ALTERNATIVE MOTORBOAT PROPULSION SYSTEM

THE UNIVERSITY OF ARIZONA®

By: Tom Cleary, James Downing, Clint McGill, Jose E. Cardenas 2008/2009

INTRODUCTION

In order to facilitate a more ecologically friendly experience, the rafts that travel on the Glen Canyon need to be able to meet all their current abilities without harming the environment or negatively impacting the trip. This leads to functional requirements of:

1. Propel the raft downstream, so that the trip will be faster than a normal float trip would be.
2. Propel the raft upstream within an hour, so that the trip may be made twice per day.
3. Reduce harmful emissions output by the system.
4. Reduce the sound levels output by the system while moving downstream, so that the guides and passengers can hear each other and enjoy the scenery peacefully.

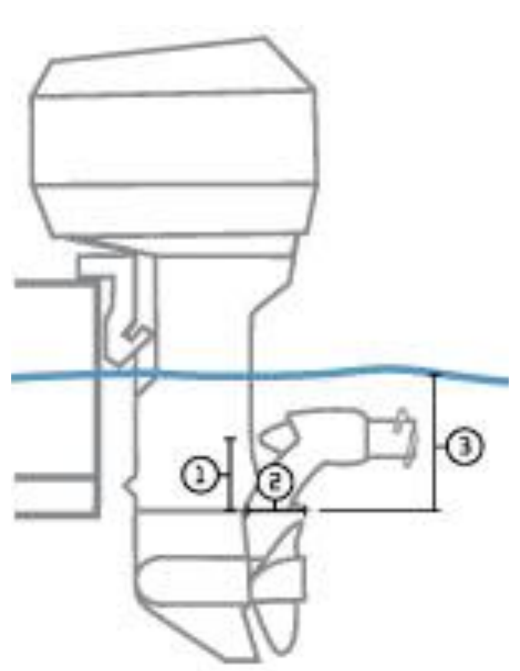
As the main purpose of this project is to reduce the ecological impact of the entire system, secondary goals include reducing the spillage and leakage of fuel, as well as implementing any other methods to be more environmentally friendly. Furthermore, the constraints imposed by the system, the GCROA (Grand Canyon River Outfitters Association), and the federal government lead to the following limitations:

1. No significant alterations to the structure of the raft, as major changes would be expensive.
2. No significant changes to the steering/guidance system, as this would necessitate additional training for the guides.
3. Must not affect the raft's ability to plane, as this would significantly affect fuel economy on the upstream portion.
4. All additions must be able to fit easily on the boat, as portability is a must.
5. Must comply with all Federal guidelines regarding travel in a National Park.
6. System must not use fossil fuels for fuel.

This leads to a simple solution: propel the raft with a quieter secondary motor downstream, while modifying the existing motor to be more ecologically friendly. After research, this led to the selection of a Minn Kota electric motor, which produces little more than a whisper, and a conversion of the main motor to ethanol.

Figure 1. Minn Kota Electric Motor

Figure 2. Cavitation Plate motor placement



METHODOLOGY

In order to power the Minn Kota electric motor with batteries alone, it would become necessary to recharge all the batteries every night, and would also likely require a large number of batteries. To avoid having to move a large number of batteries daily, we are proposing to use a generator converted to ethanol to supplement this power requirement, much like a car does with its alternator. Honda produces a quiet generator that makes less noise than a standard conversation, and several companies make ethanol compatible generators.

The next step in order to determine the exact specifications needed for the batteries, generator, and motors is to determine the efficiencies of the system. This can be done by measuring the thrust produced based on power provided to the drive shaft for each motor, the efficiency of each motor based on the operating speed, and the overall speed achieved on the raft based on the thrust provided. These will all be combined to determine a working relationship between the energy put into the motor and the resulting speed of the raft, which will likely resemble Figure 3 below, which shows this relationship for another motor and boat system. While the electric motor can be tested in a lab, the other information will be collected during a visit to the actual site later in the year.

