUEEN"

TO

DUAL FUEL OPERATION

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CONTENTS

A. INTRODUCTION STATEMENT

Over the past several months, the Red and White Fleet has worked closely with the Maritime Administration and Marine Design Associates Ltd. to assess the feasibility of converting one of our ferry vessels, the Harbor Queen, to dual fuel (CNG/diesel) as a pilot project. The Red and White Fleet believes that dual fuel technology offers an environmental and economical means of addressing marine vessel emissions and can be immediately applied to specific vessel operations. With this pilot project, we will further validate the findings of the Canadian Ministry of Transportation with their conversion of two, and a soon to be three, vessels. By partnering with Federal, State, and Local agencies to manage the initial capital costs of the conversion of the Harbor Queen, we will be able to demonstrate not only the environmental benefits of this fuel system but also its economic viability.

A conservative estimate for NOx emissions savings for this pilot project is 2.5 tons per year (emissions reductions are addressed in greater detail in the attached report); however, it should be noted that with the success of this study, the Red and White Fleet will expand the application of dual fuel technology to its entire fleet of vessels, and the related environmental benefits will multiply. Additionally, as the recently appointed Bay Area Water Transit Authority moves forward with their implementation plan to expand ferry service on San Francisco Bay to include as many as 120 ferries serving 28 Bay Area terminals, it is reasonable to extrapolate the expected emissions savings even further to an annual savings of approximately 3,000 tons[1] of NOx emissions, which is equivalent to 3.2 billion private vehicle passengers miles or removing 213,333 cars from the roads each year. [2]

We believe that with adequate funding this pilot project will lead to a shift to the use of alternative fuels by the United States passenger vessel fleet and look forward to developing partnerships with interested agencies and parties to further this project.

1 This calculation is based on the following assumptions: 120 vessels running 8 hours per day 365 days per year, the average vessel operates with 3000 horsepower including mains and auxiliaries, NOx emissions are produced at 6 grams per horsepower hour, and dual fuel technology actualizes a 40% reduction in NOx emissions.

2 Assumptions: 0.789 grams NOx per private vehicle passenger mile and 15,000 passenger miles per year per private vehicle.

B. ECONOMIC ANALYSIS OF DUAL FUEL . PREPARED BY M.D.A.

1. INTRODUCTION

The Red and White Fleet in co-operation with the Marine Administration (MARAD) U.S. Department of Transport, Washington, DC, have initiated a pilot project to convert one of their ferry boats, the M.V. “HARBOR QUEEN”, to dual fuel (natural gas/diesel) operation. Translated, this means the ferries engines can either operate on diesel fuel only or on a mixture of natural gas and diesel, this latter fuel mixture resulting in cleaner engine exhaust emissions venting to the atmosphere. The project, following the conversion, will provide the owners, environmental authorities and other interested parties with the hard data necessary to evaluate the effectiveness of this technology and will form the basis for further dual fuel conversions within the marine industry.

It should be noted that the Red and White Fleet has a history of pursuing environmental practices, and their interest in this project began in 1998 when they initiated a project to repower their ferry M.V. “HARBOR QUEEN” with modern low emission diesel main engines while applying for funds through the Carl Moyer program. These new main engines, Caterpillar Model 3406E were installed in 1999.

The climate surrounding emissions and use of alternative fuels and technologies has changed over the past few years. Regulators, engine manufacturers, environmentalists and the marine industry are working collaboratively to identify the most economical and environmentally friendly methods of addressing the ever increasing pressure on the Bay urban transit systems whilst reducing exhaust emissions. As the recently appointed Bay Area Water Transit Authority moves to develop an implementation plan for expanded ferry service on San Francisco Bay, they have been urged to assess the many technologies available which promise to make the ferry system not only the most cost effective and flexible solution to the local transportation problem but also the most environmentally friendly. Red and White are of the opinion that this dual fuel pilot project will help to achieve this goal for a clean, efficient and safe water transportation system.

To help Red and White achieve this goal they have, with Marad's approval, enlisted the professional services of M.D.A. Marine Design Associates Ltd., pioneers in the field of dual fuel design conversions, to prepare this feasibility study on the dual fuel conversion of the ferry M.V. "HARBOR QUEEN" and thereafter to provide the necessary dual fuel design documentation for submission to U.S. Coast Guard for approval.

2. HISTORICAL DEVELOPMENT OF DUAL FUELED FERRIES

Today, with the concerns of the greenhouse effects and damage to the ozone layer, Governments world wide have begun to recognize that something has to be done to reduce present day exhaust emissions whether it be from factories, cars, buses, or marine vessels. The automobile industry and engine manufacturers are already working on this pollution problem and the latest engines built today are more fuel efficient and environmentally friendly with noticeably reduced emissions. However, more needs be done in other industries, including the marine industry, noting that some progress has already been made in this field as described hereafter.

Following the successful conversion in the early 1980s of the M.V. “ACCOLADE II”, a bulk cement carrier in Australia, to operate on dual fuel (natural gas/diesel) the Provincial Government of British Columbia, Canada appointed M.D.A. Marine Design Associates Ltd. to prepare the necessary dual fuel design and obtain the necessary Canadian Coast Guard approval to convert their existing 13 year old vehicle/passenger ferry, M.V. “KLATAWA” to operate on dual fuel. On December 16th, 1985 following conversion, the ferry became the first certificated vehicle/passenger vessel in the world to operate in this medium.

With the success of the dual fuel operation on the M.V. “KLATAWA”, her sister ferry M.V. “KULLEET” which operates on the same route, was similarly converted to dual fuel operation in 1988. In addition to the main engine conversion, the genset engines were also converted to dual fuel on a 75% / 25% mixture of natural gas/diesel whilst the hot air furnace was modified to 100% natural gas. These latter modification were installed in the M.V. “KLATAWA” in 1990 during her first refit following conversion in 1985.

Unlike the M.V. “KLATAWA” whose main engines were first opened up at 30,000 hours and found to be in first class condition, the main engines in the M.V. “KULLEET” ran to 60,000 hours before requiring overhaul. This is four times longer than the average diesel fueled engine and roughly equates to running a highway truck 1.5 million miles between overhauls.

Since conversion of the “KLATAWA” and “KULLEET”, a variety of environmental benefits beyond the expected one of cleaner exhaust emissions have been realized. These are summarized as follows: -

- main engine noise reduction;
- fuel spill risk reduction; and
- reduced lubricating oil for disposal.

Presently underway for dual fuel conversion, based on an M.D.A. design approved by Coast Guard, is the 80 car/250 passenger new ferry M.V. “OSPREY” presently operating on diesel fuel on Kootenay Lake, British Columbia. The new ferry was put into service August 2000 and is scheduled for dual fuel operation by October 31st, 2001. This ferry is powered by 4 Caterpillar Model 3512 engines each of 1,280 HP at 1,600 rpm with electrical power provided by a Caterpillar Model 3306TA generator at 190 KW.

In addition, M.D.A. dual fuel design packages have been Coast Guard approved for other ferries including a 100 car ferry for the BC Ferry Corporation which has also been accorded approval from a Classification Society, Lloyds Register of Shipping, London, England, this being their first dual fuel approval ever on a vehicle/passenger ferry.

In addition to these dual fuel ferries designed by M.D.A. there are another two (2) ferries designed by others which operate on natural gas, these being the passenger ferry ERF1 operating across the Elizabeth River in Virginia and a new 100 car/passenger ferry operating in Norway. However, although they operate on natural gas fuel, they are not dual fueled ferries; the latter which can operate

on either diesel fuel alone or on a combination of natural gas and diesel, the diesel being the pilot fuel providing the spark.

