ARIZONA STATE UNIVERSITY HYBRID TEAM

ALTERNATIVE MOTORBOAT HYBRID PROPULSION SYSTEM PROJECT DESCRIPTION

1 INTRODUCTION

Preserving Glen Canyon and its surrounding area is important to the populace as well as the wildlife that call it home. The Colorado River Discovery tours make it possible for the general public to appreciate and see the millennia of history contained in the approximately 15 miles long stretch of river. From March 1 through November 30, the Colorado River Discovery provides the general public with two tours a day, per boat. The tour starts at the base of the Glen Canyon Dam and takes approximately three hours to reach the destination at Lee's Ferry.

The Colorado River Discovery is currently using a Honda 135 horsepower outboard motor as its propulsion system for the trip up and down the river. These motors can consume anywhere from six to twelve gallons of gasoline per tour. With the increasing concern of harmful emissions, noise pollution, as well as the increasing costs of fuel, there is a need to find a more ecological and cost efficient alternative to solve these problems.

An automotive hybrid drive system adapted to a smooth water boat could be a possible solution to these problems. Our team is the first with the assignment to explore this solution, however, if we used a hybrid system from an automobile, we had to consider the following:

- It would be expensive (even if we found a salvaged vehicle from a junk yard)
- An automotive hybrid drive system has many functions and components designed specifically for street driving
- We do not have the equipment or the knowledge to change parameters in the control system
    - The gas engine is designed to run only at peak efficiency
        - There are probably inputs into the vehicle control systems that must be "true" for the gas engine to turn on that the riverboat cannot satisfy
    - We would not have a way of knowing what would happen, but we know that diagnostic trouble codes are inevitable

- Sometimes automotive system shut down if there are too many diagnostic trouble codes

After a long discussion and design process, our team decided it is best to design and fabricate our own hybrid propulsion system for the pontoon river boats.

Our team consists of the following undergraduate seniors:

Member:	Major:
Brett Bowman	Engineering with Mechanical Focus
Christopher Clouser	Engineering with Mechanical Focus
Nicole Conner	Mechanical Engineering Technology: Aeronautical
Alejandro Frias	Manufacturing Engineering Technology
Christopher Gitter	Mechanical Engineering Technology: Automotive
Hanh Luc	Mechanical Engineering Technology: Automotive
Ryan McQueen	Mechanical Engineering Technology: Automotive
Jason Raymond	Mechanical Engineering Technology: Automotive
Christopher Stubbs	Mechanical Engineering Technology: Automotive

In addition to our team, our mentor is Jim Contes, a Senior Lecturer for the College of Technology and Innovation .

In order to meet our design ambitions we divided up into small teams. The smaller teams would allow us to give each subsystem of our design the extra attention and detail to produce a successful design. Each subsystem team will have its own focus and goal but will still allow us to work together and have the same design objective. The subsystems and the teams can be seen below:

<u>Electric Motor Team</u> Battery Storage and Safety Mounting of the Motor	Chris Clouser Jason Raymond
<u>Internal Combustion Engine Team</u> Fuel System Mounting of the Engine	Nicole Conner Alejandro Frias
<u>Battery System Team</u> Switches and Circuits	Christopher Gitter Christopher Stubbs
<u>Stern Drive System Team</u> Mounting of the System Steering (hydraulic?) Required safety features pertaining to inboard engines	Brett Bowman Ryan McQueen
<u>Transmission and Documentation</u> System Control Integration Drive Shafts Systems Including Lubrication	Hanh Luc

1.1 OBJECTIVE

The goal of this project is to utilize hybrid technology to design a propulsion system for the Glen Canyon smooth water pontoon riverboat ride. This would reduce fuel consumption and preserve the wilderness experience of the environment. The downstream portion of the trip will utilize an electric motor and the upstream portion of the trip will make use of an internal combustion engine. *Figure 1* depicts the pontoon riverboat to be the basis for the hybrid system.

