



Cableless Dredge Propulsion Design

Spring 2005

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Problem Introduction

Allied Engineering has been assigned the task of redesigning the propulsion system for a mid-sized dredge manufactured by **VMI Dredges**, Cushing, OK. Currently a majority of their dredges are propelled using a cable stretched across the body of water in which the dredge is working. The cable is attached at opposite ends of the water body to anchors staked in the ground. Heavy trucks or tractors are typically used as anchors. The dredge pulls itself back and forth using a hydraulic motor attached to the cable. The hydraulic drive provides an infinite variation of forward and reverse speeds, easily adjustable by valve positioning. While quite operable in forward and reverse, the dredge is limited in lateral movement due to the semi-permanent securing of the cable anchors.

A considerable amount of time is spent moving the cable anchors, often over one hour per move. In addition to the inefficient use of time, the practice of using vehicles as anchors ties up expensive equipment. A desirable design solution would decrease the overall time spent per job by focusing on improving the current propulsion system. This project involves designing a cableless dredge propulsion system for VMI's horizontal dredges.

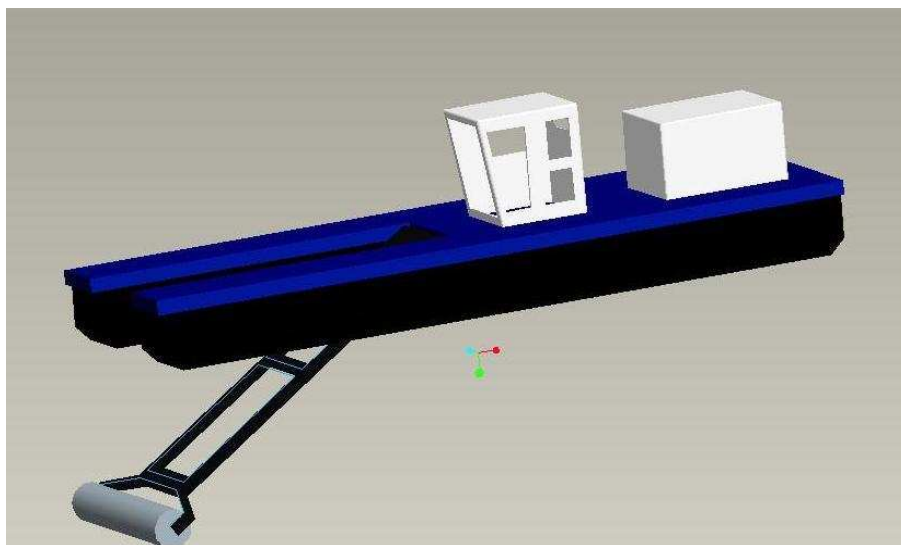


Figure 1: Dredge Image

Statement of Work

It was too large of an undertaking for one senior design team to build a full scale working dredge in one year. The finances, time and space were not available to build a full size dredge. Because of this limitation, the scope of the project was constrained to building scale models of probable final designs. This presented some difficulties such as finding the properly scaled components. However, scaled models allowed development and testing of the most feasible designs under simulated conditions. Upon VMI's approval, scaled models were the plan of action.

The use of hydraulic controls was desired by VMI's customers. Hydraulic controls have been the standard for many years in the dredging industry. However, the use of electric controls is growing and VMI looks to move in that direction. This new technology has been met with some customer resistance because of the new expertise required for working on the systems. Instituting an electrical control system would require experienced operators to become accustomed to a different type of control system and would also force operators to learn how to perform repairs on the new machinery. Most dredge operators perform their own repair and maintenance. This is especially important since VMI ships their products worldwide and paying travel expenses for a VMI technician would be prohibitive.

When instituting new technology, such as electric controls, it is important to make it as user friendly as possible to minimize the learning curve. VMI has already made the first step towards this goal because their newest machines do have electronics on the hydraulic pumps.

One important design consideration was the location of use. Current VMI dredges are designed for use in marinas, small lakes, rivers and lagoons. Each location presents unique difficulties. Lagoons present a special design problem because of the consistency and density of the sludge. This sludge is very different from sediment and other dredged materials. Also, cable systems in marinas are difficult to implement due to the fact that boats are located in the

water. In this case, cable systems are possible but may require underwater anchors. This variety of uses presented an important limitation for the design.

Another limitation brought to our attention by a working dredge's crew was the unavoidable need of the discharge pipe leading from the dredge to the deposit site. While it may be possible to eliminate the need for cable, this pipe will always be necessary for dredges of this scope. This pipe is a very important part of the system and typically requires its own trailer for transportation.

Propulsion driving force was perhaps the most important design constraint. Depending on the material on the bottom of the water body, it may be hard to support and propel tracks or star wheels. Any dredge design needs a sturdy propulsion system because of the stability required for the pump and cutter head.

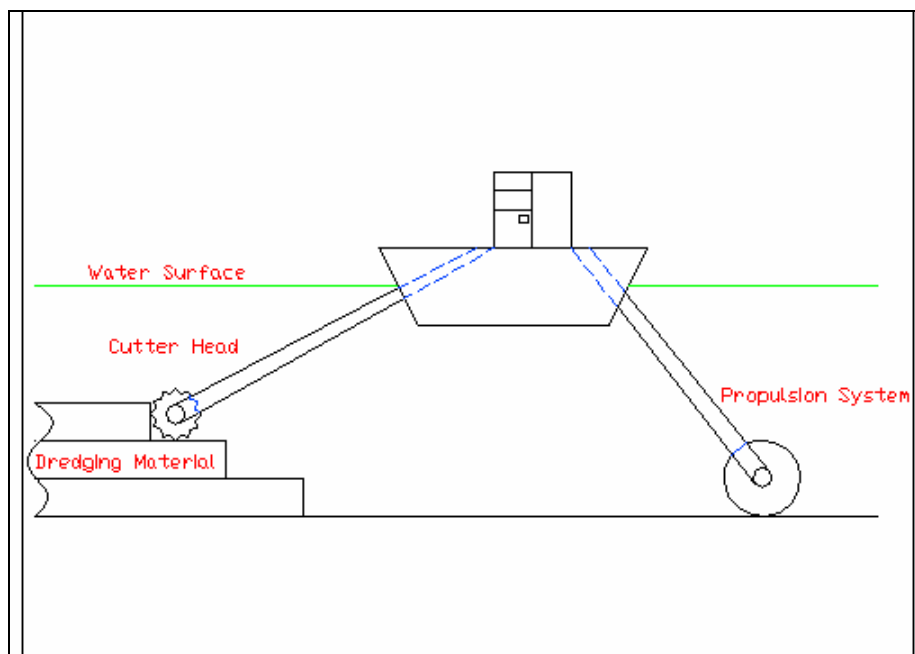


Figure 2: Conceptual Design of Dredge Propulsion

Placement of the propulsion device greatly determined the design of the overall system (fig. 2). Keeping with VMI's current design, the cutter head was located at the bow or front of the vessel. This design creates a cleared channel or path behind the cutter head. The designed propulsion unit was located on the sides of the dredging vessel outside the range of the cutter head.

There needed to be minimal design changes to the actual dredging equipment. Changing only the propulsion system would make it easier for VMI to implement our recommended design into their existing one. It would also be easier for them to fabricate without a number of major design changes. Moreover, the design must be realistic for their budget. If they choose to implement Allied Design's recommendations, the cost of implementing the design must be economically feasible for them to fabricate. In the final recommendation, it was important to remember VMI's manpower resources and shop size.

One main caveat dealt with a specific use of dredges. As mentioned above, many of VMI's dredges are used in lagoons. Lagoons of this sort typically have either rubber liners or concrete bottoms. With any sort of propulsion system that touches the bottom, there was concern of the liner tearing. The tearing of the liner should be avoided at all costs. This phenomenon forced the exclusion of lined lagoons from the proposed design.

Patent Search Information

There are many different designs for dredge propulsion. Patents have already been issued to several novel ideas. While this was somewhat unfortunate, this gave Allied Design a starting point. For abstracts and images of the listed patents, see Appendix A.

U.S. Patent # 5,782,660 (filed on July 21, 1998) incorporated the star wheel design. This patent had a large star wheel connected to the end of a boom. One of Allied Design's concerns regarding this design was its stability. It was not apparent that there were any stability considerations made in the design to allow the two drive wheels to move independently of each other. This posed a concern that inconsistencies of the pond floor may cause the dredger to tip.

Secondly, several patents have been issued that implement a track system. Patent # 4,713,896 (Dec. 22, 1987) used a track system that was raised and lowered by a scissor jack application. Patent # 6,755,701 (June 29, 2004) had a track system that was attached to a boom that raised and lowered like an arm. The most promising design was included in Patent # 5,970,634 (Oct. 26, 1999). This patent had two hydraulic cylinders attached to the track system that

kept the dredge level on the surface. This allowed the track system to follow the contour of the bottom more naturally thus reducing the risk of tipping. Each of these patents added desirable components to the final design.

Several patents VMI referred to Allied Design were patent numbers 4,676,052 (granted June 30, 1987) and 3,755,932 (granted September 4, 1973). The former implemented a paddlewheel propulsion system much like a paddlewheel river boat. This self propelled dredge incorporated a floating hull with a pair of independently controlled paddlewheels in the rear. In the second patent, number 3,755,932, the dredge was suspended by retractable legs. Large wheels were attached at the bottom of the legs for propulsion on top of the dredged material.

Engineering Specifications

Some specifications for VMI's current dredges can be found in Appendix B. This information was taken from VMI's website, www.vmi-dredges.com. The model fabricated by Allied Design was 1' x 3', approximately one-tenth scale and was operated at 30 rpm.

Initial Testing

Two major tests were performed to discern properties of several dredged materials. First, viscosity testing was executed to establish properties of dredged material in a liquid state or in a disturbed saturated state. Secondly, soil shear testing was performed to understand properties of dredged material under compaction. Several materials were tested including fly ash, river sand, lagoon sludge, lake sediment, marsh sediment, a Teller soil, and crystalline silica. The river sand was taken from the North Canadian River, the Teller soil is a soil native to Oklahoma, and the crystalline silica is a fine powder used in pool filters. A wide variety of materials were tested to obtain a range of data.

According to Stroshine, when a semisolid is subjected to a constant shearing force, it deforms continuously at a velocity that increases as the applied shearing force increases. Viscosity is used to quantify the resistance of the fluid to flow. According to Wikipedia.com, Newton's theory states that the "thicker" the

fluid, the greater its resistance to shear stress. This shear stress resistance is a resistance of the fluid's movement. This provides a resultant force equal and opposite to the direction of fluid motion. This resultant force can be harnessed for the propulsion on the auger and paddlewheel design. The viscosity testing was done with a Brookfield viscometer in the Food and Agricultural Products Center. The tests were completed with Dr. Dani Bellmer's help. Results are shown in Figure 3. It was concluded from the tests that as the speed of mixing increases, the material got increasingly easier to stir.

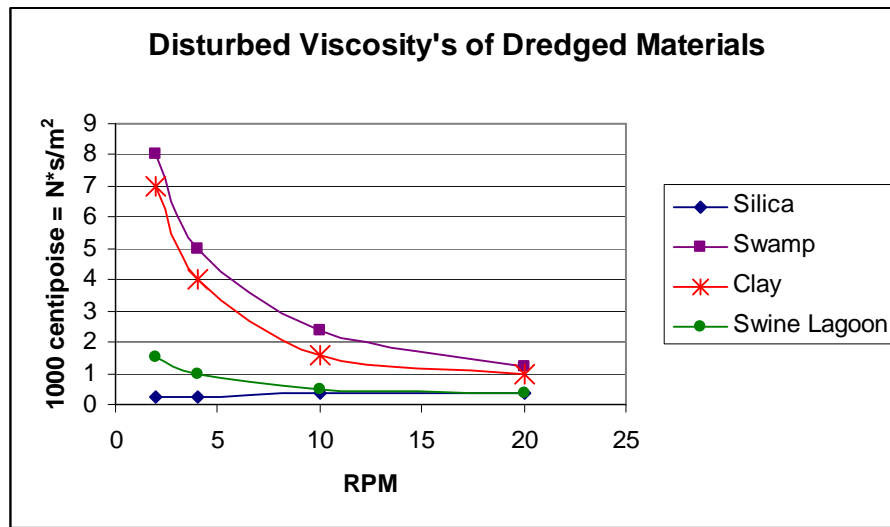


Figure 3: Viscosity Testing

The shear testing was performed in Dr. Glenn Brown's groundwater laboratory. Again, according to Wikipedia.com, the definition of shear stress is a stress state where the shape of a material tends to change without particular volume change. The term change refers to sliding forces and directional shear. In a laboratory setting, as was the case here, shear stress was achieved by torsion of a material. Direct shear of a material by a moment induces shear stress, along with tensile and compressive stress. Several sediment and sludge samples were tested under saturated conditions. Calculations were performed to determine stress and strain curves using the equations below.

$$Strain = \frac{\Delta L}{L}$$

$$Stress = \frac{P}{A}$$

The change in length was read from the testing equipment. The original length was the diameter of the core sample. In the stress equation, P represents the force applied. This was read from a dial on the machine and then converted using the machine’s calibration equations. The area was the cross sectional area of the sample. A normal force of 10 kg was used to simulate 10 ft of settlement plus 1 ft of water head. The graphical results can be seen in Figure 4. The results of Figure 4 indicated that our drive system must be designed for a maximum stress of approximately 0.35 N/cm². This figure provided a force per area that is required for the propulsion system to propel the cutter head through the wall of undisturbed material.

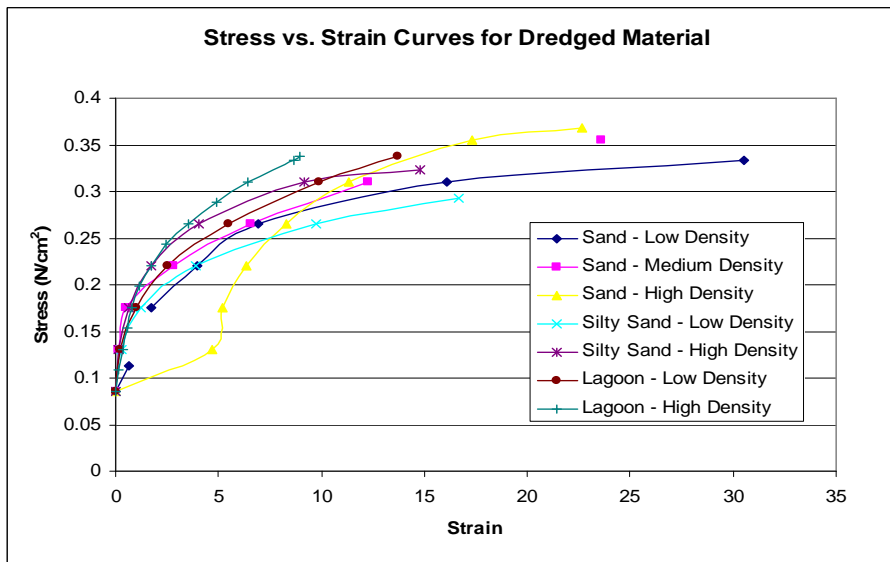


Figure 4: Stress Strain Curves

Definition of Customer Requirements

VMI left many of the design decisions to the group. This allowed great flexibility in Allied Design’s research and testing. However, the one major design requirement was that the system be cableless. This was, in fact the purpose of the entire project.

Another VMI request included the use of hydraulic controls. As mentioned above, hydraulic controls are currently the standard in the dredging industry.

While this may change in the future, hydraulic and not electric controls were implemented in the design recommendation. It was also important that existing dredges could be retrofitted to work with the cableless design. Lastly, Allied Design identified that the design should not be overly complex. This was so that the design would be relatively easy to fabricate and would be easily serviceable.

Design Concepts

Three major concepts were identified as possible solutions. They included a track system, a paddlewheel system and, at VMI's recommendation, an auger system.

The track system can be seen in Figure 5. Much like a tank, this option would have tracks to maneuver through the sediment. These tracks would connect to the dredge with a hydraulically controlled boom. This would enable the dredge to be on the water surface while the tracks move along the bottom of the water body. A problem arises if the bottom of the water body is not solid. In this scenario, the entire dredge would sink when the boom reached full extension. Therefore, the dredge must be sufficiently buoyant to support its weight as well as the weight of the tracks.

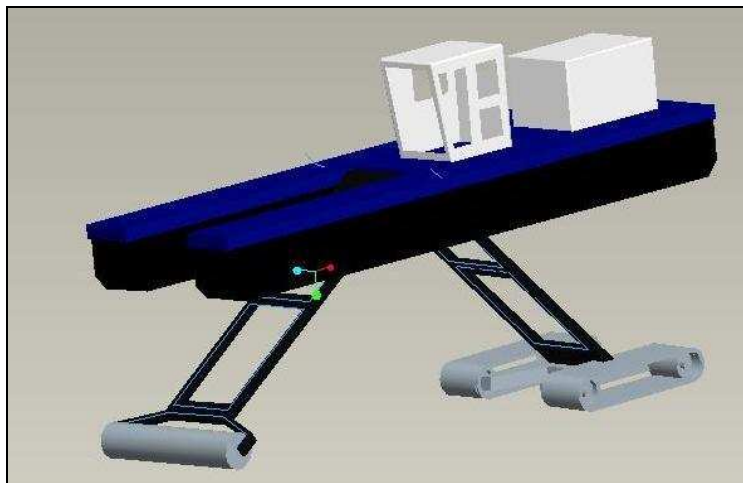


Figure 5: Track system

The paddlewheel design was similar to rice harvesters and can be seen in Figure 6. The potential design used large tires with an attached paddle wheel.