Engine controls on the dual fueled ferries ensure automatic change over from dual fuel to diesel fuel alone if any of the following malfunctions occur: -

- Incorrect Gas Pressure
- Engine Overload
- Low Control Air Pressure
- Engine Revolutions fall below 600 rpm
- Gas Leakage at the 40% lower explosive limit
- Fire Alarm

It may therefore be noted the dual fuel type operation is better suited for the vessel owner/operator. In the event the natural gas fuel is shut off, whether due to safety reasons or unavailability of gas from the shore side supply station, the vessel can still operate on diesel fuel. This cannot be provided by the natural gas engined ferries. Also worthy of note is Lloyds Register of Shipping notation that if all engines were operated on natural gas alone and not dual fuel, an alternate method of propulsion (not natural gas) must be provided.

3. DUAL FUEL COMPONENTS – EXISTING M.D.A. FERRIES

The three (3) main components associated with a marine dual fuel conversion can be identified as follows: -

1) Conversion of main engine(s) to dual fuel operation. This may also apply to the ships service generators and hot air/water furnaces.
2) Installation of an on-board natural gas supply system.
3) Provision of a shore based compressor station or alternate means of compressed natural gas supply.

As applied to the M.V. “KLATAWA” and M.V. “KULLEET”, these components may be expanded upon as follows: -

1) **Main Engine Conversion** for this project was not complex. The converted units were four-stroke, turbo-charged, fresh water after-cooled Caterpillar diesel engines. Other than the addition of gas regulators, a carburetor and a modified Woodward governor, the engine is a standard Caterpillar Model 3406-B with the timing retarded only by two degrees.

These engines can operate either on dual fuel (i.e. natural gas/diesel) or on diesel fuel only at all times. Even at high compression ratios, temperatures are too low to spontaneously ignite the natural gas and, therefore, diesel fuel injection is used as a source of ignition.

Originally the engines were adjusted to a 80% / 20% natural gas/diesel mixture at 85% load but to-date, now operate on a 91% / 9% natural gas/diesel ratio at 85% load and a 35% / 65% natural gas/diesel ratio at an idle speed of 750 rpm.

2. **On-board Natural Gas Installation System** was carefully planned, designed and installed to meet all safety requirements and licensing conditions. Safety features incorporated into the on-board natural gas system included: -

a) safety valves and vents and a breakaway connection built into the natural gas re-fueling system to ensure system integrity in the event of an unplanned disconnection during fueling;

b) gas cylinder storage inboard while being fully ventilated outboard;

c) ventilation holes in the cylinder containment shelters to prevent any gas pocket buildup;

d) fully approved natural gas storage cylinders (U.S. D.O.T. and C.T.C.), each fitted with two isolating valves and two bursting discs (failure pressure 3,600 p.s.i.) which, if activated, will ensure any escaping gas is vented overboard and upwards; *N.B. natural gas, being lighter than air will always move upwards when being released into the atmosphere);*

e) controls to ensure automatic changeover from dual fuel to diesel fuel only if any of the following main engine malfunctions occur: -
- incorrect gas pressure;
- engine overload;
- low control air pressure;
- engine revolutions fall below 600 r.p.m.; or
- gas leakage at 40% lower explosive limit (L.E.L.);

f) gas detectors in each main engine room, in each cylinder storage space and in the battery space which are connected to gas alarms both in the wheelhouse and the machinery space;

h) a first level warning at 20% L.E.L. activates a flashing light and a horn in the wheelhouse and control station to alert the crew of a leak;

i) a second level warning signal at 40% L.E.L. automatically activates the remote controlled main gas valve at the cylinders to a closed position, thereby cutting off the natural gas supply and at which time the engines revert to diesel fuel;

j) a sprinkler deluge system within each gas cylinder storage compartment which, when actuated, will keep the gas cylinders cool in the event of a fire and assist in overboard disbursement in the case of a leak or discharge *(N.B. the system is automatically activated upon registration of a 40% level alarm);*

k) nitrogen introduction into the crankcase of the main engines in the eventuality of a crankcase explosion or an engine room fire;

l) fixed $C.O._2$ smothering systems in each engine room which are manually operated from outside in the event of fire;

m) revised fire and safety drills;

n) preparation of a “Crew Safety Manual”;

o) preparation of a “Damage Control Manual”;

p) preparation of a “Gas Equipment Maintenance Manual and Plan”’

q) a training programme carried out for all ship and shore staff … with special emphasis on engineering staff training;

r) a six month interval between pressure testing of gas line flexible connections;

s) inspection of one main engine after six months (approximately 3,000 hours) of operation;

t) an emergency shut off valve between the compressor station and the vessel which activates in any emergency (eg. a burst line, an electrical failure or a breakaway); and

u) electrical and emergency shutdown controls for the shore side compressor.

3. **The Shore Installation** is comprised of a three-stage compressor, inter-coolers, a self-contained radiator, a cascade of fifty bottles and electrical, operating and emergency controls which are all housed in a 20'-0" long trailer "natural gas storage facility". Connections to the BC Gas (Utility) trunk pipeline and from the storage facility to dockside are also integral components of the shore installation. A pumping station is also provided for Ministry natural gas propelled vehicles.

Natural gas is supplied via the trunk pipeline at 120 p.s.i. It is then compressed through three stages to a working pressure of 3,600 p.s.i.. Following compression, the gas is stored in fifty (50) 520 cubic foot steel cylinders which provide a total storage capacity of 26,000 cubic feet at 3,600 p.s.i. on shore. The bottles are connected in groups of three and piped to a main manifold which connects to the ferry containment system.

The design of this compressed gas station allows for a "quick fill" of the KLATAWA's cylinders, within a full charge design time of three to four minutes. From the shore cylinders the compressed gas passes through isolating valves, non-return valves and pressure regulators to a hose connection. At the end of the hose the gas passes through a "breakaway disconnect" to the shipboard refueling connection station. Refueling

follows a Transport Canada, Marine Safety Branch, approved procedure and is carried out under the supervision of the vessel's Chief Engineer.

These components will generally apply to the conversion of the Red and White Fleet ferry, M.V. "HARBOR QUEEN" which are outlined in a later section of this report.

4. FERRY OPERATION & VESSEL PARTICULARS

4.1 FERRY OPERATION

The Red and White Fleet passenger ferry M.V. "HARBOR QUEEN" provides sightseeing cruises in San Francisco Bay on an annual basis in association with her sister vessels. The sightseeing cruises are normally of one (1) hour duration and up to six (6) or seven (7) may be performed in one day. In addition the Red and White Fleet also offer charter services of three (3) to four (4) hour duration and so a sample operational day for Bay cruises would commence at 0930 hours with generators started up and departure at 1000 hours, all the way through to 1845 hours when the engines are shut down. If there was a charter cruise, from 2000 – midnight (0000) the generators would be restarted at approximately 1900 – 1930 hours and the main engines about 1945 hours. On completion of the charter the main engines would be shut down at midnight (0000) and the generators about 30 minutes later.

For the purpose of this study, we shall assume annual operational use of the ferry to comprise 280 days in use on a 5 day week based on 180 days of 6 Bay cruises, 100 days of 7 Bay cruises plus 15 charter cruises.

4.2 VESSEL PARTICULARS

The ferry M.V. "HARBOR QUEEN' is of steel welded construction certified by U.S. Coast Guard as an Inland Passenger vessel. The vessel was built in May 1954 and further lengthened by 20'-0" in 1966. It provides passengers sight seeing services to Alcatraz and the Bay area and also special charter services. The vessel is 82'-6" in length between perpendiculars and its hull is sub divided into six (6) watertight compartments herein identified as follows from stem to stern as Fore Peak, (No. 1 Void), No. 2 Void, No. 3 Void, No. 4 Void (Engine Room), No. 5 Void and No. 6 Void (Steering Gear Compartment). The fresh water tank is located in No. 3 Void, Sewage Tank in No. 2 Void and Diesel Fuel saddle tanks in No. 5 Void.