Figure 1

1.2 GANTT CHART

The following Gantt chart, seen in *Figure 2*, will be used as our timeline to stay on task and meet our design deadline. *Figure 3,* on the next page shows our timeline on a calendar.

	Task Name	Duration	Start	Finish
1	System Selection	10 days	Mon 9/21/09	Fri 10/2/09
2	River Boat Trip	1 day	Fri 9/25/09	Sun 9/27/09
3	Component Selection	6 days	Mon 10/5/09	Mon 10/12/09
4	Assign Groups	1 day	Mon 10/5/09	Mon 10/5/09
5	Analysis	13 days	Mon 10/5/09	Wed 10/21/09
6	Attaining Parts	21 days	Wed 10/21/09	Wed 11/18/09
7	Design Review with GCROA	1 day	Fri 1/15/10	Sat 1/16/10

Figure 2

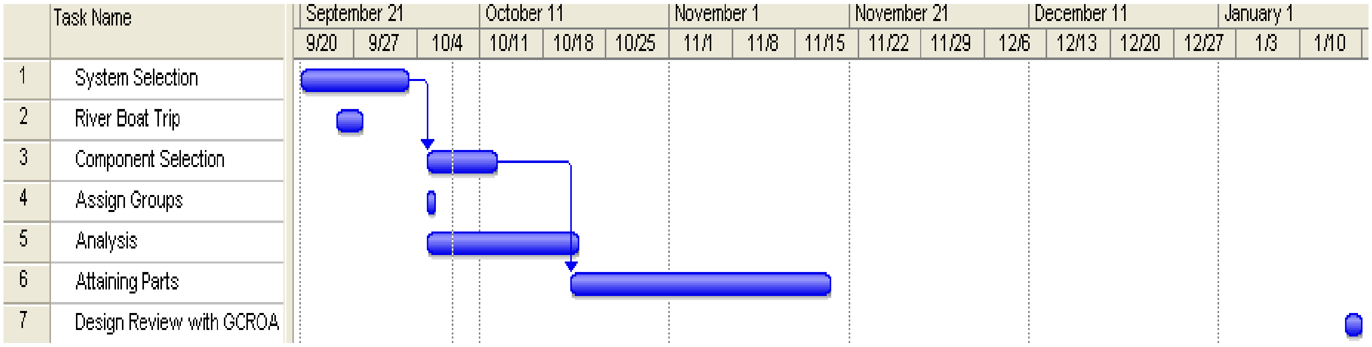


Figure 3

According to our Gantt chart, we are on track:

- ✓ We have selected a system
- ✓ Assigned groups
- ✓ Are in the process of component selection.

1.3 CRITERIA

The criteria that we would like to optimize in our design are as follows:

- Low Cost
- Low Emissions
- Low Noise Level
- Ease of Maintenance
- Ease of Manufacturing
- Durability
- Ease of Operation
- Size of Module
- Low Voltage (DC)

1.4 CONSTRAINTS

The following constraints have been established by our team:

- The system must use less than 3 gallons of fuel per round trip
- The time allow of the return trip must be less than one hour
- It must be modular for serviceability
- It must be safe and insurable
- It must have low liability
- The battery system must have enough energy for two trips
- The internal combustion engine must have close to 135hp
- The propeller system must have a trim capability
- The electric motor and the internal combustion engine must be coupled to have one drive shaft
- Must meet all EPA regulations

2 DESIGN PROCESS

The design process utilized by our team will ensure that all steps in designing the hybrid system will completely resolve the ecological and economic problems. The following steps will be accomplished by our team over the course of the year:

- Assign criteria and constraints for the system
- Brainstorm feasible systems
- Eliminate systems by utilizing a design matrix and choose the best two options
- Take the two best options from the first design matrix and create a detailed analysis of the two systems to choose the best one
- Choose components that will meet the system constraints
- Analyze choices
- Validate the choices with quantitative data
- Fabricate the system
- Test and if necessary redesign/modify to pass design specifications