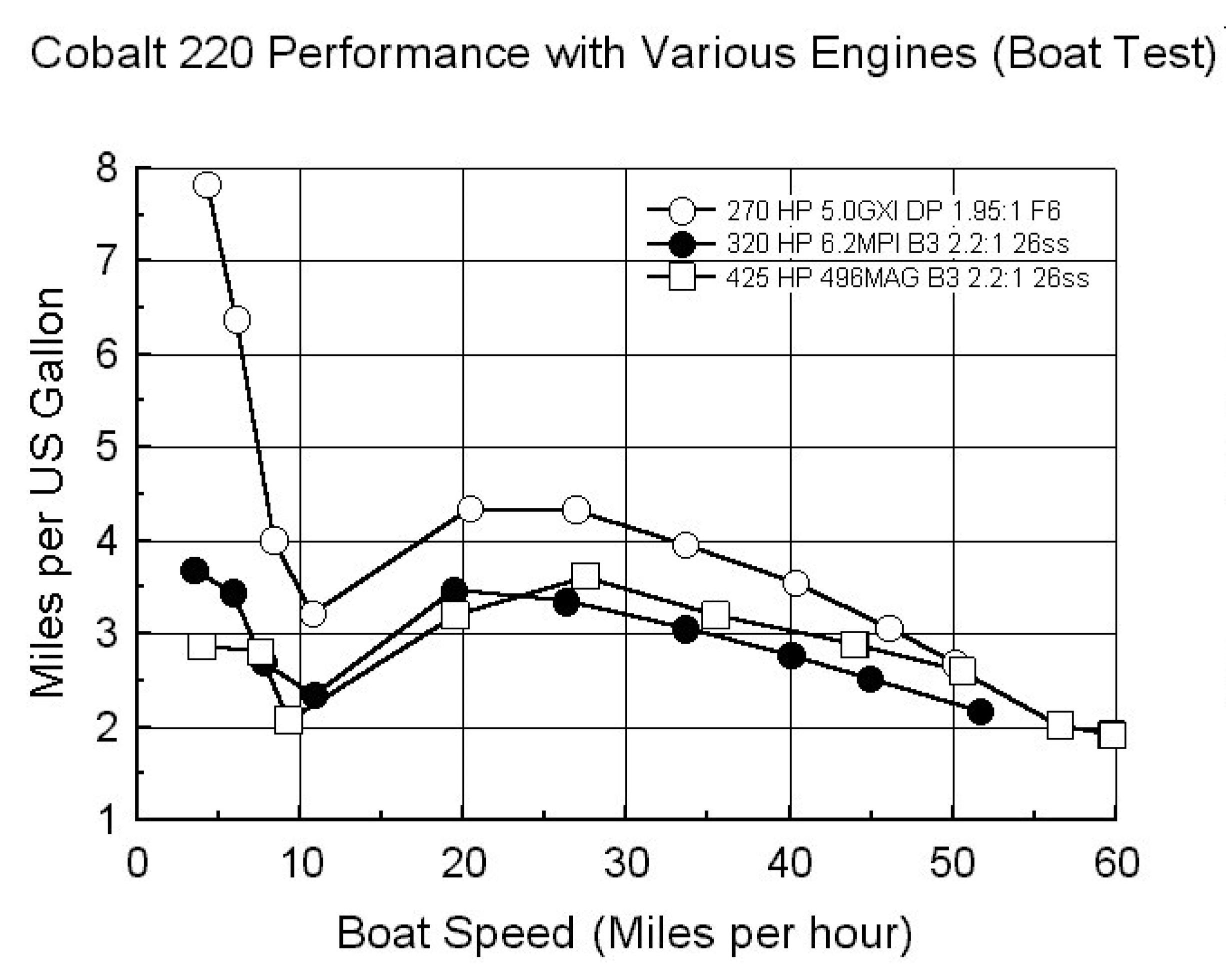


Figure 3. Sample graph of speed vs efficiency

Figure 4. Intensities of various sounds

Source	Intensity	Intensity Level	# of Times Greater Than TOH
Threshold of Hearing (TOH)	$1*10^{-12}$ W/m^2	0 dB	10^0
Rustling Leaves	$1*10^{-11}$ W/m^2	10 dB	10^1
Whisper	$1*10^{-10}$ W/m^2	20 dB	10^2
Normal Conversation	***$1*10^{-6}$ W/m^2***	***60 dB***	***10^6***
Busy Street Traffic	$1*10^{-5}$ W/m^2	70 dB	10^7
Vacuum Cleaner	$1*10^{-4}$ W/m^2	80 dB	10^8
Large Orchestra	$6.3*10^{-3}$ W/m^2	98 dB	$10^{9.8}$
Walkman at Maximum Level	$1*10^{-2}$ W/m^2	100 dB	10^{10}