Above the main deck, there are two passenger deckhouses, the lower main deckhouse accommodating 188 passengers. This deckhouse is outfitted with a bar at the aft end, engine room access and casing port and starboard at roughly midships and a ladies and gents toilet at the forward end port and starboard. A stairway at the forward end of this deckhouse leads up to the Passenger Lounge on the Upper Deck which is sized to accommodate 212 passengers. The deck over is an open deck off limits to passengers and has a wheelhouse located forward and buoyancy apparatus at the rear. The main mast is located at near midships. The funnel casings port and starboard terminate a few feet above this deck at the after end.

Principal Particulars of the ferry are as follows: -

Length over decks	84'-11"
Length between Perpendiculars	82'-6"
Breadth extreme at 8'-4 5/8" above base	27'-7½"
Breadth extreme at 8'-6¼" above base	27'-6¾"
Depth amidship bottom of keel to Main Deck at side	8'-2 13/16"
Full Mean Draft	5'-0"
Full Displacement	154.00 Long Tons
Diesel Fuel Capacity	2,600 gallons
Fresh Water Capacity	900 gallons
Main Engines	2 x Caterpillar Model 3406E engines
Generators	2 x Caterpillar Model 3304 engines with 30 KW generators
Number of passengers	400
Number of crew	3

5. FUEL CONSUMPTION

The average yearly diesel fuel consumption was calculated individually for the two (2) main engines and one (1) of the two (2) diesel driven generator sets. Based on 180 days of 6 Bay cruises, 100 days of 7 Bay cruises plus 15 charter cruises, the total diesel fuel consumption has been calculated to be 40,375 US gallons.

MACHINERY	ANNUAL CONSUMPTION		
Main Engines	35,787 US gallons	=	135,454 litres
Genset Engines	4,588 US gallons	=	17,366 litres
TOTAL	**40,375 US gallons**	**=**	**152,820 litres**

6. DUAL FUEL CONVERSION DETAILS – "HARBOR QUEEN"

6.1 GENERAL

Unlike the Canadian ferry boats M.V. "KLATAWA" and the M.V. "KULLEET" with their engine rooms located above deck and which have been certificated by Transport Canada, Marine Safety Branch (Canadian Coast Guard) to operate on dual fuel (natural gas/diesel), the M.V. "HARBOR QUEEN" has its two (2) main engines and genset engines located below deck. However M.D.A. does not consider this a major problem as several of their dual fuel conversion designs, such as a 100 car/passenger ferry for the BC Ferry Corporation and an 80 car/passenger ferry for the British Columbia, Ministry of Transportation and Highways, both with their main engines and generator engine below deck, have been approved by Transport Canada. The 100 car/passenger ferry for BC Ferry Corporation has also been approved by Lloyds Register of Shipping.

Details of the dual fuel conversion and capital costs of such on the M.V. "HARBOR QUEEN" are described in the following paragraphs.

6.2 FUEL CONSUMPTION & STORAGE

Following conversion of the M.V. "HARBOR QUEEN" to dual fuel (natural gas/diesel) operation and based on experience from similar type conversions of other vessels, M.D.A. assessed the fuel consumption characteristics of the M.V. "HARBOR QUEEN".

Natural gas to diesel fuel ratios were assumed to be 80% / 20% for the main engines at 1,200 rpm to 1,820 rpm (full load), and 50% / 50% at 1,000 rpm to 1,200 rpm and 35% / 65% at 645 rpm (idle). For the generator engines a constant 75% / 25% ratio was used. Based on these ratios M.D.A. calculated an annual savings of 31,276 US gallons of diesel fuel which would be replaced by 4,569,455 standard cubic feet (s.c.f.) of natural gas.

Based on refueling the ferry twice a day with compressed natural gas (CNG) from a shore based compressor station, the volume of CNG required aboard the ferry is 12,000 scf. Assuming a 2,400 psi pressure in the supply line and gas storage cylinders this results in the requirement for two (2) 24" O.D. x 14'-0" long CNG storage cylinders on board the vessel.

6.3 FERRY & EQUIPMENT MODIFICATIONS

From M.D.A.'s experience of dual fuel installations it is envisaged the natural gas supply system onboard the M.V. "HARBOR QUEEN" will comprise a bunkering/refueling station located above the Main Deck in way of the fiddley/casing either port or starboard. This station would be recessed inboard to accommodate a quick connect/disconnect fitting, an insulating union, check valve, shut-off valve and pressure-gauge. The supply piping, double strong carbon steel (XXS), would then be led up through the casing and then cross inboard at the deck level forming the top of the Passenger House on the Upper Deck. The supply piping is then led to the natural gas storage cylinder(s) via a shut off valve. The natural gas storage cylinders will be to ASME construction approved by U.S. DOT and fitted with two (2) isolating valves and two (2) bursting disc (failure pressure 3,600 psi). The supply piping from the cylinder(s), still at the same deck level, would then be pressure regulated in two (2) stages from 2,400 psi down to just under 5 psi and led below deck through the top and lower passenger deckhouses into the engine room. The supply piping prior to being led below deck shall be fitted with a ball valve and actuator assembly which will automatically shut off the supply of natural gas at a 40% lower explosive limit (L.E.L.).

The supply piping running vertically through the passenger deckhouses into the engine room shall be housed within a pipe pillar and, within the engine room, will be run within a ventilation pipe trunk mechanically vented to atmosphere. The main supply pipe will be teed off to run to each main engine and genset engine where a shut off valve, micron filter and a pressure gauge is fitted. A shut off valve is also arranged in the piping on entry into the engine room as well as purge connections and vents to atmosphere with isolating valves.

Sheet metal exhaust hoods shall be installed over each engine and the hoods mechanically exhaust vented. The ventilation pipe trunk around the gas supply piping in the engine room shall be similarly exhaust vented.

In the event either of the two (2) extraction fans fails to operate, the engines can only operate on diesel.

Gas sensors shall be located within the exhaust hoods over the engines and at high points on the engine room deckhead. Each sensor is linked into a gas detection control module located in the wheelhouse. The control modules respond to sensor signals at 20% and 40% L.E.L. gas concentration readings. At 20%, warning is given via audible and visual signals located in the wheelhouse and engine room. A 40% warning causes the automatic closure of the entire system and activates audible and visual alarms throughout the vessel. Simultaneously, the gas lines are vented to atmosphere through solenoid operated valves.

The two (2) existing Caterpillar Model 3406E diesel main engines and the two (2) existing Caterpillar Model 3304 diesel genset engines will be converted “in situ” to dual fuel (natural gas/diesel) operation.

Discussions have been held with Gas Technologies Inc. (G.T.I.) from Florida, an engineering company with experience in dual fuel conversion of various existing and new diesel engines throughout the United States. At present the company is retained by the Ministry of Transportation and Highways, Province of British Columbia to convert the four (4) Caterpillar Model 3512B diesel main engines, each 1280, and the two (2) Caterpillar Model 3306 generator set diesel engines, 190KW capacity engines on their newly built 80 car/250 passenger ferry M.V. “OSPREY 2000”. This ferry was developed from a preliminary design by M.D.A. who also prepared the dual fuel conversion design package.

With regards the dual fuel conversion of the main and genset engines aboard the M.V. “HARBOR QUEEN”, G.T.I. foresee no great difficulty in performing this retrofit task aboard the ferry. In addition to the onsite conversion of the engines, G.T.I. will also provide a training class to the ferry staff for the safe operation and maintenance of their dual fuel system. Their system will also be submitted to U.S. Coast Guard for approval.

As an alternate to G.T.I. for the dual fuel engine conversion, Clean Air Partners of San Diego, the company responsible for the conversion of new Caterpillar 3406 diesel engines to dual fuel will also be approached to quote on this project with regards a retrofit on site as proposed by G.T.I.