These wheels were attached to the dredge similarly to the track system with a hydraulic boom. The attached paddles would provide additional traction by pushing the sediment simulating a paddlewheel. These paddles provided additional propulsion.

This extra propulsion is proportional to the density of the sediment. As mentioned earlier in the testing section, the denser the fluid, the greater its resistance to shear stress. The resultant force could be harnessed for the propulsion on the paddlewheel design. This design has been used on rice farming equipment. Because of the saturated conditions of rice paddies, this extra traction and propulsion is necessary. The extra traction provided by the paddlewheel could provide sufficient driving force to operate a dredge. Like the track system, the sinking of the dredge may be an issue. With a paddlewheel design, the weight of the dredge would be spread over a smaller surface area than the track system which may cause the problem of sinking to be exacerbated. In this case, additional power or larger tires would be needed.

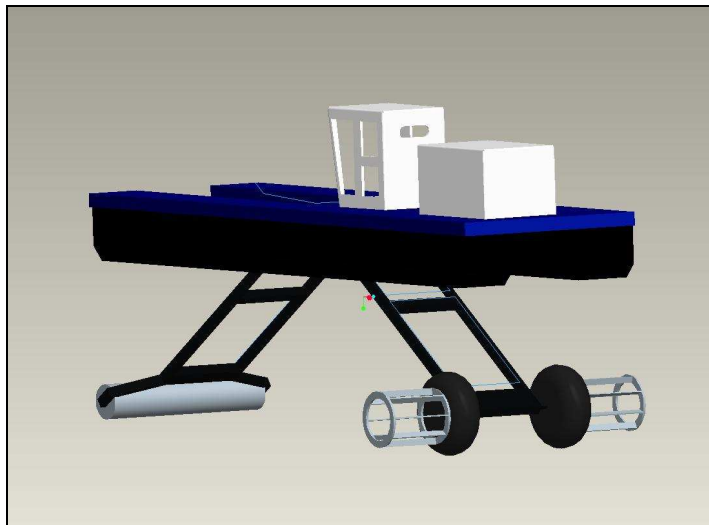


Figure 6: Paddlewheel system

The auger system can be seen in Figure 7 and would also use the sediment at the bottom of the body. The screw augers would be lowered to the bottom of the body and rotate through the sediment. This rotation would provide the propulsion for the dredge. This system would provide a great amount of

forward force because of the high torque capabilities associated with augers. Top speed for this design would be relatively slow. However, stability may be an issue with this system. If the bottom of the water body were sloped perpendicular to the direction of travel, the augers may tend to slide since the traction of the auger flighting is effective only in the direction of travel. However, a longer flighting pitch may provide a greater resistance to this perpendicular movement.

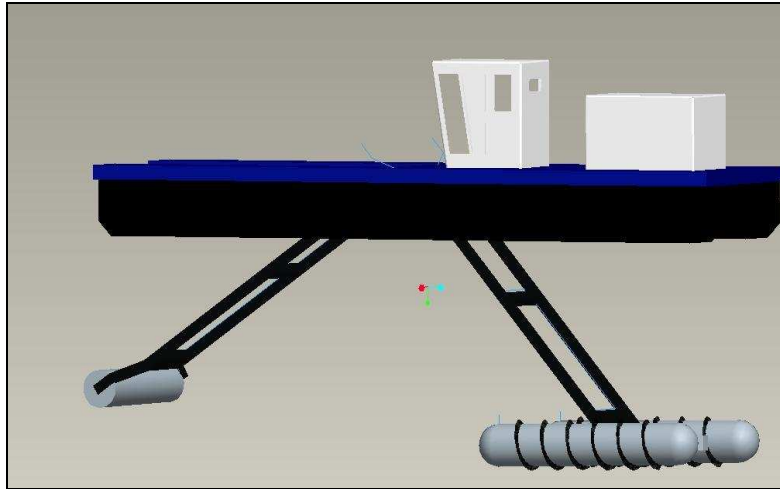


Figure 7: Auger system

Feasibility Evaluation

Several criteria were considered to determine feasibility. These included cost, maintenance, maneuverability, and ease of fabrication.

The cost of the various solutions will be relatively small compared to the cost of a dredge. All designs will require a hydraulic boom to raise and lower the dredge. This boom will require a motor and controls. Individual designs each have their own associated costs. For example, the track system will involve purchasing rubber tracks. The paddlewheel design will require large agricultural tires, metal for vanes, and a drum for floatation. For the auger design, large screw augers will be needed.

All solutions were considered from a maintenance viewpoint. Like existing dredges, this was a factor that could not be eliminated with any amount of design work. However, Allied Design strove to minimize the maintenance of any recommended design. The hydraulic boom on all the possible designs will have

a small level of maintenance to keep it running properly. The track system will require repair on or replacement for the grousers. The paddlewheel system will occasionally require new tires as well as mending any bent or broken vanes. The auger system will also require mending of broken or bent flighting. Of the three options, the track system will likely have the highest maintenance costs due to the number of moving parts. Of course, it is important to keep the dredge clean while not operating in order to minimize undue wear and corrosion.

As discussed above in the Client Requirement section, serviceability was an important consideration. This, along with operation and controllability, made up a third important design criteria. Regarding controllability, it was ideal to have each of the propulsion mechanisms operating independently. This design criteria was necessary for directional control of the dredge. The boom design that is standard on each solution will occasionally need to be serviced either by the contractor or an experienced mechanic. The paddlewheel system will be the most easily serviced because that design is the least complex.

The various solutions will each require significant fabrication. Obviously, all designs will require fabrication of a hydraulic boom. The track design will require fabrication similar to that of a Caterpillar track system or a tank. Tracks and various other metal parts will be necessary for this. For the paddle design, vanes will need to be made out of steel. Regarding the auger design, large screw conveyors will need to be purchased or fabricated in house.

Determination of Designs

As mentioned earlier in this report, three designs were chosen for testing. The three designs included a track system, a paddlewheel design and an auger design. A model of each was fabricated and tested under simulated conditions. Upon testing, Allied Design selected one final design for large scale fabrication by VMI. The final recommendation was made at the end of the spring semester.

Implementation of Design

After the designs were finalized, parts were ordered from various dealers. Most of the specialty parts for the paddlewheel design were purchased from the

radio control hobby store in Stillwater, Stillwater Hobby. The augers and gears were ordered for the team by VMI through Allied Bearings. Miscellaneous parts were ordered from the Reid Tool Supply Company or purchased from Lowe's Home Improvement store. The purchase of the tracks became a problem as the model track supplier was unreachable. To remedy this, it was decided to fabricate tracks using a specialized roller chain.

Though parts for all the designs were fabricated simultaneously, the paddlewheel design was completed first. Sixteen gauge steel was used to construct paddles which were attached to the wheels (fig. 8). The long frame was designed to offset the moment created by the turning rear wheels. Smaller tires were used at the front of the design and the motor mounted towards the rear of the body just forward of the axle. (fig. 9).

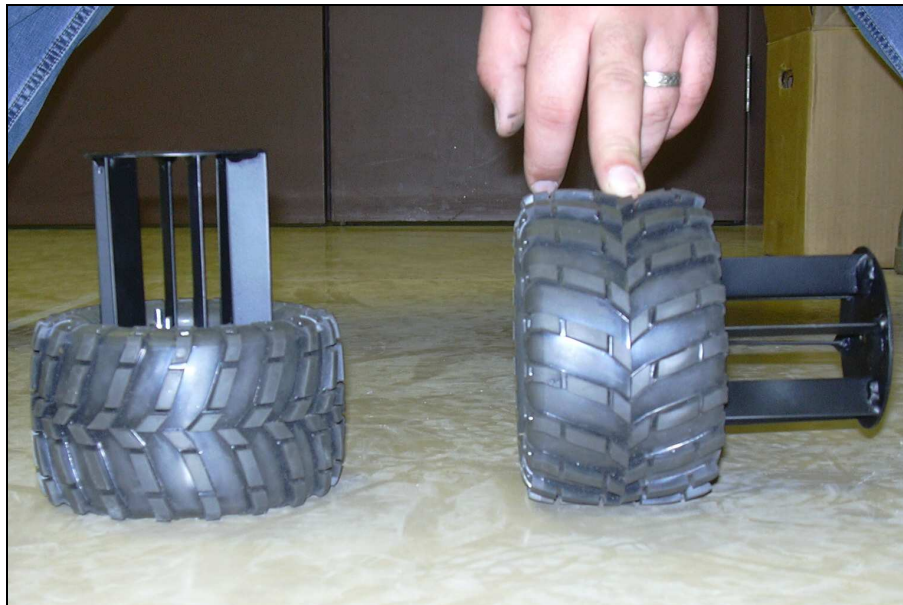


Figure 8: Paddlewheels

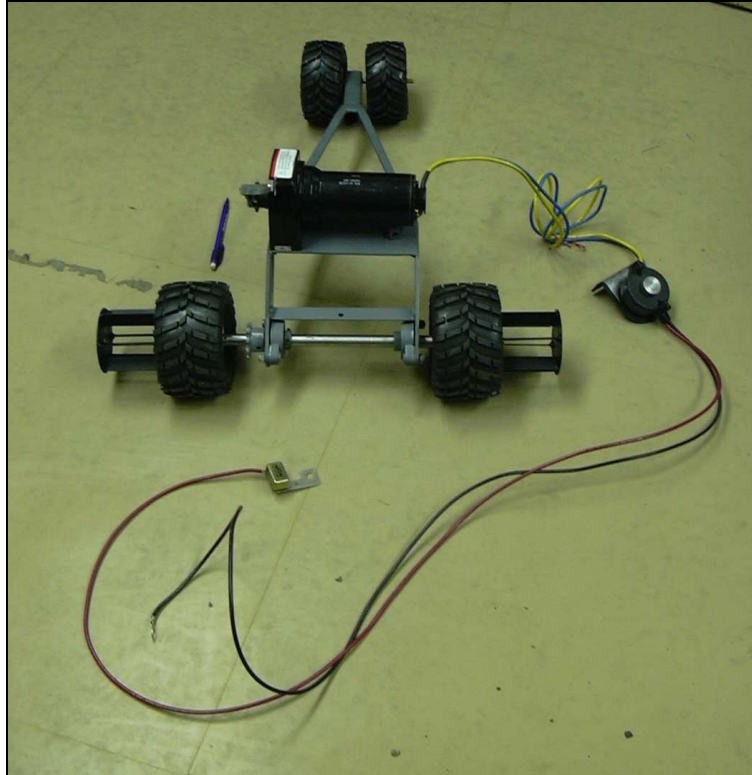


Figure 9: Final Paddlewheel Design

Secondly, the tracks were fabricated. As mentioned above, it was not possible to order a complete track system. The final track design included ordering sixty links of roller chain. Half inch angle iron was welded to this for grousers (fig. 10). A track body was constructed with the motor mounting near the center of the body to maintain an even weight distribution (fig. 11).

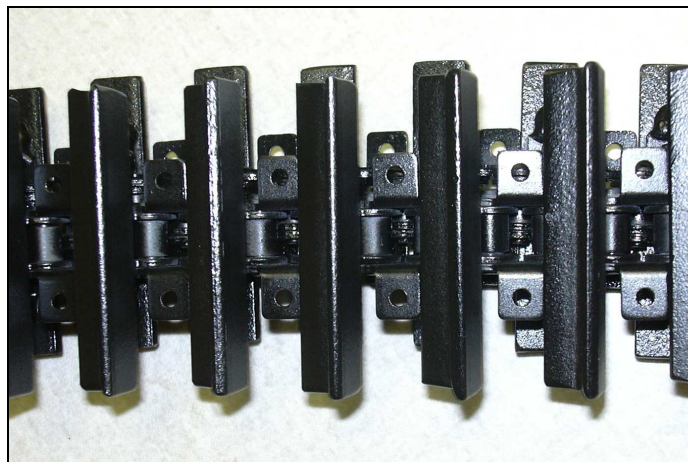


Figure 10: Track Grousers

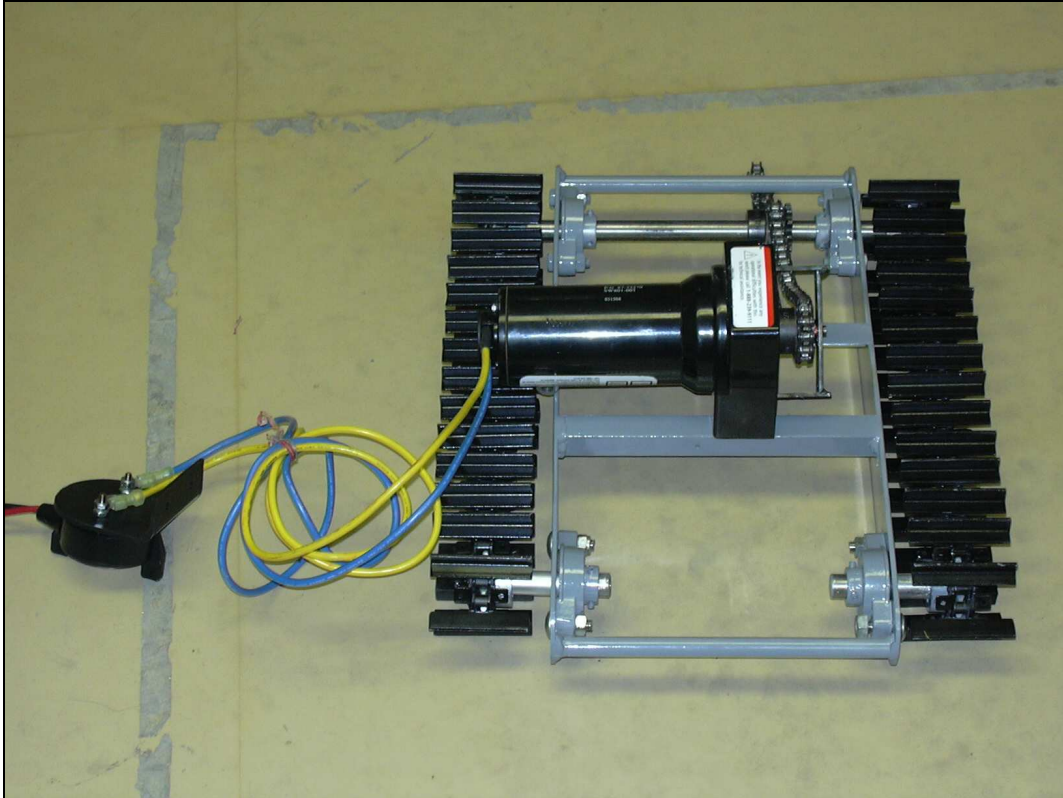


Figure 11: Final Track Design

Lastly, the auger design was made. Three varying sizes of auger flighting were tested in order to study the effects of their different characteristics. The flighting specifications are shown in table 1 and images of the final augers are shown in figures 12 and 13. Augers #1 and #2 were custom made while #3 was a standard size and pitch.

Table 1: Auger Characteristics

	Outside Diameter (in.)	Shaft Diameter (in.)	Pitch (in.)
Auger 1	4 ½	2 ½	4 ½
Auger 2	3 ½	2 ½	3 ½
Auger 3	4	1 ¼	4



Figure 12: Fabricated Augers Exhibiting Various Flighting; auger #1 top, auger #2 middle, auger #3 bottom



Figure 13: End View of Augers

The auger flighting was welded to thin-walled pipe to make complete augers. The body of the auger design was then fabricated (fig. 14). In order to keep the chain drive out of the way of the spinning augers, gears were used. The motor was mounted near the front of the system.

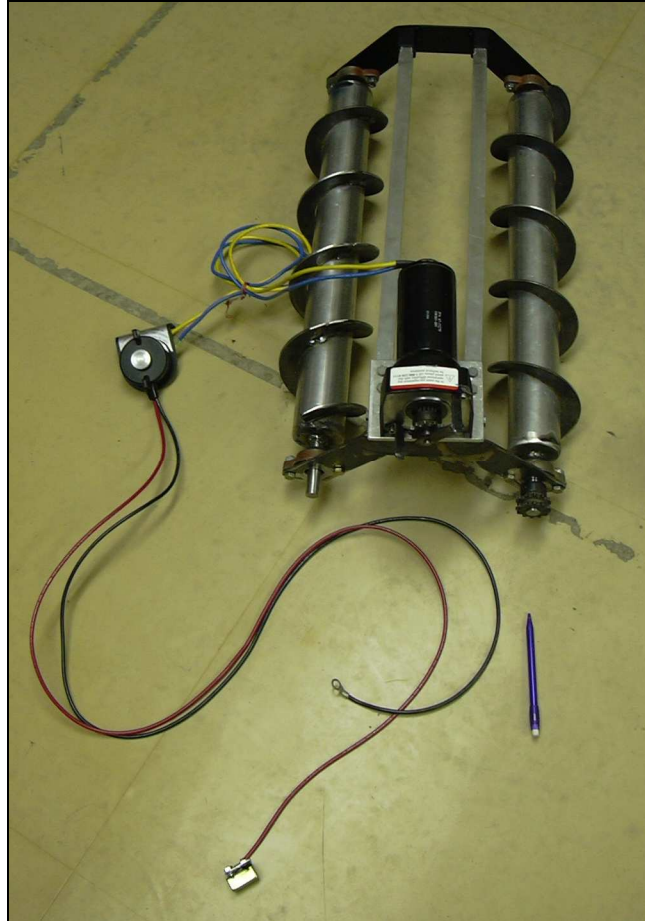


Figure 14: Final Auger Design

Early in the building phase, it was decided to have all models share the same power system. The models were built such that the motor could be easily switched between the designs. This eliminated the need to buy three power systems which was significant as motors were one of the more expensive items in the budget.