Front Rows of Rock Concert	$1*10^{-1}$ W/m^2	110 dB	10^{11}
Threshold of Pain	$1*10^{1}$ W/m^2	130 dB	10^{13}
Military Jet Takeoff	$1*10^{2}$ W/m^2	140 dB	10^{14}
Instant Perforation of Eardrum	$1*10^{4}$ W/m^2	160 dB	10^{16}

The amount of power a battery can continuously supply is determined by the type of battery. Below is a sample of the discharge capacity of a standard lead acid battery. Based on the power consumption of the motor, a battery system could be selected to accommodate the needs of the system.

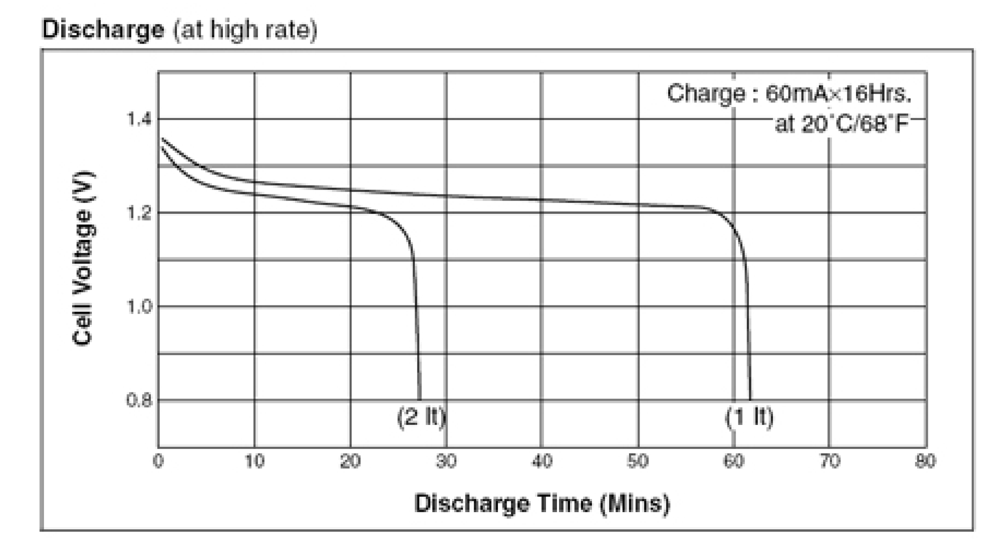


Figure 5. Sample battery discharge rates vs. time.