To supply the ferry with compressed natural gas (CNG), and for the purpose of this study, a shore based natural gas compressor station would be located in the area of the Red and White Fleet ferry dock facility. This station would be somewhat similar in configuration but of less capacity than the compressor station in Vancouver, BC, which services the “KULLEET” and “KLATAWA, and would include a supply line to the ferry with a “breakaway” fueling connection.

7. ESTIMATED CONVERSION COSTS

The estimated cost in 2001 dollars to effect the modifications for dual fuel on the M.V. “HARBOR QUEEN”, all as generally outlined in this report is $200,000. This cost also includes the conversion of both the main and genset engines to dual fuel (natural gas/diesel) operation.

The cost to supply and install the shore based natural gas compressor station complete with supply line to the ferry float is $300,000.

The cost estimate for the on-board natural gas system is predicated on receiving US Coast Guard approval on the modifications described within the report. Engineering design costs for the onboard natural gas supply system and the shore side compressor station are excluded.

8. OPERATIONAL & MAINTENANCE COST SAVINGS

In comparison to a diesel fuel only operation, conversion of the M.V. "HARBOR QUEEN" to a natural gas and diesel operation is expected to result in a number of savings on an ongoing basis. These savings are evidenced by lower operational and maintenance costs actually achieved following similar engine dual fuel conversions on the Canadian ferries "KLATAWA" and "KULLEET".

In this section of the report we describe our analysis of the cost savings expected and the principal assumptions upon which this analysis is based. Our work in this area included the following:

- Fuel consumption evaluation and estimates of diesel fuel only operation as well as dual fuel operation.

- Engine rebuild requirements and costs using comparable data from the "KLATAWA" and "KULLEET" and also from the Red and White Fleet's records.

- Discussions with the Natural Gas Supply Companies regarding the supply and installation of a shore based natural gas compressor station.

- Cost evaluations associated with fuel consumption and maintenance over a twenty five (25) year period to fairly profile operational and maintenance cost savings expected relative to the initial investment required.

Our evaluations have focused on the most obvious costs savings expected to occur. The four (4) principal areas of cost savings are as follows:

- fuel cost savings;
- reduced requirement for main engine overhaul;
- reduced requirement for generator engine overhaul; and
- lubricating oil and filter savings.

9. FUEL COST SAVINGS

As described in Section 5, the amount of diesel fuel which would be saved annually on a 280 day operational period after conversion is estimated at 31,276 US gallons (118,380 litres). This equates to 4,569,455 standard cubic feet (scf) of natural gas consumed annually.

Diesel fuel prices fluctuate, based primarily on world supply and demand conditions and expectations concerning crude oil. The price of diesel fuel has varied in the past and will continue to fluctuate in the future. Present diesel fuel prices in California, and specifically in the Bay area, are high and are quoted at $1.20 per US gallon (32¢/litre) but have been as low as 59¢/ US gallon (16¢/litre) in the recent past.

Until recently, it could be stated that natural gas prices were not subject to the same influences as diesel oil prices and although some increase could be expected over the long term, natural gas prices would remain stable. However, here in California, with the high energy demand, and without the “in State” source of electrical supply to meet this demand, the price of natural gas is higher than that experienced in other parts of the country or the world.

Given the uncertainty of future diesel oil and natural gas prices we have carried out this economic analysis for the M.V. “HARBOR QUEEN” using diesel fuel at $1.20 per US gallon (31.7¢/litre) and natural gas at 70¢ per therm which equates to 97.4¢ per US gallon (25.7¢/litre). We would note that natural gas prices in the Bay area are coming down and that 70¢ therms are being sold on five (5) year contracts. The economic analysis also includes the savings expected when the costs of diesel fuel and natural gas are the same. The financial summary in the final chapter of this report includes several additional diesel price scenarios.

FUEL SAVINGS ON A 280 DAY OPERATIONAL PERIOD

Diesel Fuel Savings @ $1.20 per US gallon	$ 37,531.20
Less Natural Gas cost @ 97.4¢ per US gallon	30,462.82
Net Savings	**$ 7,068.38**

When the price of diesel fuel and natural gas is similar there would be no fuel savings but if the diesel fuel becomes more expensive, the fuel savings from conversion to natural gas will be higher. In the reverse, when the price of diesel becomes less than natural gas, the ferry has the option of operation on diesel fuel only until such time as the diesel fuel cost equalizes or increases beyond the cost of natural gas.

9.2 REDUCED REQUIREMENTS FOR MAIN ENGINE OVERHAULS

The extended length of service for main engines operating on dual fuel (natural gas/diesel) has been demonstrated with the post conversion performance of the Canadian ferry M.V. “KLATAWA” and, more specifically, her sister vessel the M.V. “KULLEET” with her main engines running up to approximately 60,000 hours before overhaul (rebuild). Based on this performance, on the particular engine (Caterpillar Model 3406), and on the operating characteristics of the M.V. “HARBOR QUEEN’, it is estimated that with a dual fuel operation, the vessels main engines will need to be overhauled after 50,000 hours of operation as opposed to its present diesel only operation which requires overhauls after 15,000 hours.

From the Red and White Fleet engineering records, the cost of overhauling each main engine at 15,000 hours is recorded at $21,572 for the year 2001 and thereafter this price subject to a 3% increase annually. Therefore, with two (2) main engines, the cost to overhaul this year would be $43,144.

MAIN ENGINE OVERHAUL COST COMPARISON
ANNUAL 280 DAY/8 HOUR DAY OPERATION
(2001 $ X 1,000)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Diesel	-	-	-	-	-	-	43	-	-	-	-	-	-	43	-	-	-	-	-	-	43	-	-	-	-	-
Dual Fuel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	-	-	-	-	-

As may be noted in the table, the main engines on diesel fuel only require overhaul at the 15,000 hour range and thus based on the 280 day annual operation the main engines would be overhauled in the year 2007, 2014, 2021. For the dual fuel operation, the first main engine overhaul will be required in the year 2021.

9.3 REDUCED REQUIREMENT FOR GENERATOR ENGINE REBUILDING

When the two (2) existing Caterpillar Model 3304 diesel driven generators are converted to dual fuel operation, ongoing maintenance cost savings are anticipated. In a normal 280 day/year operation service these engines on diesel fuel operation require overhaul every 8 years (18,000 hours) compared to every 14 years on dual fuel operation. From the Red and White Fleet records the cost to overhaul each generator engine is $8,000.

Using this cost for future overhauls and taking into account the ferry's 280 day annual operating periods, the comparative "diesel only" as "dual fuel" expenditures are summarized as follows: -

GENERATOR ENGINE OVERHAUL COST COMPARISON
ANNUAL 280 DAY/8 HOUR DAY OPERATION
(2001 $ X 1,000)

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Diesel	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	8	-	-
Dual Fuel	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-

As may be noted from the table the cost for overhaul of the first generator engine on diesel fuel is set for the year 2008, the second generator engine set for year 2016 and then the first generator engine again in the year 2024. On the dual fuel mode, the first generator engine would be overhauled in the year 2014 whilst the second generator would be overhauled outside of the time frame being considered for this study.

10. LUBRICATING OIL & FILTER SAVINGS

Based on experience gained with other marine engine dual fuel conversions, lube oil will need to be changed less frequently on the engines of the M.V. "HARBOR QUEEN" when the vessel is converted to and operated on dual fuel (natural gas/diesel). With a proper planned maintenance system, and a lube oil analysis program, the lube oil changes on the engines can be reduced by approximately 50%.

From the records at the Red and White Fleet lub oil changes are performed on the main engines every 500 hours per engine at a cost of $95.00 per engine. Lube oil changes to the generating engines are also performed every 500 hours at a cost of $50.00 per engine.

Fuel filter changes are performed every 1,300 hours at a cost of $46.00 per engine and on dual fuel operation these changes are expected to be reduced by 50%.