Initially all three models were to be powered using a pneumatic system. Necessary parts such as valves and pressure gages were purchased and assembled. However, before the model fabrication was fully complete, it was discovered that the pneumatic system would not be powerful enough to drive the models. The augers, especially when placed in sand, were particularly under powered. To remedy the problem, it was suggested that the team utilize the motor from a 12 volt electric winch system. A winch and other necessary parts were ordered from Surplus Center and implemented into the design successfully.

Testing of Design

All designs were tested with a load cell to measure their draft in submerged conditions. The testing procedures were loosely based upon methodology developed by Cash Maitlen at VMI (C. Maitlen, personal communication, 2004). The testing was done in the Biosystems and Agricultural Engineering Laboratory in the Environmental Prep. Laboratory. This facility provided access to water and a grated floor.

A four foot diameter tank was positioned over the grate and was filled with a uniform 6 in. layer of sand from the Cimarron River (fig. 15). A hole was drilled in the tank wall 9 in. from the bottom to allow attachment of the model to the load cell. A rectangular box was constructed to fix the load cell to the tank wall. A pin passed through the hole and connected the load cell to a chain attached to the model (fig. 16). A rubber grommet sealed the gap between the pin and the hole in the tank wall. Multi-purpose grease was used to lubricate the pin and provide additional sealing. The tank was filled with water to provide submerged testing conditions. The winch motor came with a controller which was used in testing. A 12 volt DC motor was used to power the system.



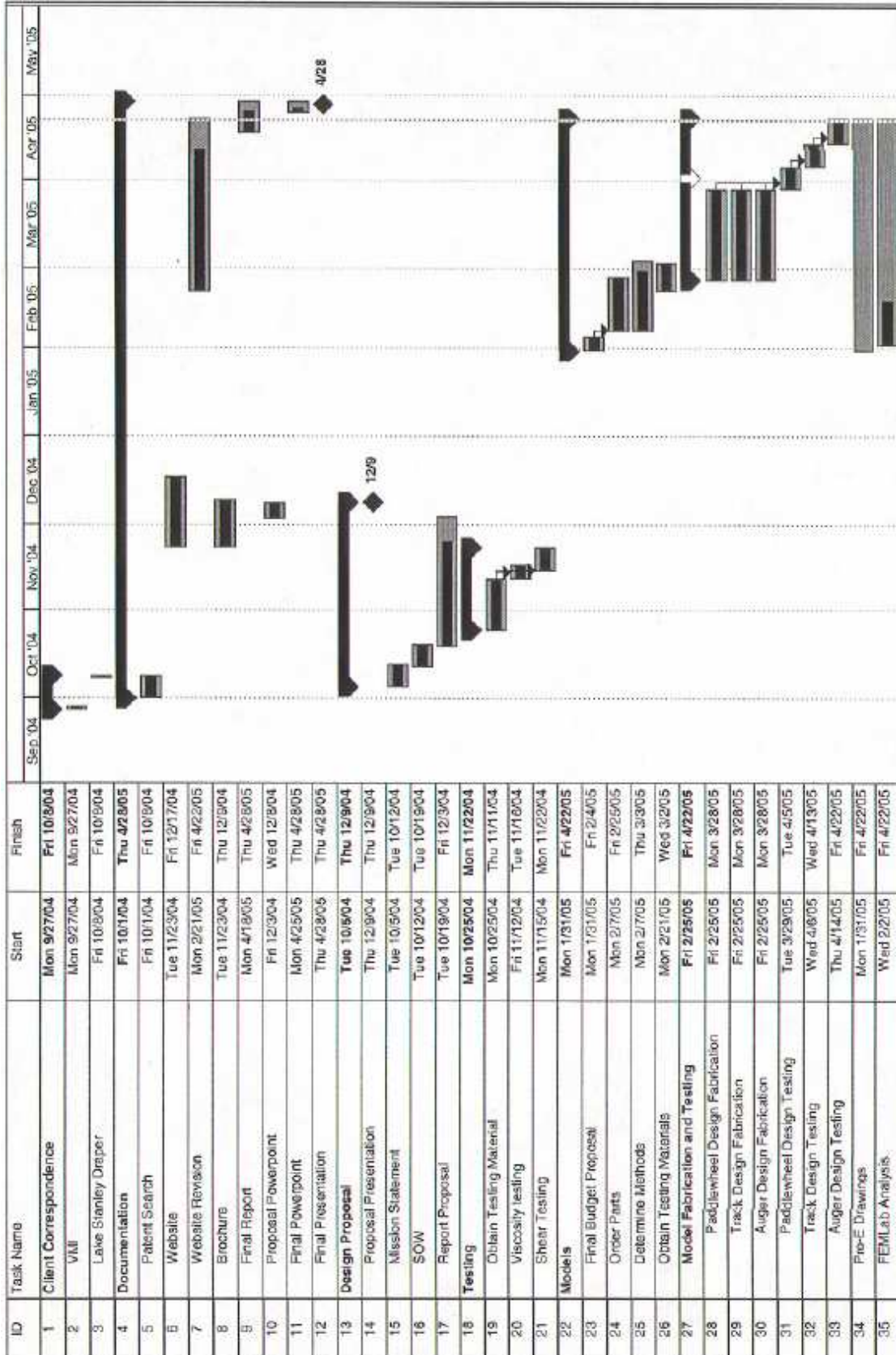
Figure 15: Testing Set-up displaying water and sand filled tank, load cell attached to tank, digital readout on chair, controller, and 12V DC battery.

The 50 lb. load cell was connected to a Chatillon DFGS digital force gauge. The digital force gauge was linked to a laptop computer via serial cable. The software allowed the data to be logged at the rate of one reading every 1.5 seconds. The load cell was calibrated before use. Between each test, the load cell was reset and the soil was raked for consistent testing. During testing, the drive systems were operated at full power for several seconds to simulate the maximum draft of the system. The transmission output at this point was approximately 30 rpm and the planetary gear reduction provided a 1/135 reduction. Each design was tested between four and six times.



Figure 16: Load Cell Apparatus

Project Schedule



Budget

The proposed budget is shown in table 2 below. This is the budget that was submitted to VMI at the beginning of the spring semester. Table 3 shows the actual budget spent on the project.

Item	Quantity	Price		Notes	Total
Tires	2	\$30.00	per 2	Local	\$30.00
Tires	2	\$25.00	per 2	Local	\$25.00
Tires	2	\$20.00	per 2	Local	\$20.00
Wheels	6	\$15.00	per 2	Local	\$45.00
Tracks	2	\$6.99	per 2	www.nelnick.com	\$6.99
Tracks	2	\$24.99	per 2	www.nelnick.com	\$24.99
Tracks	2	\$36.99	per 2	www.nelnick.com	\$36.99
Augers	6	\$134.00	per 1	Allied Bearings	\$804.00
Auger Freight	1	\$25.00	total	Allied Bearings	\$25.00
Tank	1	\$100.00	ea.	Atwoods	\$100.00
Motor	1	\$400.00	per 1	Gast MFG	\$400.00
Gears	12	\$10.00	ea.		\$120.00
Axles	20	\$1.00	per1	Local	\$20.00
Bearings	12	\$6.50	ea	Local	\$78.00
Races	10	\$6.00	ea	Local	\$60.00
Bolts + misc matl's		\$20.00	total	Local	\$20.00
Male connector	8	\$1.74	ea.	Local	\$13.92
Needle valve	1	\$16.74	ea.	Local	\$16.74
Flow Valve	2	\$41.87	ea.	Local	\$83.74
Pressure gauge	1	\$6.89	ea.	Local	\$6.89
Brass tee	1	\$23.79	ea.	Local	\$23.79
Total					\$1,961.05

Table 2: Proposed Budget

Item	Quantity	Price		Notes	Total
Tires	2	\$15.00	Per 2	Stillwater Hobby	\$15.00
Tires	2	\$23.00	Per 2	Stillwater Hobby	\$23.00
Wheels	2	\$12.00	Per 2	Stillwater Hobby	\$12.00
Wheels	2	\$5.50	Per 2	Stillwater Hobby	\$5.50
Tracks	60	\$3.21	per link	roller chain	\$192.60
Augers and Gears				entire order made by VMI	\$815.90
Pipe		\$20.63			\$20.63
Tank	1	\$100.00	ea.	Atwoods	\$100.00
Motor	1	\$173.00	ea.		\$173.00
Sprocket	1	\$10.00	ea.		\$10.00
Chain	1	\$12.00	ea.		\$12.00
Axles	20	\$1.00	ea.		\$20.00
Miscellaneous Materials		\$100.00			\$100.00
Research and Development					
Bearings	8	\$2.50	ea.	Stillwater Hobby	\$20.00
Races		\$12.50		Stillwater Hobby	\$12.50
Male connector	8	\$1.74	ea.		\$13.92
Needle valve	1	\$16.74	ea.		\$16.74
Flow Valve	2	\$41.87	ea.		\$83.74
Pressure gauge	1	\$6.89	ea.		\$6.89
				Total	\$1,653.42

Table 3: Actual Budget

Table 3 reflects the actual cost without shipping charges. Tax was not included because most parts were charged to a tax exempt university account. As noted in the table, VMI directly paid for a large part of the budget by ordering the augers themselves. They provided \$1,000 for the rest of the supplies. The

research and development section of the budget was to account for purchased items that were eventually excluded from the final designs.

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Appendix A: Patent Search Information



US005782660A

United States Patent [19]
Brickell et al.

[11] **Patent Number:** **5,782,660**
 [45] **Date of Patent:** **Jul. 21, 1998**

[54] **WATERCRAFT PROPULSION SYSTEM**

[75] **Inventors:** **Joseph Brickell**, Leawood, Kans.;
Garland Martin, Jonesboro, Ark.;
Daniel McDougal, Kansas City, Mo.

[73] **Assignee:** **Innovative Material Systems, Inc.**,
 Olathe, Kans.

[21] **Appl. No.:** **814,348**

[22] **Filed:** **Mar. 11, 1997**

[51] **Int. Cl.**⁶ **B63H 19/00**

[52] **U.S. Cl.** **440/36; 440/91**

[58] **Field of Search** **56/8. 9; 440/3. 440/4. 5. 36. 90. 91. 92**

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- 726,213 4/1903 Beer .
- 904,285 11/1908 Thompson 440/91
- 1,206,247 11/1916 Ream 440/36
- 1,716,607 6/1929 Wardell .

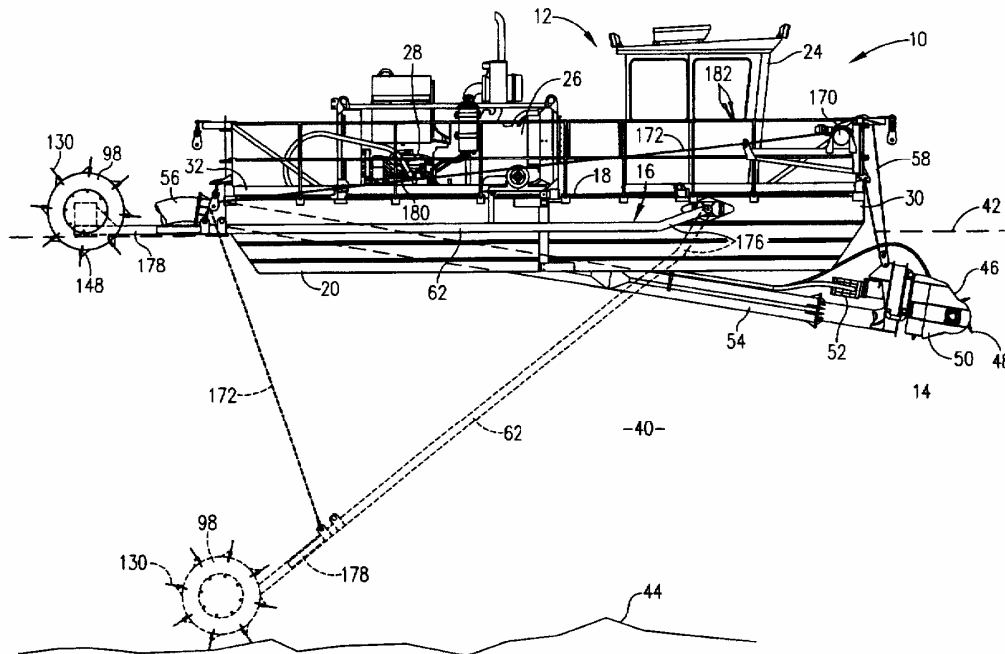
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Primary Examiner—Stephen Avila
Attorney, Agent, or Firm—Hovey, Williams, Timmons & Collins

[57] **ABSTRACT**

A watercraft propulsion system is provided for maneuvering and positioning a dredge or weed harvesting craft in shallow waterways and includes a pair of booms positioned adjacent the port and starboard sides of the craft. Submersible and reversible motors are provided at the remote end of each pivotally mounted boom for independently driving wheels provided with a plurality of circumferentially spaced blades. The wheels include an enclosed buoyancy chamber to offset the weight of the wheels and the booms, and the blades are removable and may be provided in different configurations to accommodate different operating conditions. A pumping unit including a cutterhead is provided whereby the watercraft can perform dredging or aquatic weed harvesting operations.

11 Claims, 3 Drawing Sheets





US006755701B2

(12) **United States Patent**
Dornier, II et al.

(10) **Patent No.:** US 6,755,701 B2
(45) **Date of Patent:** Jun. 29, 2004

(54) **AMPHIBIOUS VEHICLE WITH SUBMERSIBLE CAPACITY**
(75) Inventors: **Jules A. Dornier, II**, Thibodaux, LA (US); **John M. Wilson, Sr.**, Harvey, LA (US); **Dean R. Wilson, Marrero**, LA (US)
(73) Assignee: **Wilco Marsh Buggies and Draglines, Inc.**, Harvey, LA (US)
(* Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 21 days.
(21) Appl. No.: **10/151,135**
(22) Filed: **May 20, 2002**
(65) **Prior Publication Data**
US 2003/0216092 A1 Nov. 20, 2003
(51) **Int. Cl.** **B63H 19/00**
(52) **U.S. Cl.** **440/36; 37/307**
(58) **Field of Search** **40/36; 114/258; 114/313, 322; 37/307, 313, 320, 332, 345; 440/36**

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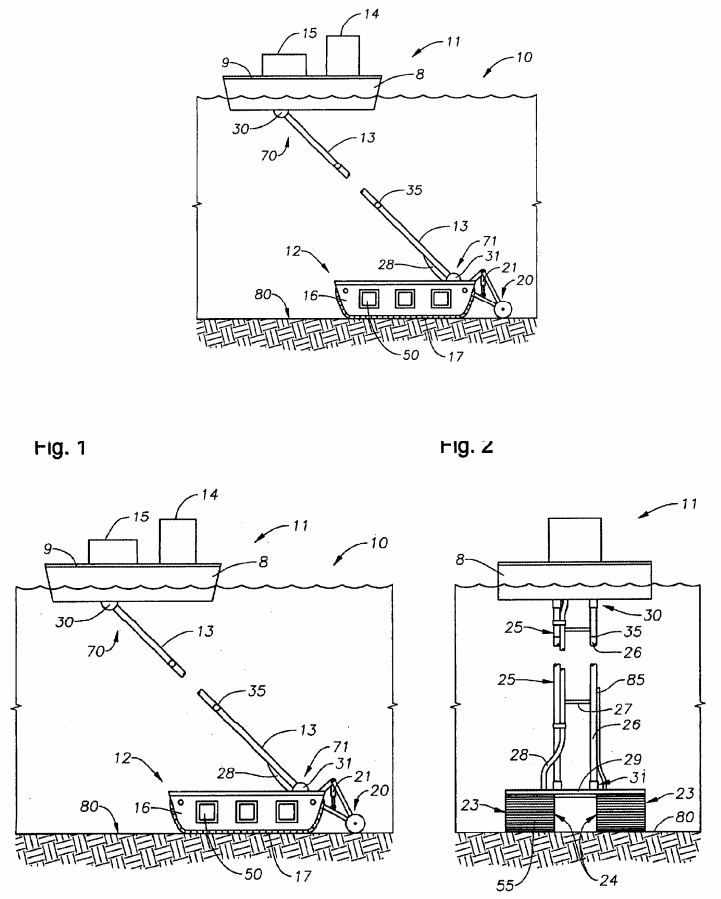
Primary Examiner—Jesus D. Sotelo
(74) Attorney, Agent, or Firm—Conley Rose, P.C.

(57) **ABSTRACT**

An amphibious vehicle with submersible capacity includes a first portion and a second portion, coupled by an extension, and a valve assembly. The first portion is capable of floating on water while the second portion is contemporaneously submerged beneath the surface and performing a variety of operations on the water's bottom. The valve assembly allows the vehicle to move between an amphibious mode and a submerged mode.

26 Claims, 5 Drawing Sheets

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U.S. Patent Jun. 29, 2004 Sheet 1 of 5 US 6,755,701 B2

United States Patent [19]

Jennens

 [11] **Patent Number:** **4,713,896**

 [45] **Date of Patent:** **Dec. 22, 1987**

 [54] **INSHORE SUBMERSIBLE AMPHIBIOUS MACHINES**

 [76] **Inventor:** Eric G. Jennens, 1978 McDougall Street, Kelowna, British Columbia, Canada, V1Y 1A3

 [21] **Appl. No.:** 773,181

 [22] **Filed:** Sep. 6, 1985

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 631,764, Jul. 17, 1984, abandoned, and a continuation-in-part of Ser. No. 478,882, Mar. 23, 1983, abandoned, and a continuation-in-part of Ser. No. 358,602, Mar. 15, 1982, abandoned, and a continuation-in-part of Ser. No. 249,602, Apr. 10, 1981, abandoned.