2.1 BRAINSTORMING AND THE DESIGN MATRIXES

A design matrix is used by engineers to develop and eliminate the best solution for a problem given certain specifications/criteria. Matrix criterion are rated by numbers on how they meet the desired criteria. The higher number is awarded to solutions that best fit the criteria and solutions that fall below receive lower rating. We have brainstormed the following options for our hybrid system design and created a design matrix, as seen in *Figure 4* on the next page, to aid us in choosing the right design:

- Inline PT-

  Will utilize a stern drive apparatus and have an inline configuration in the following order (as seen in *Figure 4*):

  Internal combustion engine (IC), sprag clutch (SC), electric motor (M), drive shaft (DS), and lower unit stern drive (LU)
- Parallel PT; Longitudinal-

  Will utilize a stern drive apparatus, have a longitudinal configuration, and consist of the following (as seen in *Figure 4*):

  The electric motor and internal combustion engine will have separate shafts that will translate power into a transfer case that will connect to a main driveshaft. The main driveshaft will then connect to a lower unit stern drive
- Parallel PT; Transverse:

  Will utilize a stern drive apparatus and have a transverse configuration to make more room for passengers. It will consist of (as seen in *Figure 4*):

  A transverse mounted electric motor and internal combustion engine that will be geared transversely to mesh with a gear box. The gear box will then connect it to a driveshaft and then a lower unit stern drive
- Hybrid Outboard (IC and electric motor together as one outboard unit):

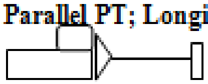
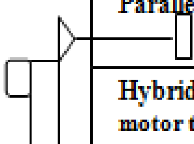
Will utilize the 135 hp Honda Outboard Motor, an electric motor, and necessary components for smooth operation

- Locomotive Motor 3 phase ac:

  Will consist of a separate electric motor that utilizes the internal combustion engine as the generator for the batteries

PROBLEM SOLVING MATRIX

(After the River Rafting Trip)

ALTERNATIVES / SPECIFICATIONS	Low Cost	Low Emissions	Low Noise Level	Ease of Maintenance	Ease of Manufacturing	Durability	Ease of Operation	Size of Module	Low Voltage (DC)		TOTALS
Inline PT; IC-M-GB-DS-LU 	11	11	11	7	11	7	11	3	16		88
Parallel PT; Longitudinal 	7	7	7	3	7	3	3	7	11		55
Parallel PT; Transverse 	3	3	3	1	3	1	1	1	3		19
Hybrid Out Board (IC & motor together one outboard	16	1	1	16	16	16	7	16	7		96
Locomotive Motor 3 phase ac	1	16	16	11	1	11	16	11	1		84

Rating: 16-11-7-3-1

16=good; 1=poor

Figure 4

We decide to explore the best two choices indicated by our design matrix to validate our final decision. The inline power train with a stern drive and the modified 135 hp Honda outboard motor were the top two rated choices.

We created another design matrix that can be seen in *Figure 5*, below.

PROBLEM SOLVING MATRIX

(After the River Rafting Trip)

ALTERNATIVES / SPECIFICATIONS	Low Cost	Low Emissions	Low Noise Level	Ease of Maintenance	Ease of Fabrication	Durability	Ease of Operation	Size of Module	Ease of Reproduction	Commodity Parts	Accessibility	TOTALS
Inline PT; IC-M-GB-DS-LU	1	7	7	1	7	7	1	1	7	7	7	53
Hybrid Outboard Powertrain	7	1	1	7	1	1	7	7	1	1	1	35

Rating: Good=7 Poor=1

Figure 5

From the design matrix in *Figure 5*, we decided to design an inline stern drive hybrid system.

2.2 COMPONENT SELECTION

The component selection is critical to our analysis. We have been researching different engines, stern drives, and electrical motors for our inline-stern drive propulsion system. After the component selection process we will start to analyze and validate our system to meet our design constraints. A great deal of research has already been accomplished on the components listed. We are now analyzing the various components for functionality and searching for them on the internet. Our Gantt chart timing is on target and the team is progressing nicely.