Based on this information, the annual cost of lube oil and filter changes for the M.V. "HARBOR QUEEN", and the savings from selecting the dual fuel alternative, are as follows: -

LUBE OIL & FILTER SAVINGS
ANNUAL 280 DAY/8 HOUR DAY OPERATION

	Diesel	Dual Fuel	Annual Savings with Dual Fuel
Main Engines	$ 950.00	$ 475.00	$ 475.00
Generator Engines	$ 500.00	$ 250.00	$ 250.00
Total Savings with Dual Fuel Operation			**$ 725.00**

In summary, operating the M.V. "HARBOR QUEEN' on dual fuel, as opposed to diesel fuel alone is expected to reduce the cost of lubricating oil and filters by about $725.00 per year on an annual 280 day/8 hour operation.

10.1 DUAL FUEL SAVINGS SUMMARY

The operating and maintenance cost savings which are expected to result from converting the M.V. “HARBOR QUEEN” to dual fuel (natural gas/diesel) operation are summarized below: -

ANNUAL 280 DAY/8 HOUR DAY OPERATION
DIESEL FUEL @ $1.20/GALLON & NATURAL GAS @ 97.4¢/EQUIVALENT GALLON

	Diesel	Dual Fuel
Fuel Cost	$ 48,450/yr	$ 41,382/yr
Main Engine Rebuilding	every 15,000 hrs	every 50,000 hrs
Generator Engine Rebuilding	every 18,000 hrs	every 31,500 hrs
Lubricating Oil & Filter	$ 1,450/yr	$ 725/yr

ANNUAL 280 DAY/8 HOUR DAY OPERATION
DIESEL FUEL @ $1.20/GALLON & NATURAL GAS @ $1.20/EQUIVALENT GALLON

	Diesel	Dual Fuel
Fuel Cost	$ 48,450/yr	$ 48,450/yr
Main Engine Rebuilding	every 15,000 hrs	every 50,000 hrs
Generator Engine Rebuilding	every 18,000 hrs	every 31,500 hrs
Lubricating Oil & Filter	$ 1,450/yr	$ 725/yr

11. COMPARATIVE ECONOMIC ANALYSIS OF ENGINE CONVERSION

We concluded our evaluation by comparing the costs associated with converting the M.V. “HARBOR QUEEN” to dual fuel operation with the financial benefits expected as a result. This economic analysis provides an appreciation of the relative value of the dual fuel alternative to the U.S. Department of Transport in general and to the Red and White Fleet in particular. Our analysis does not address the environmental benefits associated with this conversion to natural gas usage. These benefits, as noted from the M.V. “KLATAWA” and M.V. “KULLEET” dual fuel conversions, are as follows:

- cleaner exhaust emissions;
- engine noise reduction;
- fuel spill risk reduction; and
- reduced lubricating oil for disposal.

The financial analysis results are summarized below.

11.1 ECONOMIC EVALUATION OVERVIEW

Our economic evaluation compared the costs and financial benefits associated with choosing to convert the M.V. “HARBOR QUEEN” and to operate the vessel on dual fuel. It was carried out in a fair and objective manner. While more detailed analysis will be required in some areas, the results of our work are considered to be realistic and achievable within the limits imposed by the scope of our study.

We have not carried out an analysis of future projections for diesel oil and natural gas prices in the San Francisco Bay Area. Given the energy supply/demand situation currently, any estimates we provide without a thorough analysis are subject to review and assessment. We believe, however, that it is important for the Red and White Fleet and the U.S. Department of Transport to appreciate the impacts on dual fuel conversion given a range of future pricing for both diesel oil and natural gas. Our financial calculations, therefore, have been

prepared for the following price scenarios based on recent prices in the San Francisco Bay area:

- Natural gas price stays at current levels of 70¢/therm or 97.4¢/US gallon or 25.7¢/litre;

- Diesel oil price is considered at five levels:
  1) the same equivalent price as natural gas (i.e. 25.7¢/litre);
  2) the currently quoted local price of 31.7¢/litre;
  3) the current price + 10% = 34.9¢/litre;
  4) the current price + 20% = 38.0¢/litre; and
  5) the current price + 30% = 41.2¢/litre;

We emphasize that an important, but not the only, factor impacting the economics of converting the M.V. "HARBOR QUEEN" to diesel fuel operation is **the difference in price between diesel oil prices and natural gas prices in the future.** The diesel price scenarios described above have been applied to give the reader an appreciation of the financial benefits of conversion if the relative difference in price between natural gas and diesel oil ranges from 0% to 60%.

Our economic analysis effectively compares the $500,000 investment required ($300,000 for the shore station and $200,000 for vessel modifications) for dual fuel operation of the M.V. "HARBOR QUEEN" with the cost savings expected to be achieved over a 25-year period. We have assumed a realistic 280 day per year operational scenario to estimate operational costs and savings as described earlier.

As an important part of the financial evaluation, we have provided a calculation of the internal rate of return which can be expected from the dual fuel conversion and operation investment. Where applicable during the 25-year analysis period, we have also identified when the conversion project reaches the "breakeven" point (i.e. when the cumulative savings equate to the investment made). It is important to note that the **environmental benefits and risk reduction**

associated with this project, which are considerable, are given zero value (i.e. they are not accounted for) in this economic analysis.

We conclude the economic assessment by providing a summary of investment, savings achieved, rate of return achieved and the "breakeven" year if the capital investment attributable to the M.V. "HARBOR QUEEN" conversion project is less than the estimated $500,000.

This lower investment could be achieved in two ways:

1) if the Red and White Fleet secures government or foundation grants towards the capital costs because of the environmental benefits; and/or

2) if a sister ship within the fleet is similarly converted so that the capital cost of the shore-side compressor station can be shared amongst two or more vessels.

11.2 INVESTMENT VERSUS SAVINGS

The investment required of $500,000 will generate ongoing operational savings in the future, with the relative level of these savings increasing as the price of diesel oil increases compared to the price of natural gas. Investment and savings are summarized on the following table under the assumption that the conversion takes place in 2001 and the M.V. "HARBOR QUEEN" operates during the entire 2002 season and thereafter using the dual fuel configuration.

For each year of operation over 25 years, the extra costs associated with the conversion are shown as negative numbers and the savings are shown as positive numbers. A separate column of fuel cost savings is provided for each of the fuel price scenarios described above. Clearly, the higher diesel fuel prices become relative to the price of natural gas the more savings will be achieved.

All projected savings and expenses have been inflated using an inflation rate of 3% per annum which reflects a conservative but realistic assumption regarding future inflationary impacts.

11.3 INVESTMENT RATE OF RETURN

By estimating the internal rate of return (ROR) which can be expected from the proposed conversion investment of $500,000 we can effectively describe the financial benefits associated with the selection of the dual fuel alternative at various levels of diesel fuel prices. This ROR calculation takes into account the longer term savings that are expected to be realized from the dual fuel operation.

The estimated internal ROR of the described investment in dual fuel operation of the M.V "HARBOR QUEEN" (assuming that the investment is made in 2001 in conjunction with the dual fuel conversion) is summarized below for the five diesel fuel price scenarios referenced earlier.

INTERNAL ROR OVER 25 YEARS
280 DAY OPERATION

Diesel Fuel Price (2001 $)	25.7¢/l	31.7¢/l	34.9¢/l	38.0¢/l	41.2¢/l
Annual ROR on $500,000 (2001 $)	- 1.6%	1.9%	2.2%	2.4%	2.6%

A summary of the investment and savings used to calculate the above rates of return is provided in the following table. The "cum svgs" column provides a running total, for each pricing scenario, of the net cost in each year once all cumulative savings have been taken into account. At the highest diesel price of 41.2¢/litre, the total accumulated savings from conversion are projected to surpass the $500,000 investment made in 2001. The shaded number under the "cum svgs" column indicates that, at this average diesel fuel price, the project will "breakeven" in 2026. For the other price scenarios, the "breakeven" year will occur later.