 [51] **Int. Cl.⁴** B63G 8/00

 [52] **U.S. Cl.** 37/54; 56/9; 91/51; 114/333; 114/337; 114/312; 114/270

 [58] **Field of Search** 37/54, 56, 58; 114/334, 114/335, 270, 312, 274, 336, 337, 333; 244/31; 91/51; 400/179; 440/113; 56/8, 9

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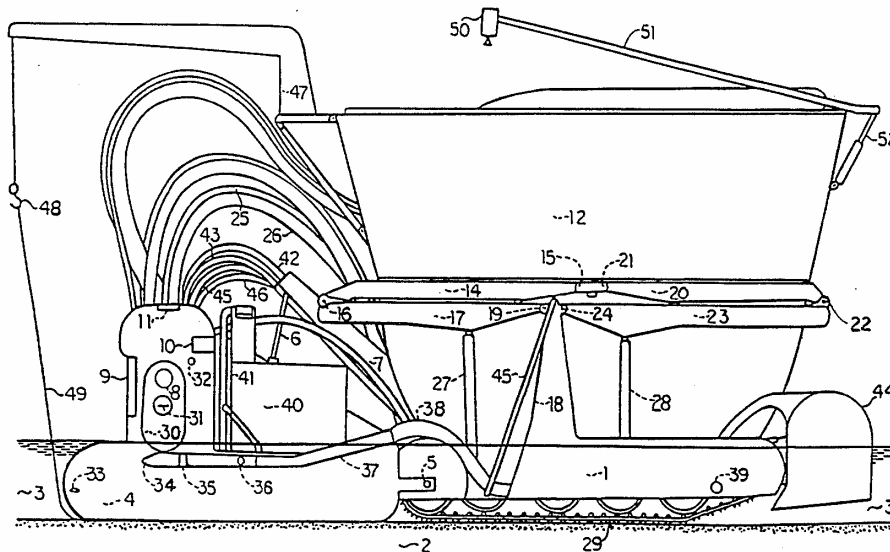
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Primary Examiner—Clifford D. Crowder

 [57] **ABSTRACT**

A submersible unit comprises a portable, open or closed bottomed pneumatic chamber mounted on flexible drive tracks controlled by personnel from the chamber for operation along the bottom of a body of water, on the surface, at intermediate levels, in the air and on land. A safety chamber, connected to the submersible unit by an extendable linkage, can limit the depth of submergence of the submersible unit, stores cargo and carries power. Flooded compartments in the submersible unit and the safety chamber are supplied with compressed air to control the supported load and depth of submergence. Various accessories carried by the underwater unit enable the performance of a number of different on and under the water and land based tasks. A special pneumatic circuit enables equipment and propulsion to be controlled by touch control panels. A majority of operations are contained within the machine to minimize contamination of surrounding areas.

57 Claims, 31 Drawing Figures




United States Patent [19]
Dann et al.

[11] **Patent Number:** 5,970,634
 [45] **Date of Patent:** Oct. 26, 1999

- [54] **SEMI-SUBMERSIBLE MACHINE FOR REMEDIATION OF CONSTRUCTED DRAINAGE AREAS**
- [76] Inventors: **James A. Dann, Ruby G. Dann**, both of 2492 Timberline Dr., Winter Park, Fla. 32792

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- [21] Appl. No.: **09/024,652**
- [22] Filed: **Feb. 17, 1998**

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- Related U.S. Application Data**
- [60] Provisional application No. 60/064,121, Nov. 3, 1997.
 - [51] **Int. Cl.⁶** **A01B 13/00**
 - [52] **U.S. Cl.** **37/301; 37/410; 37/406; 37/340; 56/10.7**
 - [58] **Field of Search** **37/301, 304, 307, 37/340, 341, 342, 405, 406, 410, 403; 56/16.9, 13.7, 10.7**

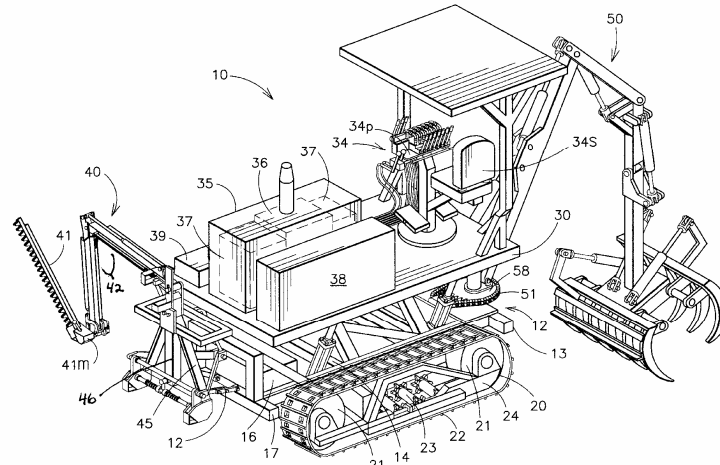
Primary Examiner—Victor Batson
Attorney, Agent, or Firm—Elsie C. Turner

[57] **ABSTRACT**

A semi-submersible machine moves on rotatable endless belt tracks over diverse surfaces and has two tools on articulated booms for remediation of roadside drainage ditches, retention ponds and other shallow water bodies. One tool is a cutter bar for cutting vegetation at a plurality of angles and positions above or under water, and the other tool is a rotatable pair of opposing clawlike jaws for raking or scouring soil above or under water to restore percolation performance, and to remove loosened vegetative matter without removing soil and water. The vehicle is submersible to a depth of forty inches, and can traverse a slope of thirty degrees while its tilting control platform remains above water and level, thereby maintaining stability of the vehicle.

- [56] **References Cited**
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9 Claims, 8 Drawing Sheets



U.S. Patent Oct. 26, 1999 Sheet 2 of 8 5,970,634

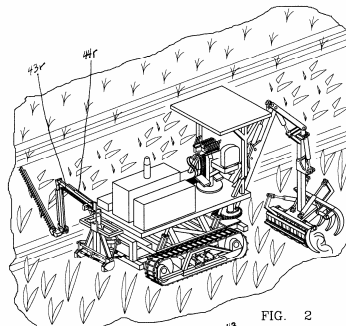


FIG. 2

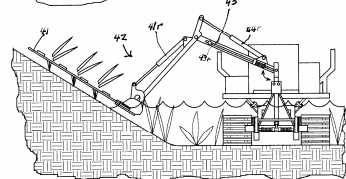


FIG. 3

United States Patent [19]

Cargile, Jr.

[11] **3,755,932**
 [45] **Sept. 4, 1973**

[54] **JACK-UP DREDGE**

[76] Inventor: **Neil H. Cargile, Jr.**, c/o American Marine & Machinery Co., P.O. Box 1067, Nashville, Tenn. 37202

[22] Filed: **June 23, 1971**

[21] Appl. No.: **155,934**

[52] U.S. Cl. **37/67, 37/56, 61/46.5**
 [51] Int. Cl. **E02f 3/88**
 [58] Field of Search **37/56, 73, 67, 61/46.5**

[56] **References Cited**

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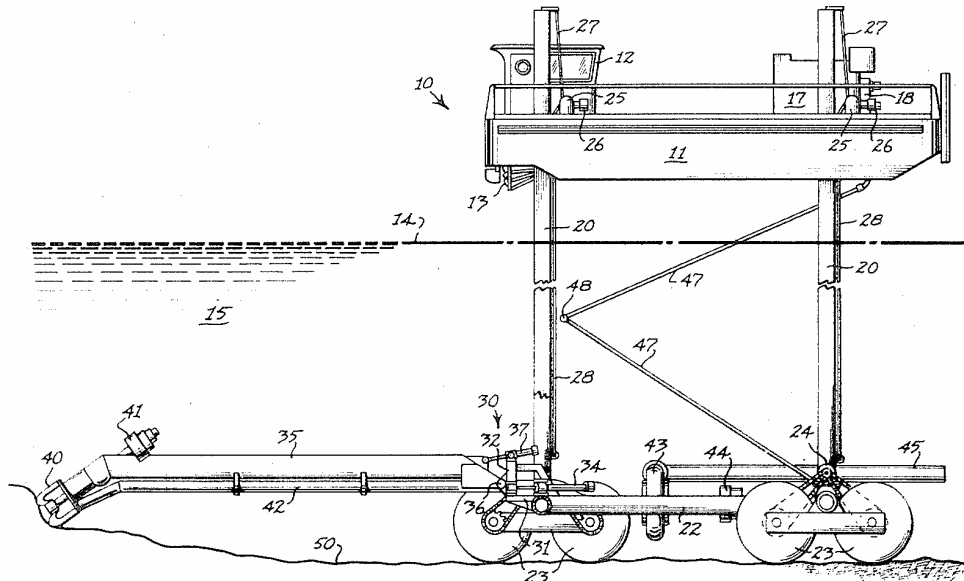
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Primary Examiner—Robert E. Pulfrey
Assistant Examiner—Clifford D. Crowder
Attorney—Harrington A. Lackey

[57] **ABSTRACT**

A dredge having a hull connected to a mobile platform by vertically extendable and retractable legs so that the mobile platform can be lowered to engage and move over the bottom of a body of water, and further so that the hull can be jacked-up above the surface of the water after the platform has engaged the bottom. Mounted upon the platform for operative engagement with the bottom is the dredging tool, such as a rotary cutter head, which may be mounted on the outer extremity of a ladder swingably mounted at its inner end to the platform. The hull is adapted to be propelled on the surface of the water when the platform is retracted, and is also adapted to support personnel and the controls for the operation of the dredge. A separate propulsion means is provided for moving the platform along the bottom.

1 Claim, 2 Drawing Figures



Appendix B: VMI Dredge Specifications

Mini-Dredge Specifications				
	MD-415	MD-615	MD-620	MD-815
General				
Length	33' 6" O.A.	37' 6" O.A.	43' 0" O.A.	38' 6" O.A.
Height	8' 0" with cab	8' 6"		8' 10"
Width	8'6" transport	9' 0"		9'11"
	9' 0" working			
Weight	20,000 lbs.	23,000 lbs.	25,000 lbs.	29,000 lbs.
Cutter Assembly	21"	21"		21"
Size	21" Dia. x 8' 6" with full width flow through suction	21" Dia. x 9' with full width flow through suction		21" Dia. x 9' 11" with full width flow through suction
Speed	Variable 0-120 RPM forward and reverse	Variable 0-250 RPM forward and reverse		Variable 0-100 RPM forward and reverse
Torque	30,000 in.-lb.	30,000 in.-lb.		30,000 in.-lb.
Working Capacity				
Cut	21" Deep x 8' 6" Wide	21" Deep x 9' Wide		21" Deep x 9' 11 " Wide
Operating Depth	Variable to 15' max	Variable to 15' max	Variable to 20' max	Variable to 15' max
Engine				
Type	Cummins	Cummins		Cummins
Power	174 BHP @ 2500 RPM	260 BHP @ 2200RPM		340 BHP @ 2200 RPM
Pump				
Type	Hi-Chrome, centrifugal, recessed impeller			
Impeller	18"	22"		25"
Suction	4"	6"		8"
Discharge	4"	6"		8"
Capacity	Variable to 1000 GPM @ 130' Head (water @ 68 F) @ 1400 RPM	Variable to 2000 GPM @ 140' Head (water @ 68 F) @ 1140 RPM		Variable to 3000 GPM @ 125' Head (water @ 68 F) @ 960 RPM

Dredge Propulsion System

Senior Design - Spring 2005

Laura Christianson

Shane Ice

J. D. Karber



Allied Design



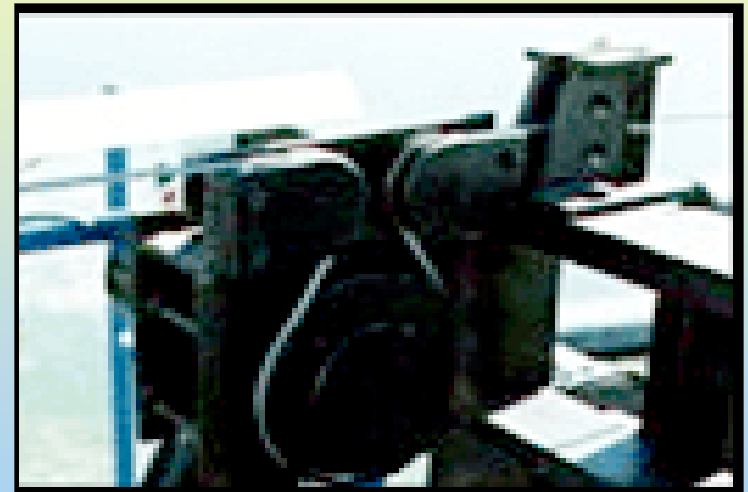
Sponsor



- Sponsored by VMI of Cushing, Oklahoma
- Represented by Cash Maitlen
- Offers over 30 years of dredge manufacturing experience
- Manufactures, rents, and sells dredging equipment and accessories



- Current design consists of a cable and winch system
- Requires cable anchors on the banks or in the water
- Limits mobility and the advancement of the anchors is time consuming



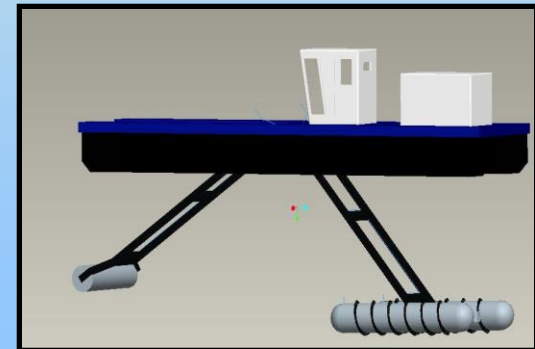
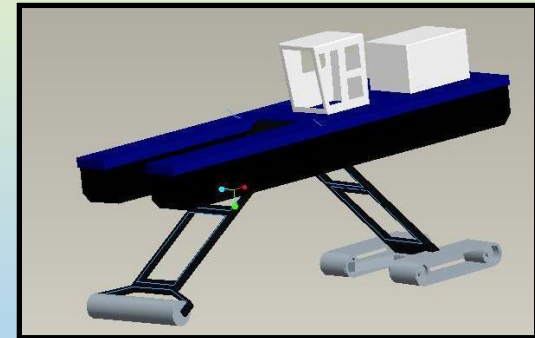
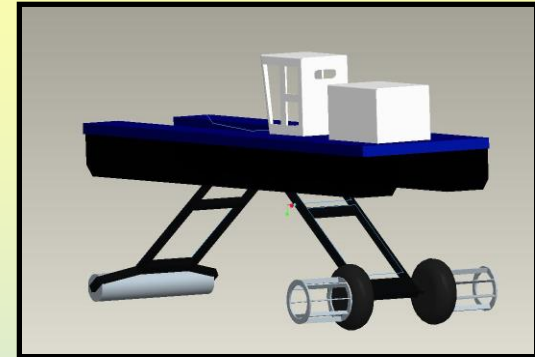
Problem Statement

Design of a cableless dredge propulsion system for light duty dredges for use in marinas, lagoons, and small lakes.