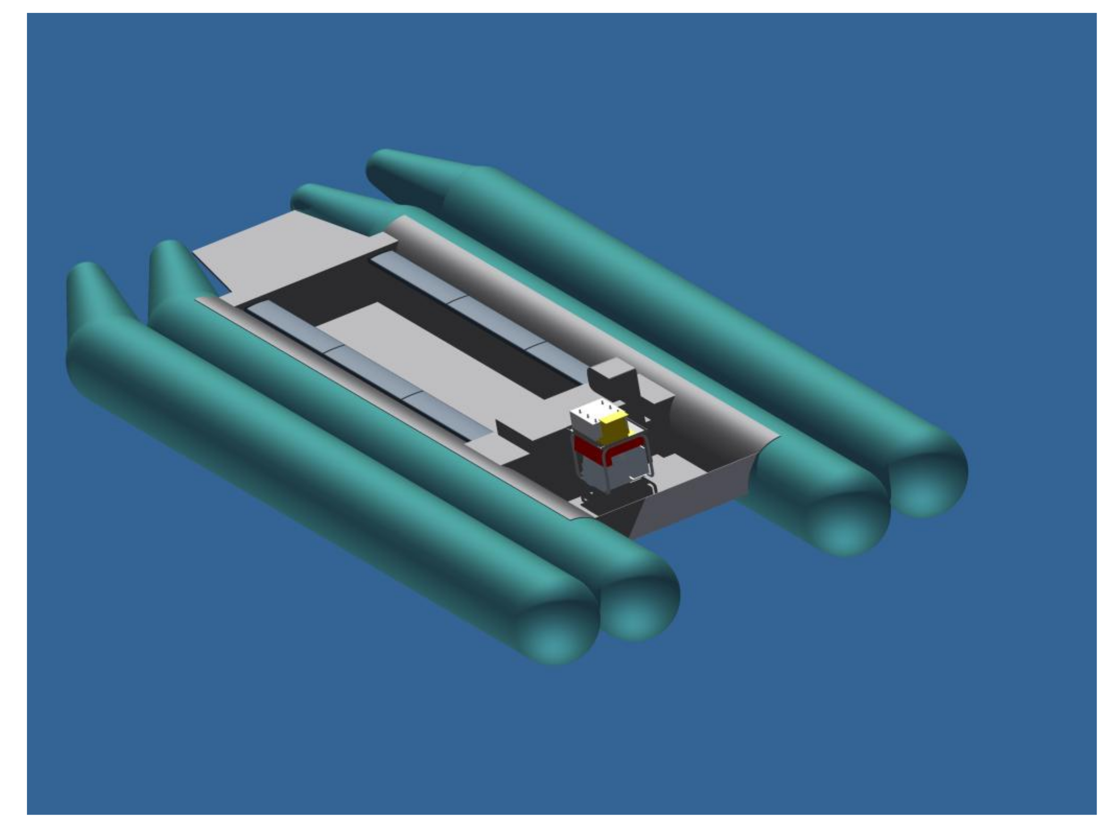


Figure 6. 3D Representation of raft with system

System Requirements:

Functional requirements:
- Propel raft up stream
- Propel raft down stream
- Reduce emissions
- Reduce sound levels

Secondary goals:
- Reduce fuel spillage and leakage
- Lower ecological impact

Constraints:
- Do not change boat structure
- Comply with all Federal Guidelines regarding travel in a National Park
- Do not change steering/guidance system significantly
- Must be able to fit on the raft
- Must not affect boats ability to plane

Metrics:
- Generate enough power to plane raft (amount TBD)
- Less emissions than current system (measurement TBD)
- At least 3 db less than current system

Figure 7. System requirements, constraints, and metrics

Based on the power requirements of the motor, which requires a maximum of 98 amps, this leads to the conclusion that it is not highly feasible to power the system alone. For this reason, a generator has been chosen to supplement the power. The chief challenges with this are that we need at least 3600 Watts to be supplied by the generator and converted to 36 Volts DC. Assuming 80% efficiency of conversion, this means the most likely size for a generator that would be powerful enough would be a 4500 Watt generator. Unfortunately, a converter of this power can cost upwards of four thousand dollars. Thus, we will be working on a proof of concept, and try to demonstrate that the batteries can be supplemented with a generator, even if the generator does not provide all the power the motors need.

CONCLUSIONS

Colorado River Discovery wants four main things out of the new propulsion system: the power to get back upstream, 15 miles, in an hour or less, a reliable system that is also durable, non-fossil fuel propulsion and a silent operation for the downstream tour. An extensive system is needed to meet these requirements. The ethanol converted Honda creates the power needed to reach 18 mph and get back upstream. Both the Honda engine and Honda generator already are durable and reliable, and the dual system redundancies add to the reliability. Also the dual system, electric and ethanol, allow for a quiet mode during tours. The generator creates the most noise. The ethanol converted generator is below the noise requirements, but it will be housed in a sound box to ensure quiet ambience on the river.

Most of the parts of the design are off the shelf parts. So the main challenge will not be creating the system, but instead finding the parts that will not exceed the very limited budget or fabricating inexpensive alternatives. The end goal is to have a working design that will be implemented on one of Colorado River Discovery's raft, but the main focus of the will be on converting a Honda generator to ethanol and creating a sound box for it.