A rate of return calculation was used for this study which incorporates a "finance rate" for the capital investment of 7% and a "re-investment rate" for positive cash

flows of 5%. As mentioned earlier, an inflation rate of 3% per annum was assumed.

From a purely financial point-of-view, the dual fuel conversion investment is expected to generate a nominal rate of return. Still, the savings will provide a return whenever diesel prices exceed natural gas prices in the future. However, the Red and White Fleet, the City of San Francisco and the State of California will all benefit from the unquantified benefits of cleaner exhaust emissions, reduced engine noise, reduced fuel spill risk and reduced lubricating oil disposal.

11.4 RATE OF RETURN & BREAKEVEN IMPACTS OF LOWER CAPITAL INVESTMENT

It may be possible, indeed likely, that the Red and White Fleet could effectively reduce the capital investment attributed to the M.V. “HARBOR QUEEN” dual fuel conversion. As mentioned earlier, an investment lower than $500,000 might be achieved through one of two ways, or a combination thereof:

1) if the Red and White Fleet secures external grants through government and/or foundations as a result of the considerable environmental benefits expected; and/or

2) if a sister ship, or other ship, within the fleet is similarly converted to dual fuel operation so that the $300,000 cost of the shore-side compressor station can effectively be shared amongst two or more vessels.

Lower capital investment attributed to the M.V. “HARBOR QUEEN” dual fuel conversion would significantly enhance the economic return of this project. We have prepared two spreadsheets which summarized the expenses, savings, rate of return on investment and “breakeven” year using a capital investment of $250,000 instead of $500,000. These spreadsheets are similar to those included earlier in this chapter, except for the lower investment, and are included in the following two pages.

The second of the two spreadsheets provides the rate of return and "breakeven" year for an investment of $250,000. As can be seen, the effective rate of return and timing for repayment of the investment are substantially enhanced under this lower investment scenario. The results of this analysis are summarized in the following table.

INTERNAL ROR OVER 25 YEARS & BREAKEVEN YEAR
280 DAY OPERATION

Diesel Fuel Price (2001 $)	25.7¢/l	31.7¢/l	34.9¢/l	38.0¢/l	41.2¢/l
Annual ROR on $250,000 (2001 $)	1.2%	4.8%	5.0%	5.2%	5.5%
Breakeven Year with $250,000 Investment	After 2026	Late 2015	Mid 2015	Mid 2014	Early 2014

By applying this lower investment cost to the financial evaluation, the conversion project is shown to generate significant rates of return at the current diesel price to natural gas price ratio and higher. Repayment of the invested capital is expected within 13 to 14 years under these assumptions, which will be realized.

It will be important for the Red and White Fleet and the U.S. Department of Transport to consider **all** aspects of the dual fuel conversion project including possible subsidies, the number of vessels eventually to be converted and the significant environmental benefits.

C. SUMMARY OF INITIAL FINDINGS ON PROPOSED CONVERSION OF M.V. "HARBOR QUEEN" TO DUAL FUEL OPERATION PREPARED BY M.D.A.

1. INTENT

Based on the March 2001 survey of the passenger ferry boat M.V. "HARBOR QUEEN" carried out by M.D.A. and following discussions with the Owner/Operator and various suppliers of dual fuel equipment, a feasibility study will be developed to determine the estimated capital cost of equipment necessary in the conversion of the ferry to dual fuel operation with U.S. Coast Guard approval. The capital cost will include:

a) the main engine and genset engine conversion,

b) the on-board natural gas supply system including natural gas storage cylinder(s), supply piping and valves, gas detection units and alarms, exhaust ventilation system, etc., and

c) the shore side natural gas supply system.

The study will then determine the pay-back period of capital costs based on a fixed price for the supply of compressed natural gas against varying costs of diesel fuel.

Subsequently a dual fuel design package will then be prepared by M.D.A. and submitted to U.S. Coast Guard for approval. Following acceptance by U.S. Coast Guard, bids would then be called for items a), b), and c) after which dock and sea trials on dual fuel would be carried out to the approval of the Owners and U.S. Coast Guard.

2. FERRY DESCRIPTION

The ferry M.V. “HARBOR QUEEN’ is of steel welded construction certified by U.S. Coast Guard as an Inland Passenger vessel. The vessel was built in May 1954 and further lengthened by 20’-0” in 1966 and provides passengers sight seeing services to Alcatraz and the Bay area and also special charter services. The 82’-6” length between perpendiculars vessel main hull is sub divided into six (6) watertight compartments herein identified as follows from stern to stern as Fore Peak, (No. 1 Void), No. 2 void, No. 3 Void, No. 4 Void (Engine Room), No. 5 Void and No. 6 Void (Steering Gear Compartment). The fresh water tank is located in No. 3 Void, Sewage Tank in No. 2 Void and Diesel Fuel saddle tanks in No. 5 void.

Above the main deck, there are two passenger deckhouses, the lower main deckhouse accommodating 188 passengers. This deckhouse is outfitted with a bar at the aft end, engine room access and casing port and starboard at roughly midships and a ladies and gents toilet at the forward end port and starboard. A stairway at the forward end of this deckhouse leads up to the Passenger Lounge on the Upper Deck which is sized to accommodate 212 passengers. The deck over is an open deck off limits to passengers and has a wheelhouse located forward and buoyancy apparatus at the rear. The main mast is located at near midships. The funnel casings port and starboard terminate a few feet above this deck at the after end.

Principal Particulars of the ferry are as follows: -

Length over decks	84'-11"
Length between Perpendicular	82'-6"
Breadth extreme at 8'-4$^{5}/_{8}$" above base	27'-7½"
Breadth extreme at 8'-6¼" above base	27'-6¾"
Full Mean Draft	5'-0"
Full Displacement	154.00 Long Tons
Diesel Fuel Capacity	2,600 gallons
Fresh Water Capacity	900 gallons
Main Engines	2 x Caterpillar Model 3406E engines
Generators	2 x Caterpillar Model 3304 engines with 30 KW generators
Number of passengers	400
Number of crew	3

3. DESCRIPTION OF DUAL FUEL SYSTEM ON HQ

Following survey of the ferry M.V. “HARBOR QUEEN” and discussions with the Owner/Operator, Red and White Fleet, the conversion of the vessel to dual fuel would appear to be fairly straight forward, subject of course to U.S. Coast Guard being of similar mind.

The three (3) main components incorporated in the Canadian dual fuel ferries will generally apply to this conversion, these components comprising:

a) Main and genset engine conversions,
b) On-board natural gas supply system, and
c) Shore based Compressor Station.

These components may be developed as follows:

a) Main & Genset Engine Conversions

Discussions have been held with Gas Technologies Inc. (G.T.I.) from Florida, an existing Engineering Company with experience in dual fuel conversion of various existing and new diesel engines throughout the United States and at present retained by the Ministry of Transportation and Highways, Province of British Columbia to convert the four (4) Caterpillar Model 3512B diesel main engines, each 1280, and the two (2) Caterpillar Model 3306 generator set diesel engines, 190KW capacity engines on their newly built 80 car/250 passenger ferry M.V. “OSPREY 2000”. This ferry was developed from a preliminary design by M.D.A. and who also prepared the dual fuel conversion design package.

With regards the dual fuel conversion of the main and genset engines aboard the M.V. “HARBOR QUEEN”, G.T.I. foresee no great difficulty in performing this retrofit task aboard the ferry. In addition to the onsite conversion of the engines, G.T.I. will also provide a training class to the ferry staff for the safe operation and maintenance of their dual fuel system. Their system will also be submitted to U.S. Coast Guard for approval.