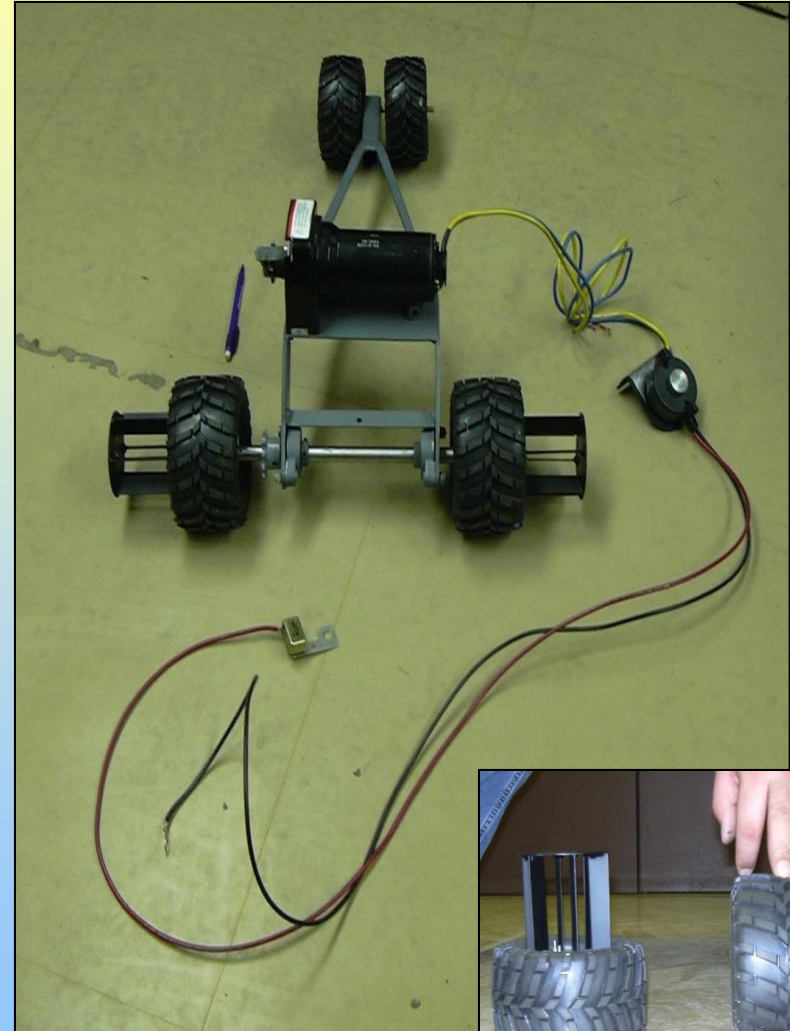
Design Plan

- Fabricate 1/10th scale of each design concept
 - Paddlewheel System
 - Track System
 - Auger System
- Placement Configuration



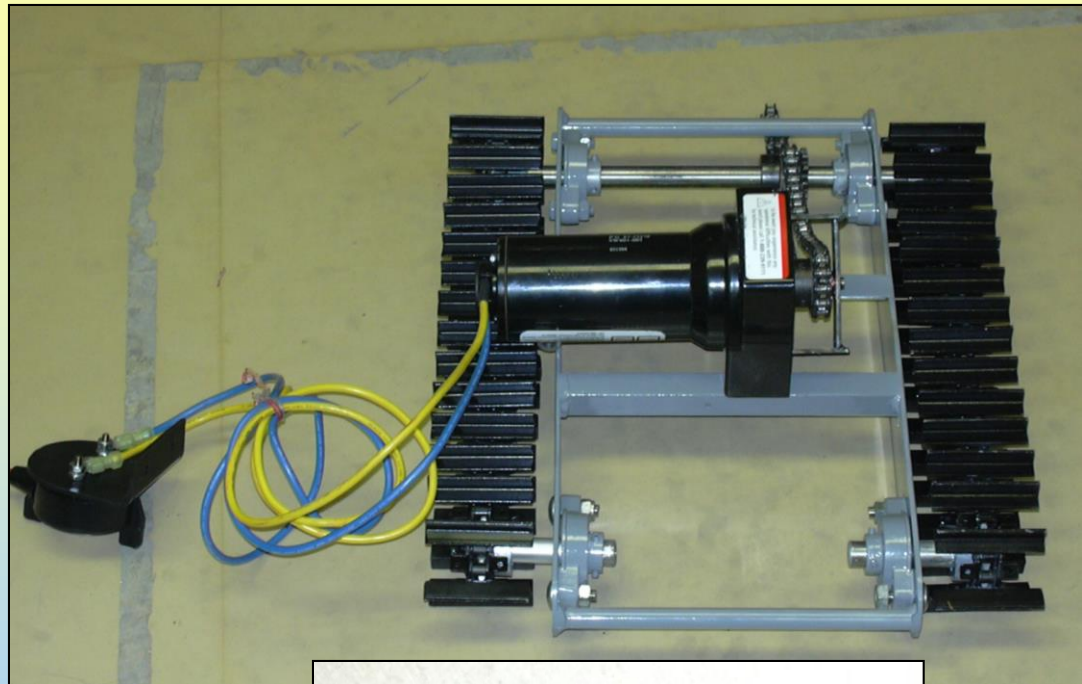
Paddlewheel System

- Rubber tires with caged paddles on side
- Sixteen gauge steel paddles
- Long frame to offset the moment created by the turning rear wheels



Track System

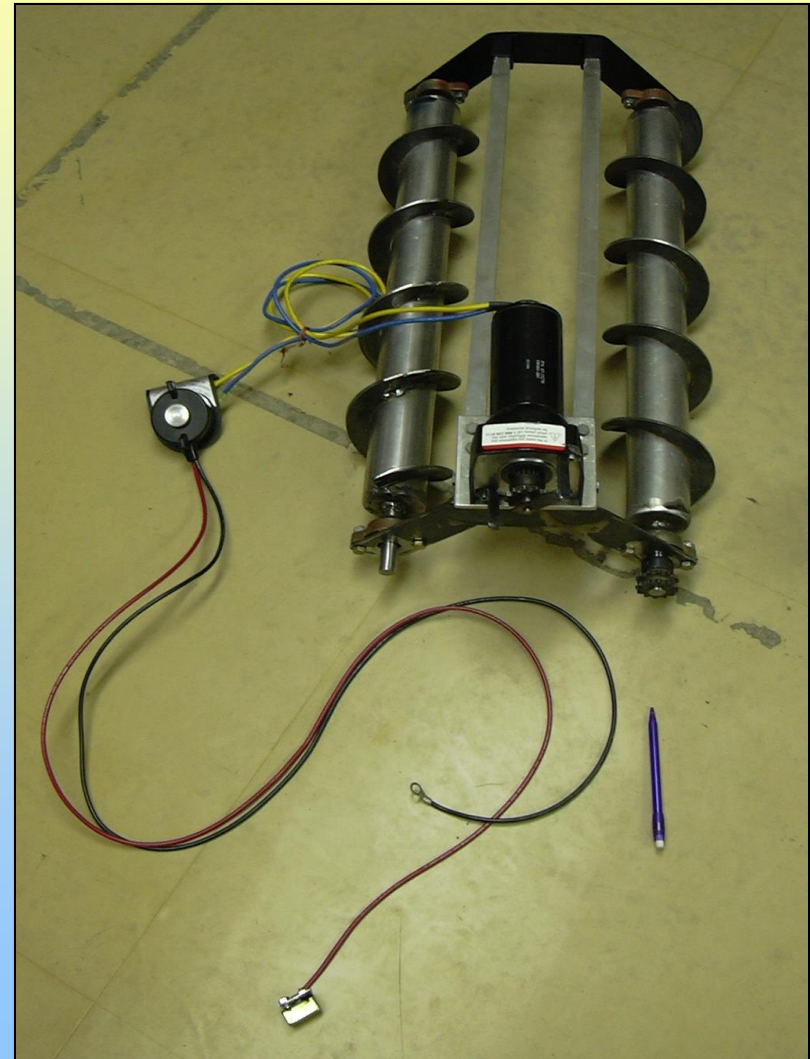
- Sixty links of specialized roller chain
- ½ in. angle iron welded on for grousers
- Motor near the center for even weight distribution



Auger System

- Dual screw augers
- Several types tested

	Outside Diameter (in.)	Shaft Diameter (in.)	Pitch (in.)
Auger 1	4 ½	2 ½	4 ½
Auger 2	3 ½	2 ½	3 ½
Auger 3	4	1 ¼	4



Prototype Testing

- 4' diameter tank
- 5" sand from Cimarron River and 1.5' water
- 50 lb. load cell attached to each drive system
- Chatillon digital gauge and laptop computer



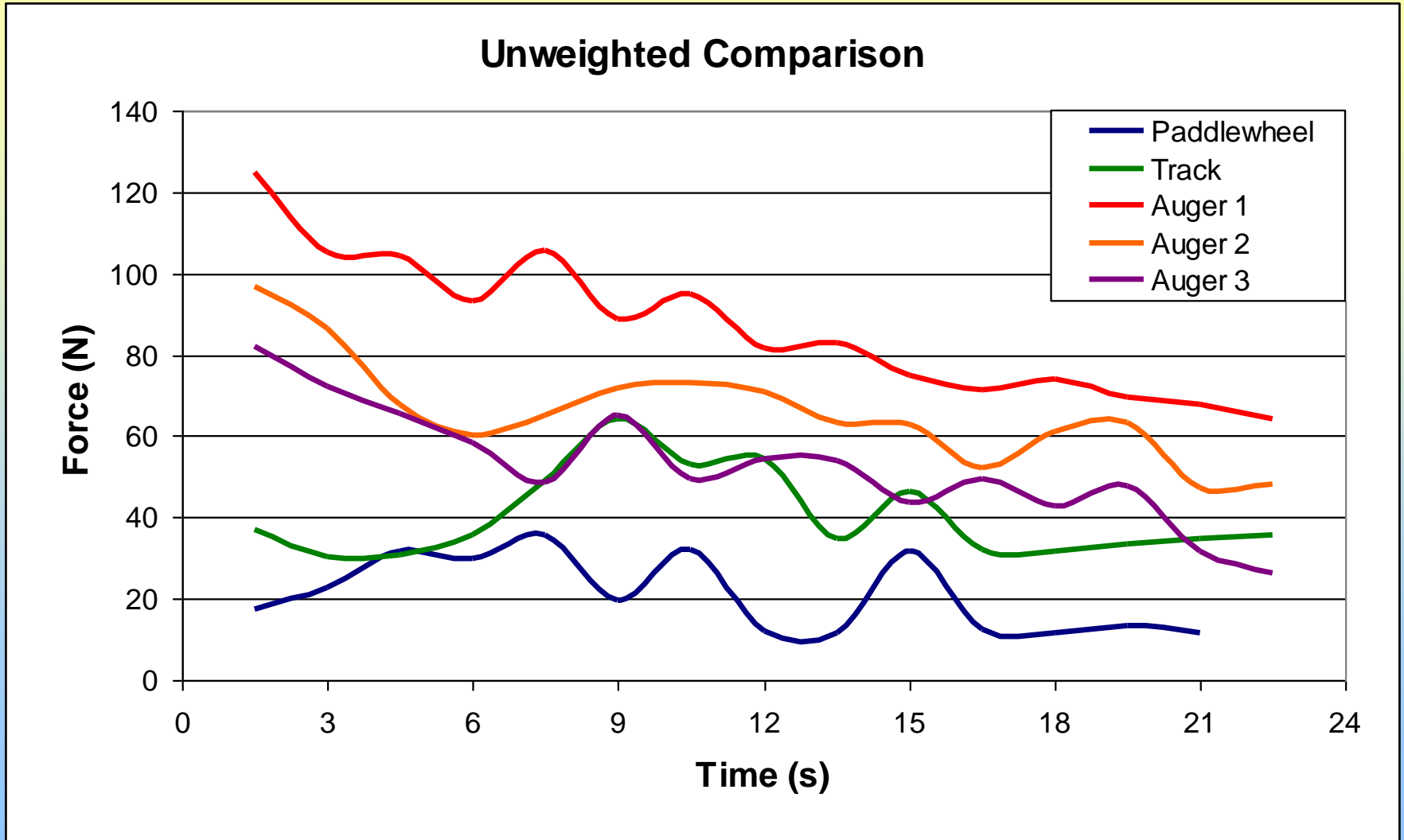
Prototype Testing

- Drive systems were operated at full power
- Transmission output was 30 rpm and the planetary gears had a 1/135 reduction
- Data logged at 1 reading/1.5 seconds
- Each design was tested between four and six times.



Testing Results

Unweighted Comparison

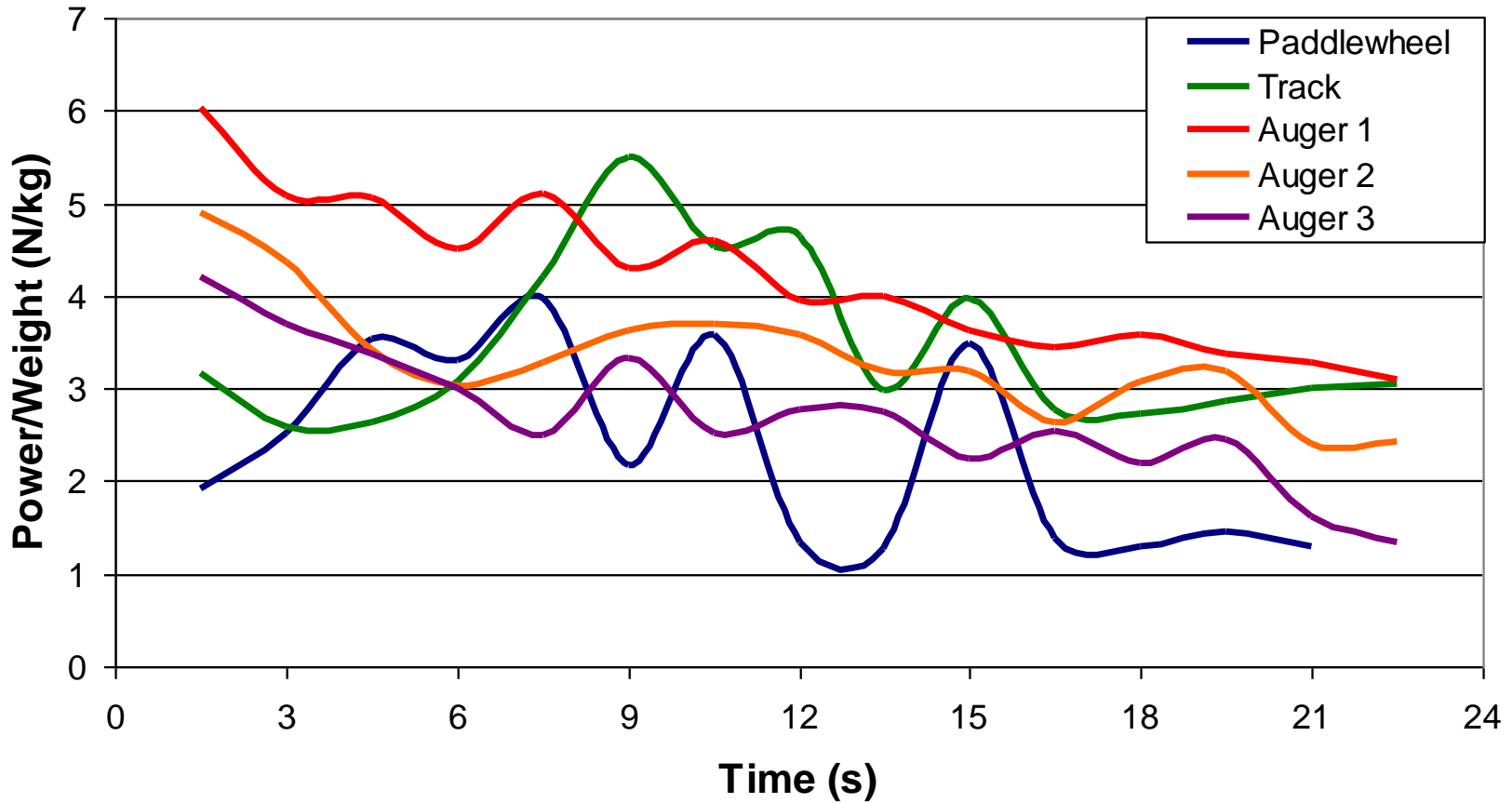


Normalizing the Data

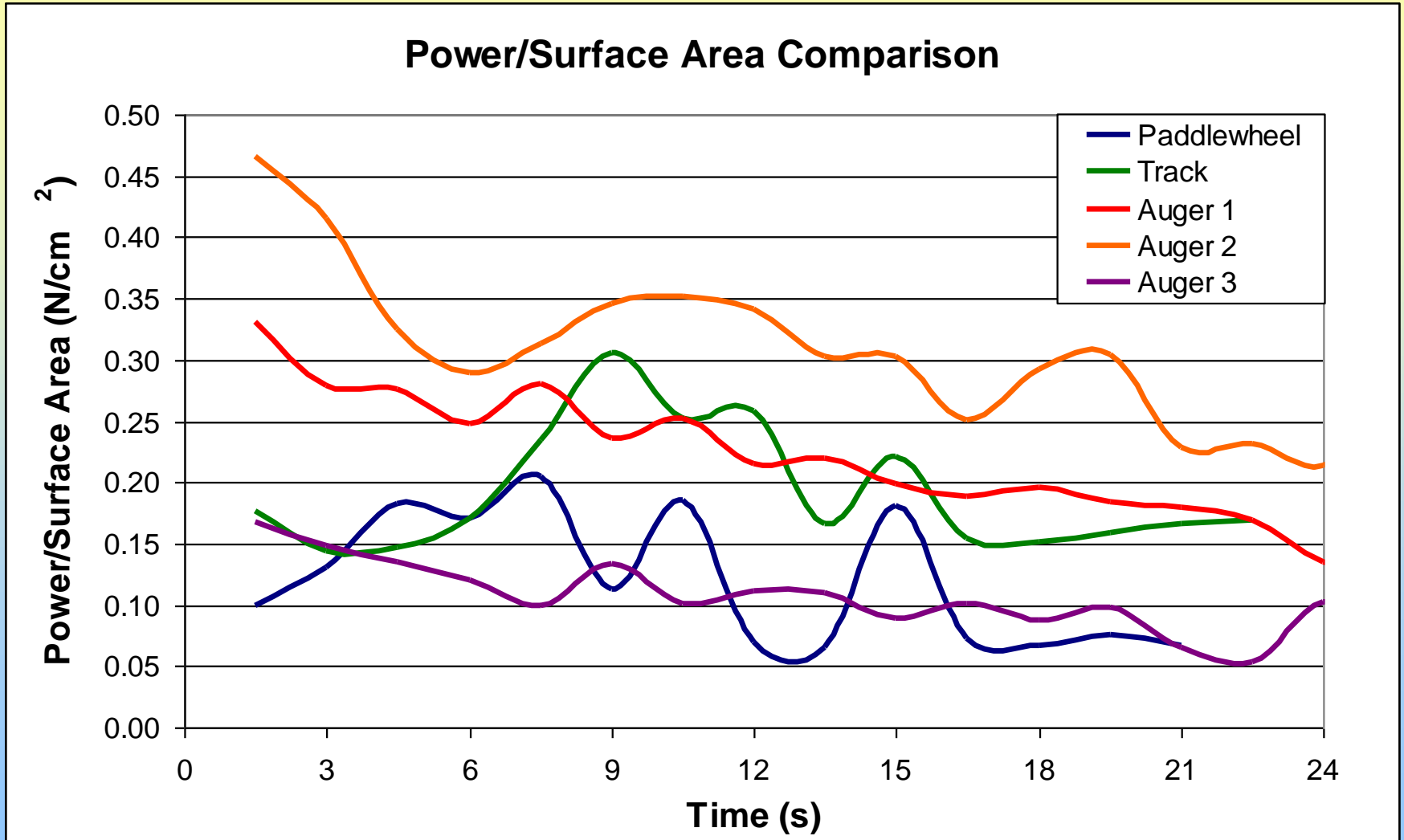
- Weight
- Surface Area

	Weight (kg)	Surface Area (cm²)
Paddlewheels	9.0	175
Tracks	11.7	105
Auger 1	20.7	377
Auger 2	19.8	208
Auger 3	19.5	488

Power/Weight Comparison



Power/Surface Area Comparison



- Augers are recommended
 - Large drawbar pull
 - High surface area
 - Performed well in normalized data evaluations
- Tracks
 - Decent performance in normalized data
 - High maintenance
- Paddlewheels
 - Lowest drawbar pull
 - Data fluctuations



Budget

Proposed Budget

Total : \$1,930

Item	Cost
Paddlewheel Design	\$120
Track Design	\$70
Auger Design	\$800
Tank	\$100
Motor	\$400
Gears	\$120
Misc.	\$320

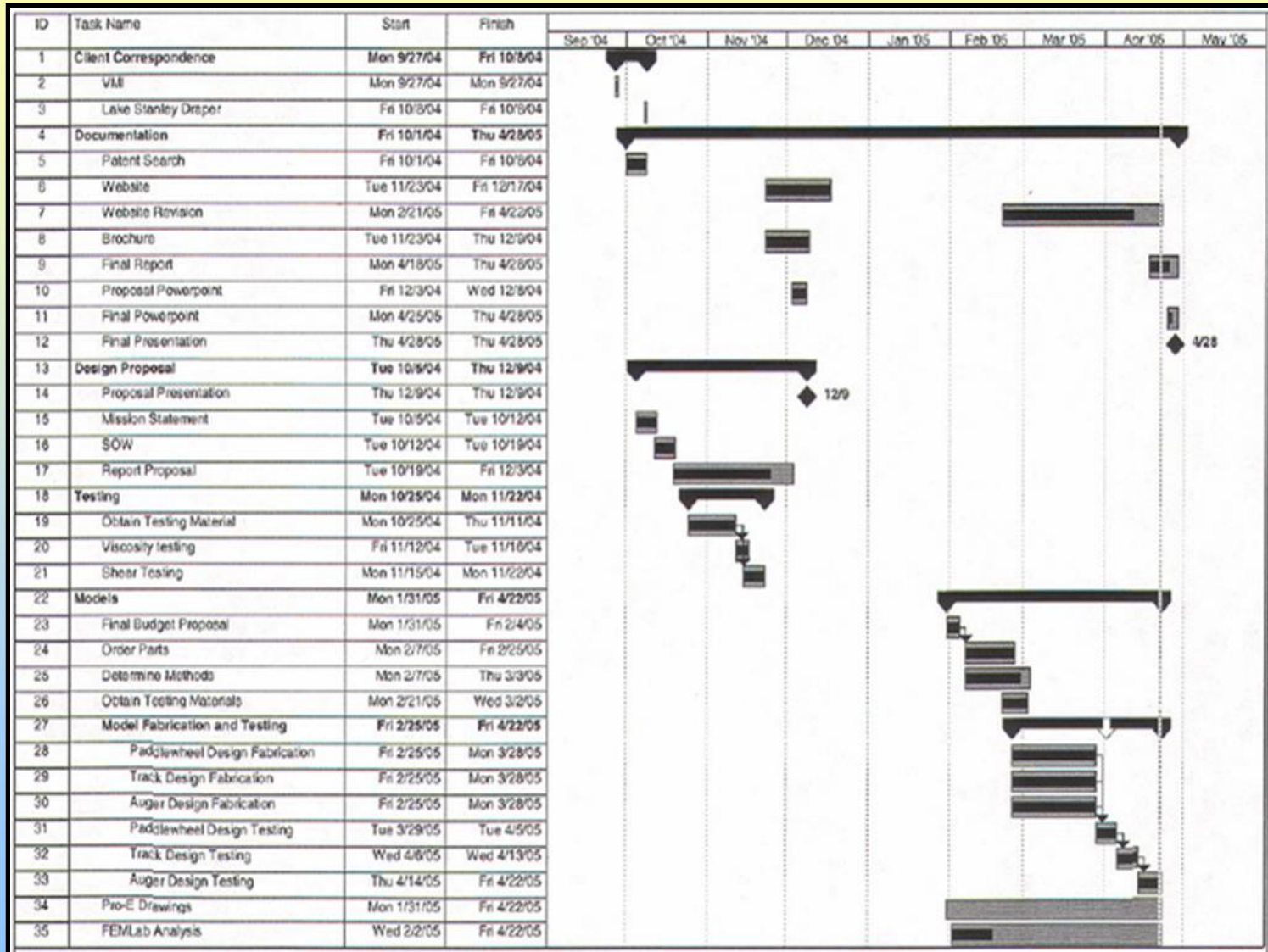
Actual Budget

Total : \$1,630

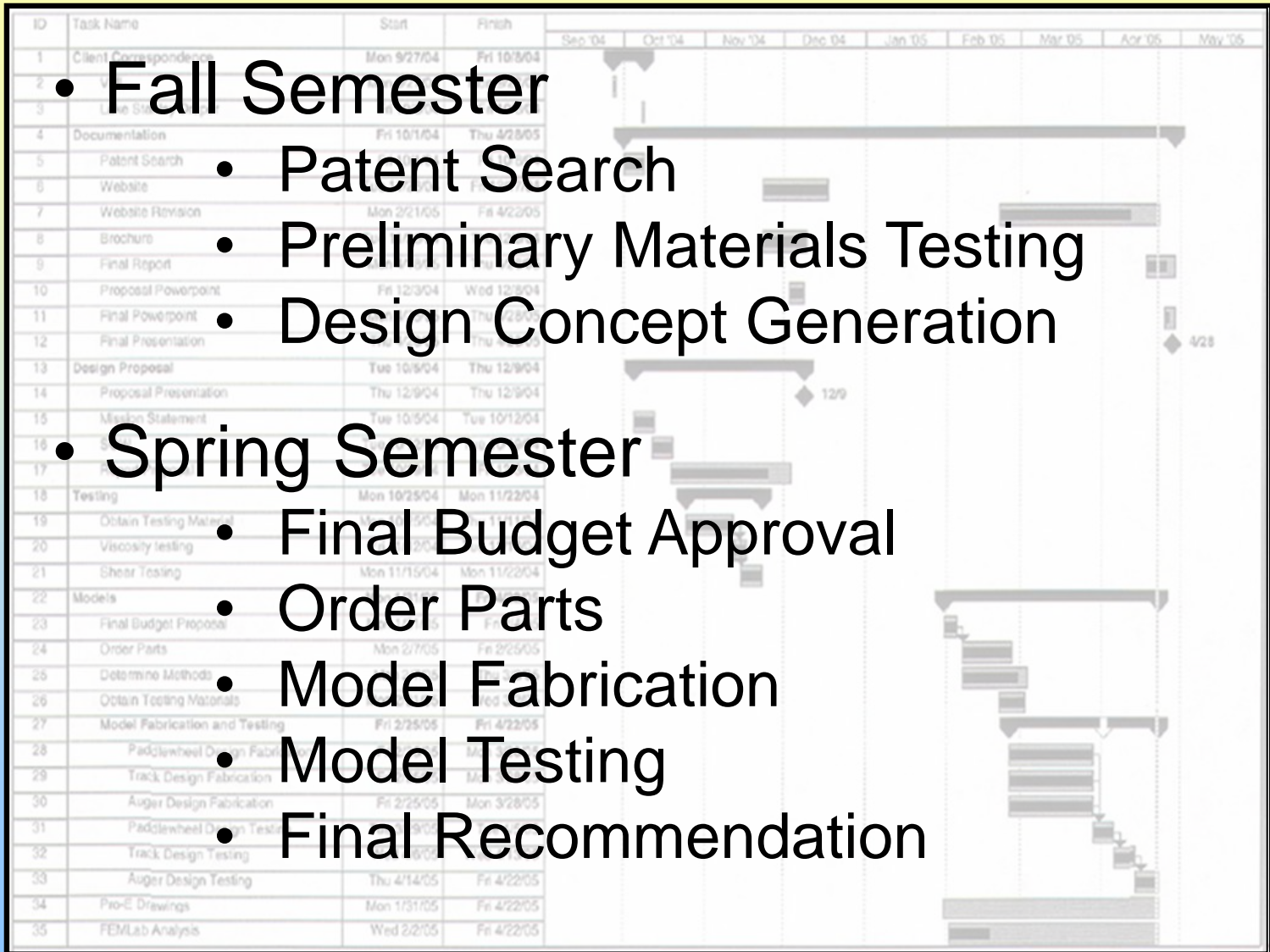
Item	Cost
Paddlewheel Design	\$60
Track Design	\$190
Auger Design	\$700
Tank	\$100
Motor, sprocket, chain, etc.	\$215
Gears	\$115
Misc.	\$100
R & D	\$150



Project Schedule



Project Schedule



- Fall Semester

- Patent Search
- Preliminary Materials Testing
- Design Concept Generation

- Spring Semester

- Final Budget Approval
- Order Parts
- Model Fabrication
- Model Testing
- Final Recommendation



Thank You

We would like to thank:

- VMI
- the Biosystems Engineering department

A special thanks goes to:

- Mr. Cash Maitlen
- Dr. Paul Weckler
- Dr. Glenn Brown
- Dr. Dani Bellmer
- Mr. Wayne Kiner
- Dr. John Solie
- Dr. Doug Hamilton
- Our parents and spouses



Thank you

Questions



Allied Design



Cableless Dredge Design

Laura Christianson

J. D. Karber

Shane Ice

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Problem Introduction

Allied Engineering has been assigned the task of redesigning the propulsion system for a mid-sized dredge manufactured by **VMI Dredges**, Cushing, OK. Currently a majority of their dredges are propelled using a cable stretched across the body of water in which the dredge is working. The cable is attached at opposite ends of the water body to anchors staked in the ground. Heavy trucks or tractors are typically used for these anchors. The dredge pulls itself back and forth using a hydraulic motor attached to the cable. The hydraulic drive provides an infinite variation of forward and reverse speeds, easily adjustable by valve positioning. While quite operable in forward and reverse, the dredge is limited in lateral movement due to the semi-permanent affixation of the cable anchors.

A considerable amount of time is spent moving the cable anchors, often over one hour per move. In addition to the inefficient use of time, the practice of using vehicles as anchors obviously ties up expensive equipment that are more useful for their intended purpose. A desirable design solution would decrease the overall time spent per job by focusing on improving the current propulsion system. This project involves designing a cableless dredge propulsion system for VMI's horizontal dredges.

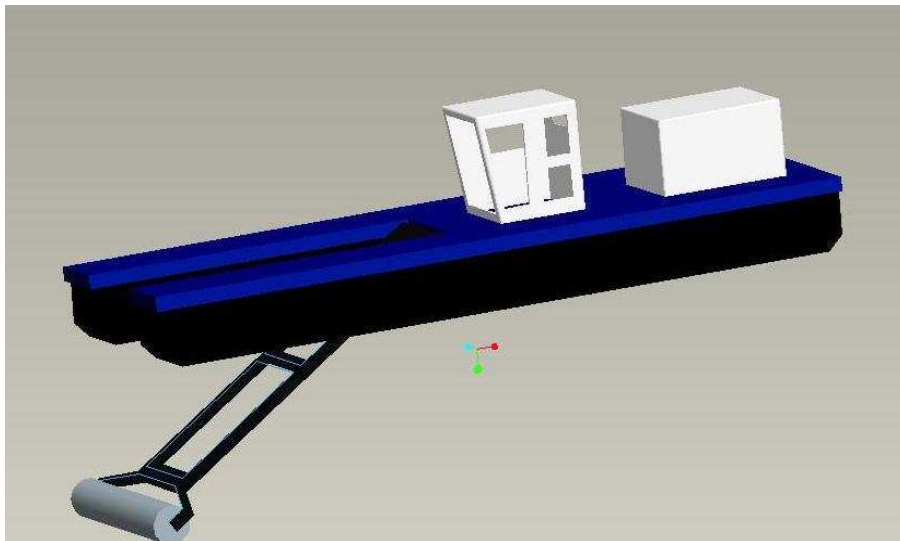


Figure 1: Dredge Image

Statement of Work

It is obviously too large an undertaking for one senior design team to build a full scale working dredge in one year. The finances, time and space would not be feasible to build a full size dredge. Because of this limitation, the scope of the project has been constrained to building scale models of probable final designs. This will present some difficulties such as finding the properly scaled components. However, scaled models will allow development and testing of the most feasible designs under simulated conditions. Upon VMI's approval, scaled models are the plan of action.

The use of hydraulic controls is desired by VMI's customers. Hydraulic controls have been the standard for many years in the dredging industry. However, the use of electric controls is growing and VMI looks to move in that direction. This new technology has been met with some customer resistance because of the new expertise required for working on the systems. Instituting an electrical control system would require experienced operators to become accustomed to a different type of control system and would also force operators to learn how to perform repairs on the new machinery. Most dredge operators perform their own repair and maintenance. This is especially important since VMI ships their products worldwide and paying travel expenses for a VMI technician would be prohibitive.

When instituting new technology, such as electric controls, it is important to make it as user friendly as possible to minimize the learning curve. VMI has already made the first step towards this goal because their newest machines do have electronics on the hydraulic pumps.

One important design consideration is the location of use. Current VMI dredges are designed for use in marinas, small lakes, rivers and lagoons. Each location presents unique difficulties. Lagoons present a special design problem because of the consistency and density of the sludge. This sludge is very different from sediment and other dredged materials. Also, cable systems in marinas are difficult to implement due to the fact that boats are located in the

water. In this case, cable systems are possible but may require underwater anchors. This variety of uses presents an important limitation for the design.

Another limitation brought to our attention by a working dredge's crew is the unavoidable need of the discharge pipe leading from the dredge to the deposit site. While it may be possible to eliminate the need for cable, this pipe will always be necessary for dredges of this scope. This pipe is a very important part of the system and typically requires its own trailer for transportation.

Propulsion driving force is perhaps the most important design constraint. Depending on the material on the bottom of the water body, it may be hard to support and propel tracks or star wheels. The dredge needs a sturdy propulsion system because of the stability needed for the pump and cutterhead.

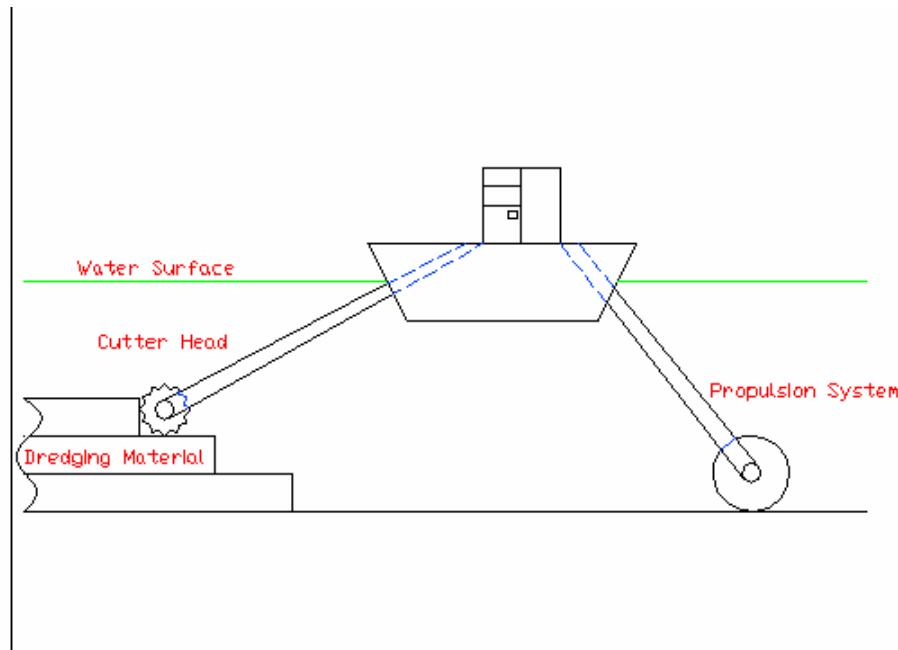


Figure 2: Conceptual Design of Dredge Propulsion

Placement of the propulsion device will greatly determine the design of the overall system. Keeping with VMI's current design, the cutter head will be located at the bow or front of the vessel. This creates a cleared channel or path behind the cutter head. The pathway could provide the propulsion system direct contact to the water body's floor eliminating the need to drive through the undisturbed material. This concept would only be feasible if the style of dredging was like that of Figure 2.

For this scenario, the propulsion unit will be located within the range of the cutter head. The other configuration would be to place the unit on the sides of the dredging vessel outside the range of the cutter head. This setup would require driving through the undisturbed material. This would pose a rolling resistance on the driving mechanism which would require either a larger driving force or a larger footprint such as wider tires.

There needs to be minimal design changes to the actual dredging equipment. Changing only the propulsion system will make it easier for VMI to implement our recommended design into their existing one. It will also be easier for them to fabricate without a number of major design changes. Also, the design must be realistic for their budget. If they choose to implement Allied Design's recommendations, the cost of the design must be feasible for them to fabricate. In any final recommendation, it is important to remember VMI's manpower resources and shop size.

One main caveat deals with a specific use of dredges. As mentioned above, many of VMI's dredges are used in lagoons. Lagoons of this sort typically have either rubber liners or concrete bottoms. With any sort of propulsion system that touches the bottom, there is concern of the liner tearing. The tearing of the liner should be avoided at all costs. This phenomenon may force the exclusion of lined lagoons from the proposed design.

Patent Search Information

There are many different designs for dredge propulsion. Patents have already been issued to several novel ideas. While this is somewhat unfortunate, this does give Allied Design a starting point. For abstracts and images of the listed patents, see Appendix A.