As an alternate to G.T.I. for the dual fuel engine conversion, Clean Air Partners of San Diego, the Company responsible for the conversion of new Caterpillar 3406 diesel engines to dual fuel will also be approached to quote on this project with regards a retrofit on site as proposed by G.T.I.

b) On-board Natural Gas Supply System

As stated earlier, this system generally comprises a fueling station, supply piping and valves to the natural gas storage cylinders, pressure regulating valve(s), supply piping shut off/relief valves the main and genset engines, gas sensors and detection units and alarms, hoods over the main engines mechanical exhaust ventilated as is the double walled supply piping in the engine room and nitrogen protection for the engine crankcases. No gas will be supplied if the main exhaust fans are not operating.

For the purpose of this study, our calculations for sizing the natural gas cylinder storage capacity on board the ferry is based on a scenario of four (4) Bay cruises each of approximately one (1) hour duration. This represents a recorded 22 U.S. gallon consumption of diesel fuel per cruise used by the two (2) main engines and one (1) genset engine. The total 88 U.S. gallons diesel fuel used on the four (4) Bay cruises on a dual fuel operation would be replaced with approximately 10,000 standard cubic of natural gas and 16 U.S. gallons of diesel fuel.

Returning to the onboard natural gas system, the natural gas bunkering/refueling station could be located at the fiddley/casing either port or starboard outboard above the Main Deck level. This station would be recessed inboard to accommodate a quick connect/disconnect fitting, an insulating union, check valve, shut-off valve and pressure-gauge. The supply piping, double strong carbon steel, (XXS) would then be led up through the casing and then cross inboard at the deck level forming the

top of the Passenger House on the Upper Deck. The supply piping is then led to the natural gas storage cylinder(s) via a shut off valve. The natural gas storage cylinder will be to ASME construction approved by U.S. DOT and fitted with two (2) isolating valves and two (2) bursting disc (failure pressure 3,600 psi). The supply piping from the cylinder(s) and still at the same deck level would then be pressure regulated in two (2) stages from 2,400 psi down to just under 5 psi and led below deck through the top and lower passenger deckhouses into the engine room. The supply piping prior to being led below deck shall be fitted with a ball valve and actuator assembly which will automatically shut off the supply of natural gas at a 40% lower explosive limit.

The supply piping running vertically through the passenger deckhouses into the engine room shall be housed within a pipe pillar and within the engine room will be run within a ventilation pipe trunk mechanically vented to atmosphere. The main supply pipe will be teed off to run to each main engine and genset engine where a shut off valve, micron filter and a pressure gauge is fitted. A shut off valve is also arranged in the piping on entry into the engine room as well as purge connections and vents to atmosphere with isolating valves.

Sheet metal exhaust hoods shall be installed over each engine and the hoods mechanically exhaust vented. The ventilation pipe trunk around the gas supply piping in the engine room shall be similarly exhaust vented.

In the event any of the two (2) extraction fans fail to operate, the engines can only operate on diesel.

Gas sensors shall be located within the exhaust hoods over the engines and at high points on the engine room deckhead. Each sensor is linked into a gas detection control module located in the wheelhouse. The control modules respond to sensor signals at 20% and 40% L.E.L. gas concentration readings. At 20%, warning is given via audible and visual signals located in the wheelhouse and engine room. A 40% warning causes the automatic closure of the entire system and activates audible and visual alarms throughout the vessel. Simultaneously, the gas lines are vented to atmosphere through solenoid operated valves.

c) Shore based Natural Gas Compressor Station

Following discussions with Bill Zeller from Pacific Gas and Electric and Al Basham from B.C. Gas E-Fuels several means and methods of providing compressed natural gas to the ferry have been explored.

The location of the shore side compressor station, for example, may be at the Owner/Operators access float to the ferry or possibly located away from these premises at an independent fueling facility.

Also under consideration is ownership of the facility as to whether it be owned by the gas supply company whose cost to provide this facility would be recovered, say over a 15 year period, in the price they set for the C.N.G. delivered to the ferry or as to it being owned and operated by the Red and White Fleet. we would note the price of the delivered compressed natural gas to the vessel comprises the price of the gas in the street pipeline plus the price to compress it to say 3,600 psi, the latter price fairly easy to fix for a number of years in the future. However the gas in the street pipeline is another matter especially here in California and may have to be negotiated with the “powers that be”.

The shore side compressor station itself will be generally similar in content to that in Canada comprising compressor, storage bottles and supply piping and break-away hose connection at the dock facility.

4. OVERVIEW OF FUELING STATION

As stated earlier, several methods are available for providing the compressed natural gas to the ferry's on-board natural gas storage cylinders at 2,400 psi to a capacity of 12,000 scf.

For the purpose of this study, we have located the on-shore natural gas station by the ticket kiosk for the Red and White Fleet. The station will be designed initially to provide 12,000 scf of natural gas approximately every six (6) to eight (8) hours. From the compressor station the natural gas supply line will be hard piped to the bunkering station located on the ferry docking float and will be equipped with the necessary shut-off valves gauges and breakaway hose connection. The estimated cost to provide this shore side compressor station is $300,000.

In the event the compressor station is not ready for trialling the ferry on dual fuel operation, it should be possible to truck the compressed natural gas to the ferry for re-fueling.

5. EMISSIONS

The main purpose of this project is to prove that the use of natural gas in the shipboard engines will reduce the present levels of exhaust emissions.

Red and White Fleet, the Owner/Operator of the ferry M.V. “HARBOR QUEEN” will bring in an independent Environmental Agency to determine the present emission levels of each of the main and genset engines operating at varying rpm’s aboard the ferry and therefore established a known base line. On completion of the dual fuel conversion the emission levels of this equipment will then be established and compared to the initial findings.

In discussion with G.T.I., the possible engineering company to carry out the dual fuel conversion of the engines, they have given a range of emission reductions as follows: -

- NOX ..... 15% to 30% decrease
- HC (reactive) ..... 20% to 80% decrease
- PM-10..... 20% to 50% decrease
- OPACITY ..... 30% to 50% decrease
- SOX ..... 50% to 70% decrease

D. BAY CRUISE EMISSIONS PROFILE

E. LETTER FROM GTI ON EMISSIONS

GAS TECHNOLOGIES, INC.
55 Weston Road Suite 329
Weston, Florida 33326
Phone: 954-217-0087
Fax: 954-217-0082

January 29, 2001

To: Whom It May Concern

From: Jason Green
Gas Technologies, Inc.

Subject: Bi-Fuel Emissions Reductions

Dear Sir or Madam:

In follow up to our conversion regarding the operation of diesel gensets on Bi-Fuel, I wanted to clarify the emissions picture as follows:

Conversion of any diesel engine to GTI bi-fuel will generally provide for reductions in harmful emissions. The extent of these emissions reductions will depend on a number of factors including age and condition of the engine, engine make and model, load factor, diesel injection system design, as well as the quality and composition of the supplied natural gas. In general terms, GTI Bi-Fuel will reduce Nox, NMHC (non-methane hydrocarbons), SOx, PM and opacity. Note that NMHC and Nox are ozone precursor emissions; these emissions react in the presence of sunlight to form ozone (smog). Bi-fueled diesel engines will typically have 20% to 50% lower ozone pre-cursor emissions. Additionally, pipeline quality natural gas has little or no sulfur content and as such, converted engines will typically produce 50% to 80% less Sox compared to 100% diesel operation.

While the above listed benefits do generally occur on nearly every application we have ever tested, the degree to which this happens will vary from engine model to engine model, as well as from engine to engine within the same engine model class. As such, we normally provide our customers with a range of emissions reduction performance for a given engine model. If we have previously tested this engine model, we can give a tighter range estimate to the customer; conversely, if we have no previous emissions data for a particular engine, we will be more conservative in our projection.