U.S. Patent # 5,782,660 (filed on July 21, 1998) incorporates the star wheel design. This patent has a large star wheel connected to the end of a boom. One of Allied Design's concerns regarding this design is its stability. It is not apparent that there are any stability considerations made in the design to allow the two drive wheels to move independently of each other. This poses a concern that inconsistencies of the pond floor may cause the dredger to tip.

Secondly, several patents have been issued that implement a track system. Patent # 4,713,896 (Dec. 22, 1987) uses a track system that is raised and lowered by a scissor jack application. Patent # 6,755,701 (June 29, 2004) has a track system that is attached to a boom that will raise and lower like an arm. The most promising design is included in Patent # 5,970,634 (Oct. 26, 1999). This patent has two hydraulic cylinders attached to the track system that will keep the dredge level on the surface. This allows the track system to follow the contour of the bottom more naturally thus reducing the risk of tipping. Each of these patents has a desirable component to the final design.

Several patents VMI referred to Allied Design are patent numbers 4,676,052 (granted June 30, 1987) and 3,755,932 (granted September 4, 1973). The former implements a paddle wheel propulsion system much like a paddle wheel river boat. This self propelled dredge incorporates a floating hull with a pair of independently controlled paddle wheels in the rear. In the second patent, number 3,755,932, the dredge is suspended by retractable legs. Large wheels are attached at the bottom of the legs for propulsion on top of the dredged material.

Engineering Specifications

Some specifications for VMI's current dredges can be found in Appendix B. This information was taken from VMI's website, www.vmi-dredges.com. Eventually, a drive system and various building materials will be specified for the design prototype. The model will be 1' x 3', approximately one-tenth scale.

Testing

Two major tests were performed to discern properties of several dredged materials. First, viscosity testing was executed to establish properties of dredged material in a liquid state or in a disturbed saturated state. Secondly, soil shear testing was performed to understand properties of dredged material under compaction. Several materials were tested including fly ash, river sand, swine lagoon sludge, lake sediment, marsh sediment, a Teller soil, and crystalline

silica. The river sand was taken from the North Canadian River, the Teller soil is a soil native to Oklahoma, and the crystalline silica is a fine powder used in pool filters. A wide variety of materials were tested to obtain a range of data.

According to Stroshine, when a semisolid is subjected to a constant shearing force, it deforms continuously at a velocity that increases as the applied shearing force increases. Viscosity is used to quantify the resistance of the fluid to flow. According to Wikipedia.com, Newton’s theory states that the “thicker” the fluid, the greater its resistance to shear stress. This shear stress resistance is a resistance of the fluid’s movement. This provides a resultant force equal and opposite to the direction of fluid motion. This resultant force can be harnessed for the propulsion on the auger and cage wheel design. The viscosity testing was done with a Brookfield viscometer in the Food and Agricultural Products Center. The tests were completed with Dr. Dani Bellmer’s help. Results are shown in Figure 3. It can be concluded from the tests that as the speed of mixing increases, the material gets increasingly easier to stir.

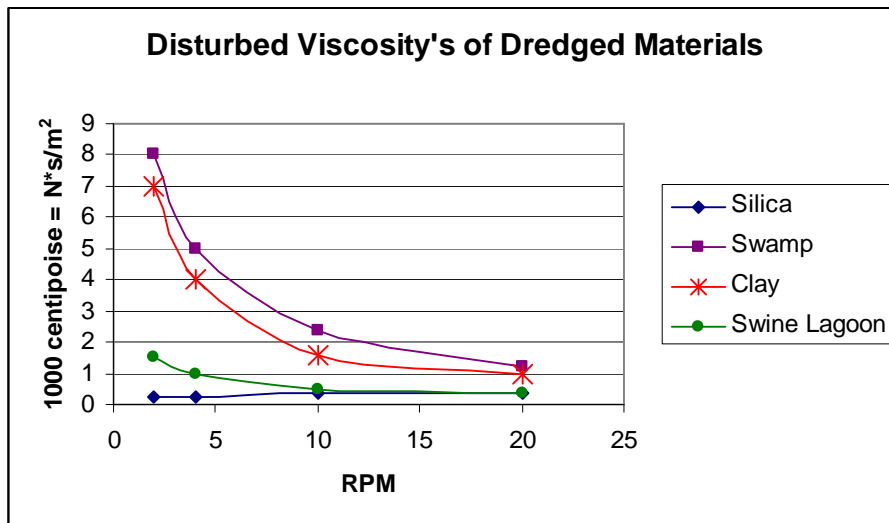


Figure 3: Viscosity Testing

The shear testing was performed in Dr. Glenn Brown’s groundwater laboratory. Again, according to Wikipedia.com, the definition of shear stress is a stress state where the shape of a material tends to change without particular volume change. The term change refers to sliding forces and directional shear. In

a laboratory setting, as is the case here, shear stress is achieved by torsion of a material. Direct shear of a material by a moment induces shear stress, along with tensile and compressive stress. Several sediment and sludge samples were tested under saturated conditions. Calculations were performed to determine stress and strain curves using the equations below.

$$Strain = \frac{\Delta L}{L}$$

$$Stress = \frac{P}{A}$$

The change in length was read from the testing equipment. The original length was the diameter of the core sample. In the stress equation, P represents the force applied. This was read from a dial on the machine and then converted using the machine’s calibration equations. The area was the cross sectional area of the sample. A normal force of 10kg was used to simulate 10ft of settlement plus 1ft of water head. The graphical results can be seen in Figure 4. The results of Figure 4 indicate that our design must be designed for a maximum stress of approximately 0.35N/cm². This figure provides a force per area that is required for the propulsion system to propel the cutterhead through the wall of undisturbed material.

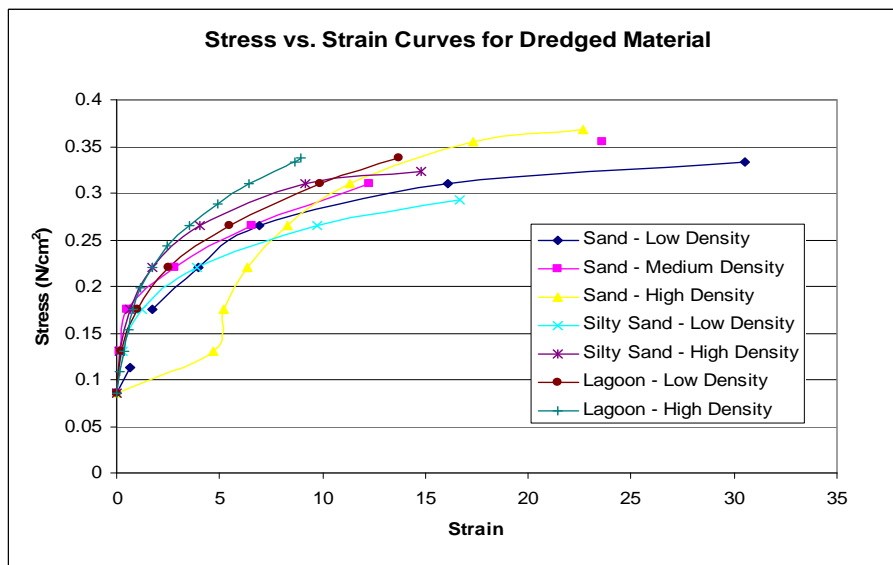


Figure 4: Stress Strain Curves

Definition of Customer Requirements

VMI has left many of the design decisions to the group. This allows great flexibility in Allied Design's research and testing. However, the one major design requirement is that the system be cableless. This is, in fact the purpose of the entire project.

Another VMI request included the use of hydraulic controls. As mentioned above, hydraulic controls are currently the standard in the dredging industry. While this may change in the future, hydraulic and not electric controls will be implemented in the design recommendation. It is also important that existing dredges could be retrofitted to work with the cableless design. Lastly, Allied Design has identified that the design should not be overly complex. This is so that design will be relatively easy to fabricate and will be easily serviceable.

Design Concepts

Three major concepts have been identified as possible solutions. They include a track system, a paddle wheel system and, at VMI's recommendation, an auger system.

The track system can be seen in Figure 5. Much like a tank, this option would have tracks to maneuver through the sediment. These tracks would be rubber and would connect to the dredge with a hydraulically controlled boom. This would enable the dredge to be on the water surface while the tracks move along the bottom of the water body. A problem arises if the bottom of the water body is not solid. In this scenario, the entire dredge would sink when the boom has reached full extension. Therefore, the dredge must be sufficiently buoyant to support its weight as well as the weight of the tracks.

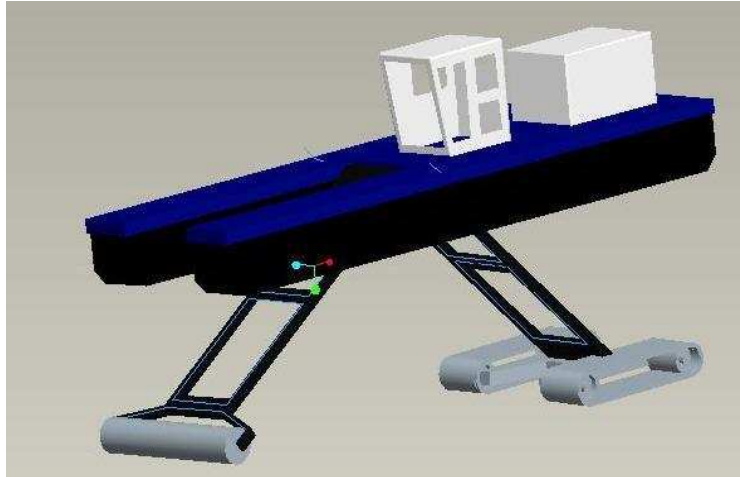


Figure 5: Track system

The paddle/cage wheel design is similar to rice harvesters and can be seen in Figure 6. A potential design uses large tires with an attached cage wheel. These wheels are attached to the dredge similarly to the track system with a hydraulic boom. This attached cage wheel would provide additional traction by pushing the sediment simulating a paddle wheel. The vanes on the cage wheel provide additional propulsion.

This extra propulsion is proportional to the density of the sediment. As mentioned earlier in the testing section, the denser the fluid, the greater its resistance to shear stress. The resultant force can be harnessed for the propulsion on the cage wheel design. This design has been used on rice farming equipment. Because of the saturated conditions of rice paddies, this extra traction and propulsion is necessary. The extra traction provided by the cage wheel could provide sufficient driving force to operate a dredge. Like the track system, the sinking of the dredge may be an issue. With a cage wheel design, the weight of the dredge would be spread over a smaller surface area than the track system which may cause the problem of sinking to be exacerbated. In this case, additional power or larger tires would be needed.

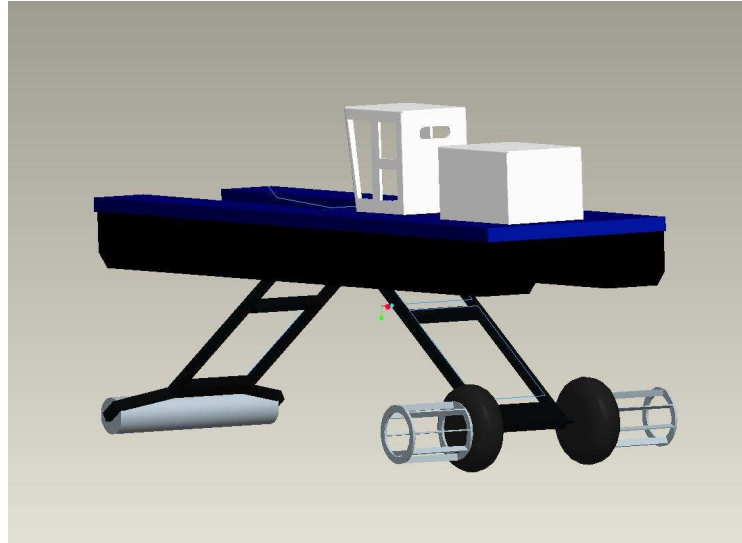


Figure 6: Paddle wheel/cage wheel system

The auger system can be seen in Figure 7 and would also use the sediment at the bottom of the body. The screw augers would be lowered to the bottom of the body and rotate through the sediment. This rotation would provide the propulsion for the dredge. This system would provide a great amount of forward force because of the high torque capabilities associated with augers. Top speed for this design would be relatively slow. However, stability may be an issue with this system. If the bottom of the water body were sloped perpendicular to the direction of travel, the augers could tend to slide since the traction of the auger flighting is effective only in the direction of travel.

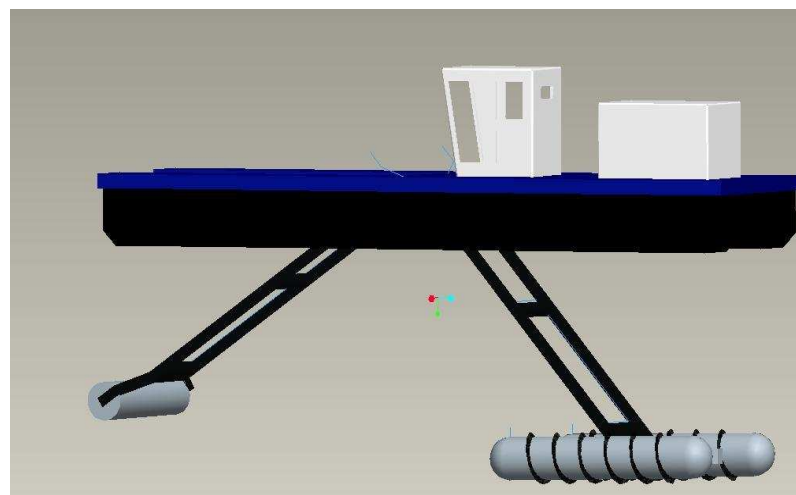


Figure 7: Auger system

Feasibility Evaluation

Several criteria must be considered to determine feasibility. These include cost, maintenance, controllability, and ease of fabrication. Note that until prototypes of the designs are built in the spring, these criteria cannot be fully identified and evaluated.

The cost of the various solutions will be relatively small compared to the cost of a dredge. All design will require a hydraulic boom to raise and lower the dredge. This boom will require a motor and controls. Individual designs each have their own associated costs. For example, the track system will involve purchasing rubber tracks. The cage wheel design will require large agricultural tires, metal for vanes, and a drum for floatation. For the auger design, large screw augers will be needed. All these items and other additional necessities will be priced before the final recommendation is made.

All solutions will have to be considered from a maintenance viewpoint. Like existing dredges, this is a factor that can not be eliminated with any amount of design work. However, Allied Design strives to minimize the maintenance of any recommended design. The hydraulic boom on all the possible designs will have a small level of maintenance to keep it running properly. The track system will require repair on or replacement for the rubber. The cage wheel system will occasionally require new tires as well as mending any bent or broken vanes. The auger system will also require mending of broken or bent flighting. Of the three options, the track system will likely have the highest maintenance costs due to the cost of the rubber tracks. Of course, it is important to keep the dredge clean while not operating in order to minimize undue wear.

As discussed above in the Client Requirement section, serviceability is an important consideration. This, along with operation and controllability, makes up a third important design criteria. These factors fall under the category of usability. Regarding controllability, it is ideal to have each of the propulsion mechanisms operating independently. If this is not feasible, stability issues could arise which in turn decreases the controllability of the dredge. This is a potential problem for all the dredge designs but the augers in particular would be prone to

this type of failure. The similar boom design that is standard on each solution would occasionally need to be serviced either by the contractor or an experienced mechanic. The cage wheel system would be the most easily serviced because the design is least complex.

The various solutions will each require significant fabrication. Obviously, all designs will require fabrication of a hydraulic boom. The track design will require fabrication similar to that of a Caterpillar track system or a tank. Rubber tracks and metal parts will be necessary for this. For the paddle design, cage wheels and vanes will need to be made out of steel. Regarding the auger design, large screw conveyors will need to be bought or made.

Determination of Designs

As mentioned earlier in this report, three designs have been chosen for testing. Upon testing, Allied Design anticipates selecting one final design for large scale fabrication. The three potential designs include a track system, a paddle wheel/cage wheel design and an auger design. A model of each will be fabricated and tested under simulated conditions. The final recommendation will be made at the end of the spring semester.

Project Schedule

See Attached Appendix C

Proposed Budget

The proposed budget is shown in the figure below. The total estimated expense at this time is \$1000.

Item	Amount Necessary	Approximate Purchase Date	Cost
Small submersible motor and mechanical parts for fabrication of models	various	2/1/2005	\$500
Metal for fabrication	various	2/1/2005	\$100
Rubber tracks	4	2/1/2005	\$100
Augers	4	2/1/2005	\$100
Tires	4	2/1/2005	\$100
Testing Tank	150 gallon	3/1/2005	\$100

Figure 8: Proposed Budget

References

Stroshine, Richard. 1998. Physical Properties of Agricultural Materials and Food Products. Purdue University: West Lafayette , Indiana.

VMI Dredges. <http://www.vmi-dredges.com/> . Date Accessed: September 2004.

Wikipedia: The Free Encyclopedia. Newton's Theory. Modified 14 December 2004. Accessed 15 December 2004.

Wikipedia: The Free Encyclopedia. Shear Stress. Modified 14 December 2004. Accessed 15 December 2004.

Appendix A: Patent Search Information

See attached.