Based on a broad range of emissions testing experience with our Bi-Fuel System, we are confident that operation of your gensets on Bi-Fuel will produce emissions reductions in the following ranges:

1. Nox: 15% - 30% decrease
2. HC (reactive): 20% - 80% decrease
3. PM-10: 20% - 50% decrease
4. Opacity: 30% - 50% decrease
5. Sox: 50% - 70% decrease

CO output will increase during bi-fuel operation (as with any gas engine), however, both CO and CO2 are considered green house gases. While CO usually increases, CO2 usually decreases and we end up with a net decrease in green house gases. If you desire the lowest possible CO and THC output, we can provide 2-way catalysts which will decrease these emissions approximately 70% - 90% depending on load factor.

Please let me know if there are specific emissions thresholds that you will be required to meet. Once we know this, we will be able to determine if the Bi-Fuel System will achieve these levels (considering the baseline 100% diesel emissions output of the engine), or whether additional after-treatment will be required.

If you should have any questions, please contact me at 954-217-0087.

Sincerely,

Jason Green
Vice President

F. ENGINE CONVERSION TECHNOLOGY PRESENTED BY GTI

G. OVERVIEW OF FUNDING

PRELIMINARY OVERVIEW OF FUNDING SOURCES FOR MV HARBOR QUEEN DUAL FUEL DEMONSTRATION PROJECT[i]

1. **California Air Resources Board (CARB):** CARB is administering funds for an Emissions Reduction Credit Bank to offset the emissions of peak power plants coming online this summer to assist with the current power crisis. A proposal has been submitted to CARB to seek partial funding for the pilot project.

2. **Carl Moyer Grant:** The Carl Moyer Grant program, administered by the Bay Area Air Quality Management District, seeks to purchase long term NOx emissions reductions by selecting the lowest cost per ton savings and focuses on engine replacements and retrofits. Should the Carl Moyer Grant be funded beyond June, 2001, it is possible that the engine conversions on the Harbor Queen could be eligible for Carl Moyer funding.

3. **Bay Area Water Transit Authority (WTA):** The WTA is charged with developing an implementation plan for an expanded ferry service on San Francisco Bay. One element of the plan is to review and evaluate the application of alternative fuels in marine vessels. The WTA has indicated that funds could be made available to assist with a portion of this pilot project.

4. **Advanced Vehicle Program (AVP):** TEA-21 legislation includes funding for developing low emissions/fuel efficient vehicles. This pilot project fits the profile for AVP funding, and by working in conjunction with CALSTART, one of the seven advanced transportation technology consortia (ATTC) recognized by the Department of Transportation (DOT), we will submit a proposal for this project to DOT.

5. **State Energy Program (SEP):** The California Energy Commission (CEC) receives funds from the Department of Energy to encourage the application of energy efficient technologies. Working with the Department of Environment for the City and County of San Francisco and the local representative of the Clean Cities Coalition, we will develop a proposal to seek partial funding for the pilot project through SEP.

6. **National Energy Policy Act (EPAct):** EPAct includes federal tax deductions of up to $100,000 for the installation of clean fuel refueling stations. As we move forward with the fueling infrastructure, we will ensure that the fueling station can serve land based vehicles as well as the MV Harbor Queen, and we will seek partnerships with those who may be able to benefit from significant tax deductions.

7. **The ARB Innovative Clean Air Technologies Program (ICAT):** Through ICAT, funds are available to assist companies developing clean air technologies and creating jobs in California. With CALSTART as consultants, the Red and White Fleet will develop a proposal to seek ICAT funds for this project.

8. **Local Funding:** The Red and White Fleet is working to generate the interest of local government officials, environmental agencies, and industry leaders in this project. Currently, we are developing a proposal emphasizing environmental justice as well as equal access to efficient water transportation.

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[1] The report completed by CALSTART for DOT entitled “The Use of Natural Gas Ferries in the Golden Gate National Recreation Area” has been used as a resource to identify possible sources of funding for this project. Efforts are also being made to identify other possible sources of funding and to develop partnerships with interested parties.

H. DESIGN TIMELINE & COST ESTIMATE

PROPOSED CONVERSION OF PASSENGER FERRY
M.V. "HARBOUR QUEEN"
TO
OPERATE ON DUAL FUEL (NATURAL GAS/DIESEL)
DUAL FUEL DESIGN DOCUMENTATION

Following survey of the ferry boat M.V. "HARBOR QUEEN" by M.D.A. Marine Design Associates Ltd. on March of this year, and, based on their past experience with dual fuel conversion design and their Coast Guard approval process on the Canadian dual fuel ferries, M.D.A. foresee no great difficulty in developing the dual fuel design documentation for the M.V. "HARBOR QUEEN". Such documentation would be submitted to U.S. Coast Guard for approval and thereafter form the basis of a bid package for shipyard tendering purposes.

M.D.A. would note the Coast Guard approval on their first dual fuel conversion in 1985 (M.V. "KLATAWA) was a rather lengthy process (9 months) but subsequent approvals on their other dual fuel ferry designs were fairly quick (3 months or thereabouts) as they were handled by their Vancouver Coast Guard office and not the headquarter office in Ottawa. M.D.A. at this time would assume U.S.C.G. review and approval of the dual fuel design documentation for the M.V. "HARBOR QUEEN" would be handled by U.S.C.G. Washington, D.C., but are presently awaiting confirmation of such from the San Francisco U.S.C.G. office and also from Lt. Rob Wilcox, U.S.C.G. Washington, D.C. in order to confirm who will approve and within what approval time frame.

The dual fuel design documentation prepared by M.D.A. will comprise the following: -

- General Arrangement Outline of Natural Gas System
- Gas Piping System Arrangement
- Gas Bottle Storage Arrangement & Structure
- Gas Ventilation Arrangement
- System Specification
- Construction Cost Estimate
- Preliminary Operating Manual

Prior to commencement of the aforementioned taskings, M.D.A. staff member(s) would carry out an in-depth survey of the ferry to ensure the dual fuel design documentation is based on the current "as-fitted" arrangement.

M.D.A.'s estimated cost to provide this service is US $60,000 excluding U.S.C.G. approval costs, within an estimated time frame of 3 months. Based on this time frame and assuming a 4 month period for U.S.C.G. plan approval plus 2 month for shipyard bid purposes, commencement on the physical dual fuel conversion of the ferry M.V. "HARBOR QUEEN" could be commenced by January 2002 with completion scheduled by late March 2002 for operation on dual fuel.

I. INSTALLATION TIMELINE & COST ESTIMATE

TIME/COST ESTIMATE
FOR THE INSTALLATION OF CNG CONVERSION TECHNOLOGY
AND RELATED EQUIPMENT ON MV HARBOR QUEEN

1.	Gas storage bottles with Frames and Fittings	$ 30,000
2.	Gas System Piping, Fittings, Valves, etc.	20,000
3.	Installation of Gas System Piping	15,000
4.	Sprinkler deluge system for storage bottle	3,000
5.	Installation of sprinkler system	3,000
6.	CO2 System	1,000
7.	CO2 System Installation	1,000
8.	LP Air System	1,000
9.	Installation of LP Air System	1,000
10.	Heating for Gas Valve	1,000
11.	Installation of Heating System	1,000
12.	Ventilation system for engine room and piping	2,000
13.	Installation of #12 above	4,000
14.	Bunkering Station	5,000
15.	Gas Monitoring System and installation	25,000
16.	Visual Audio Alarms and installation	10,000
17.	Gas System Controls in Wheelhouse and engine room	15,000
18.	Installation of gas storage bottles	12,000
19.	Main Engine dual fuel technology and installation	40,000
20.	Generator dual fuel technology and installation	12,000
	TOTAL	**$ 202,000**

Given availability of equipment, the estimated installation period for the above systems is six to eight weeks.