Appendix B: VMI Dredge Specifications

Mini-Dredge Specifications				
	MD-415	MD-615	MD-620	MD-815
General				
Length	33' 6" O.A.	37' 6" O.A.	43' 0" O.A.	38' 6" O.A.
Height	8' 0" with cab	8' 6"		8' 10"
Width	8'6" transport	9' 0"		9'11"
	9' 0" working			
Weight	20,000 lbs.	23,000 lbs.	25,000 lbs.	29,000 lbs.
Cutter Assembly	21"	21"		21"
Size	21" Dia. x 8' 6" with full width flow through suction	21" Dia. x 9' with full width flow through suction		21" Dia. x 9' 11" with full width flow through suction
Speed	Variable 0-120 RPM forward and reverse	Variable 0-250 RPM forward and reverse		Variable 0-100 RPM forward and reverse
Torque	30,000 in.-lb.	30,000 in.-lb.		30,000 in.-lb.
Working Capacity				
Cut	21" Deep x 8' 6" Wide	21" Deep x 9' Wide		21" Deep x 9' 11 " Wide
Operating Depth	Variable to 15' max	Variable to 15' max	Variable to 20' max	Variable to 15' max
Engine				
Type	Cummins	Cummins		Cummins
Power	174 BHP @ 2500 RPM	260 BHP @ 2200RPM		340 BHP @ 2200 RPM
Pump				
Type	Hi-Chrome, centrifugal, recessed impeller			
Impeller	18"	22"		25"
Suction	4"	6"		8"
Discharge	4"	6"		8"
Capacity	Variable to 1000 GPM @ 130' Head (water @ 68 F) @ 1400 RPM	Variable to 2000 GPM @ 140' Head (water @ 68 F) @ 1140 RPM		Variable to 3000 GPM @ 125' Head (water @ 68 F) @ 960 RPM

Appendix C: Project Schedule

See attached Gantt Chart.

Dredge Propulsion System

Senior Design - Fall 2004

Laura Christianson

Shane Ice

J. D. Karber



Allied Design



Sponsor



- Sponsored by VMI of Cushing, Oklahoma
- Represented by Cash Maitlen
- Offers over 30 years of dredge manufacturing experience
- Manufactures, rents, and sells dredging equipment and accessories

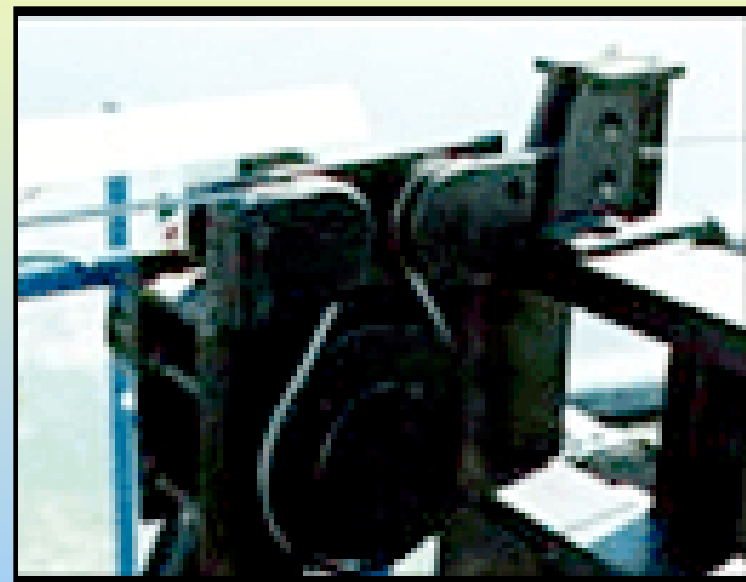


How do Dredges Work?

- Overtime, water bodies such as lakes and rivers may receive sediment due to erosion.
- A cutterheads lowers, by way of a boom, into the sediment.
- The cutterhead spins and mixes large quantities of water with the excavated material to create a slurry.
- This slurry is then pumped out of the water body.



- Current design consists of a cable and winch system
- Requires cable anchors on the banks or in the water
- Limits mobility and the advancement of the anchors is time consuming





Problem Statement

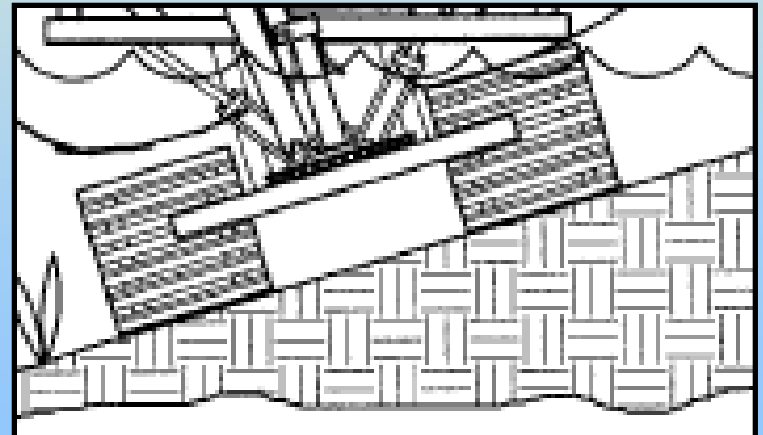
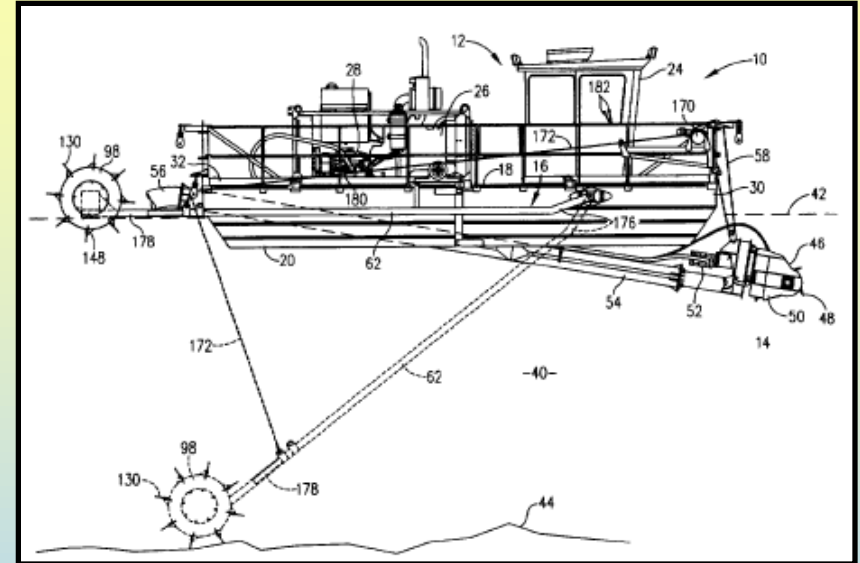


Design of a cableless dredge propulsion system for light duty dredges for use in marinas, lagoons, and small lakes.

Patent Search

Existing propulsion systems:

- Starwheel
 - 5,782,660
- Track
 - 4,713,896
 - 5,970,634
 - 6,755,701





Design Concepts



- Track System
- Paddle/Cage Wheel System
- Auger System

Design Concepts

Track System

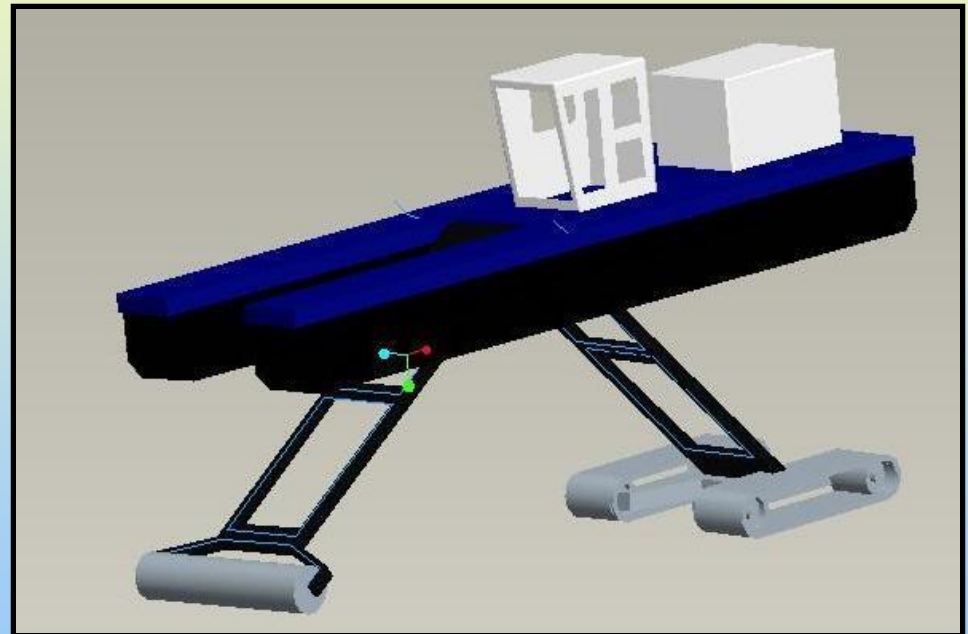
Dual rubber tracks

Pros:

- Large surface area in contact with bottom

Cons:

- Sinking of tracks in unstable bottom



Design Concepts

Paddle/Cage Wheel System

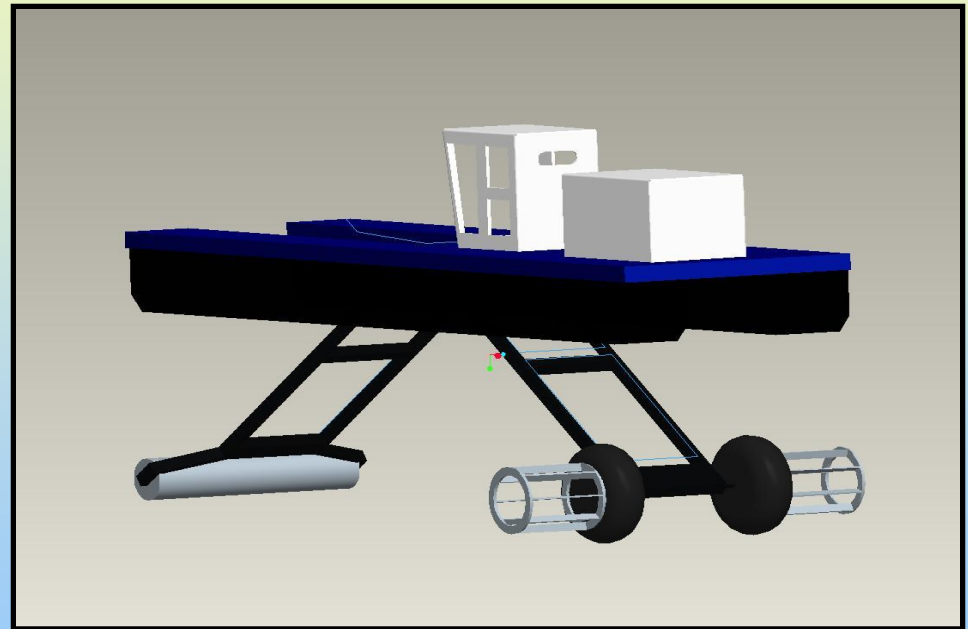
Rubber tires with caged paddles on side

Pros:

- Traction of tires plus force from paddles

Cons:

- Total submergence of paddle wheel



Design Concepts

Auger System

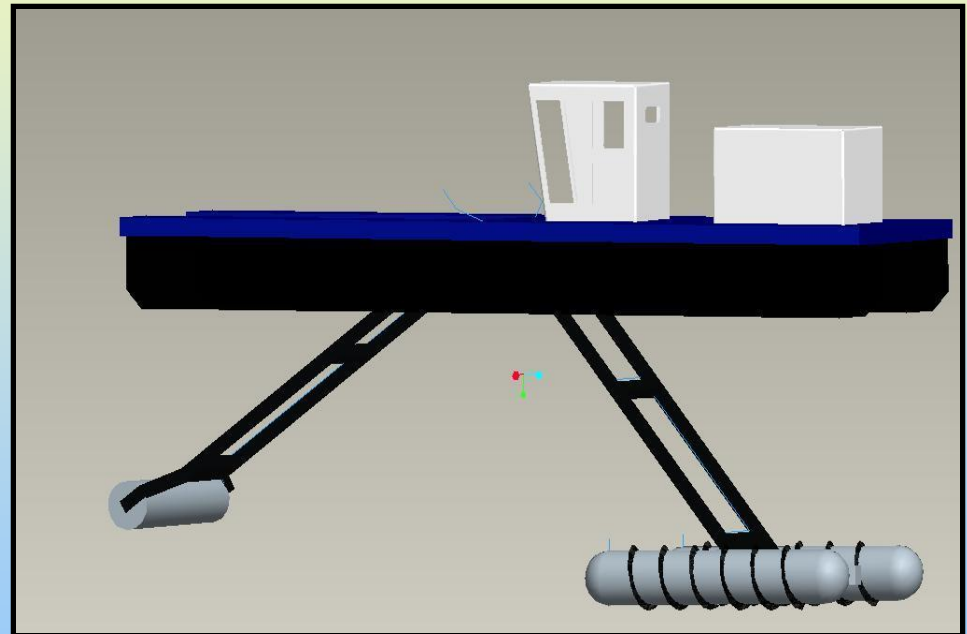
Dual screw type augers

Pros:

- Force provided by the dredging material

Cons:

- Possible limited control when operating perpendicular to an incline



Placement of System

- Placement of the propulsion system will play a key role in the selection of the final design
- Placement Configurations
 - Within path of cutter head
 - Outside the width of cutter head



Considerations

Several considerations will have to be kept in mind for design.

- Cost of fabrication
- Functionality with existing product
- Mobility effectiveness
- Operational versatility
- Terrain

Testing of Materials

Various tests were conducted on several materials suspect to dredging.

Type of materials tested:

- River sand
- Swamp
- Clay
- Fly ash
- Swine effluent
- Silica

Types of tests:

- Viscosity
- Stress/Strain

Testing of Materials

Viscosity Testing

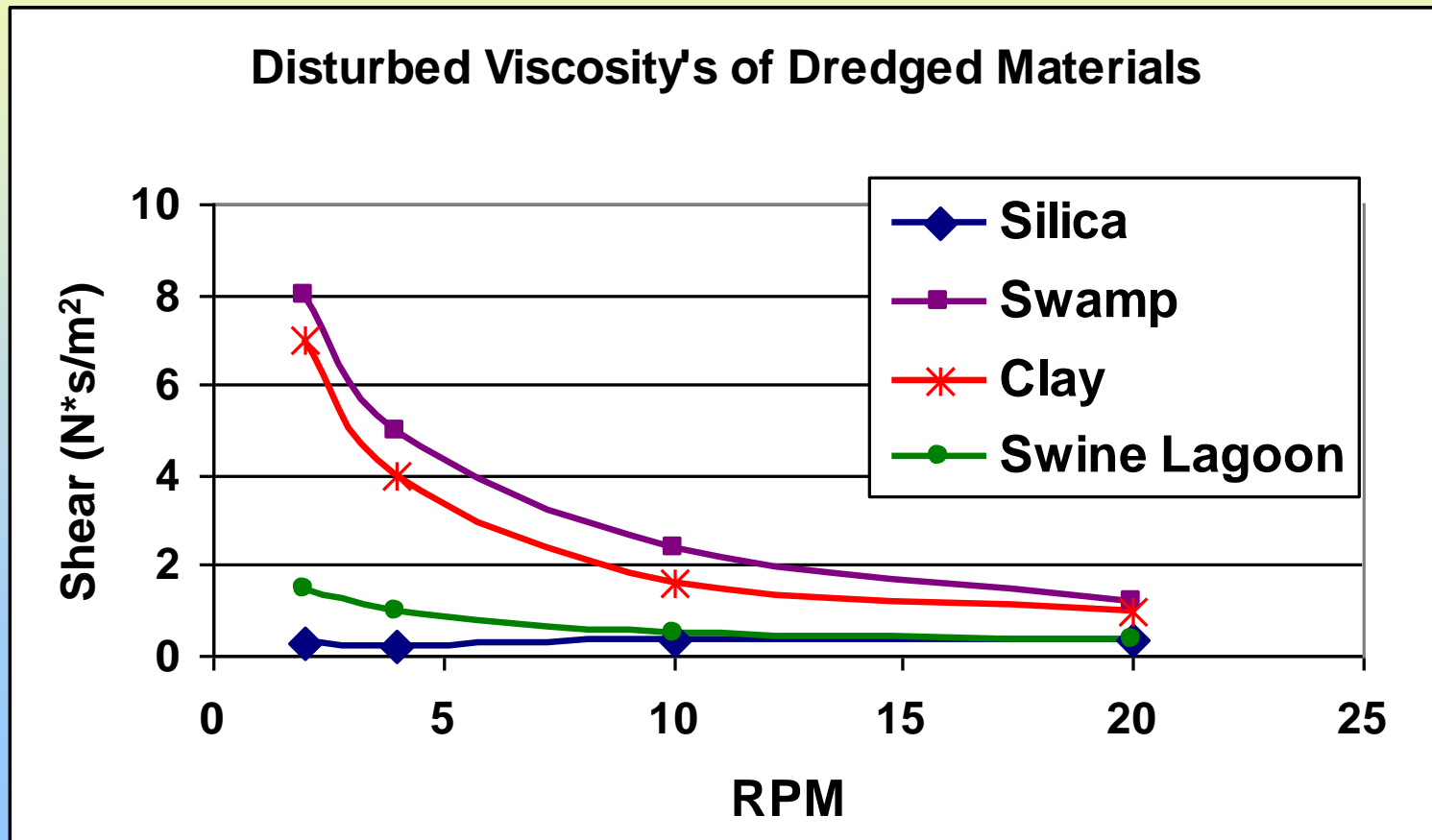
Purpose for test:

- Resistance on propulsion system
- Propulsion created by material's resistance to motion



Testing of Materials

Viscosity Testing



Testing of Materials

Shear Testing

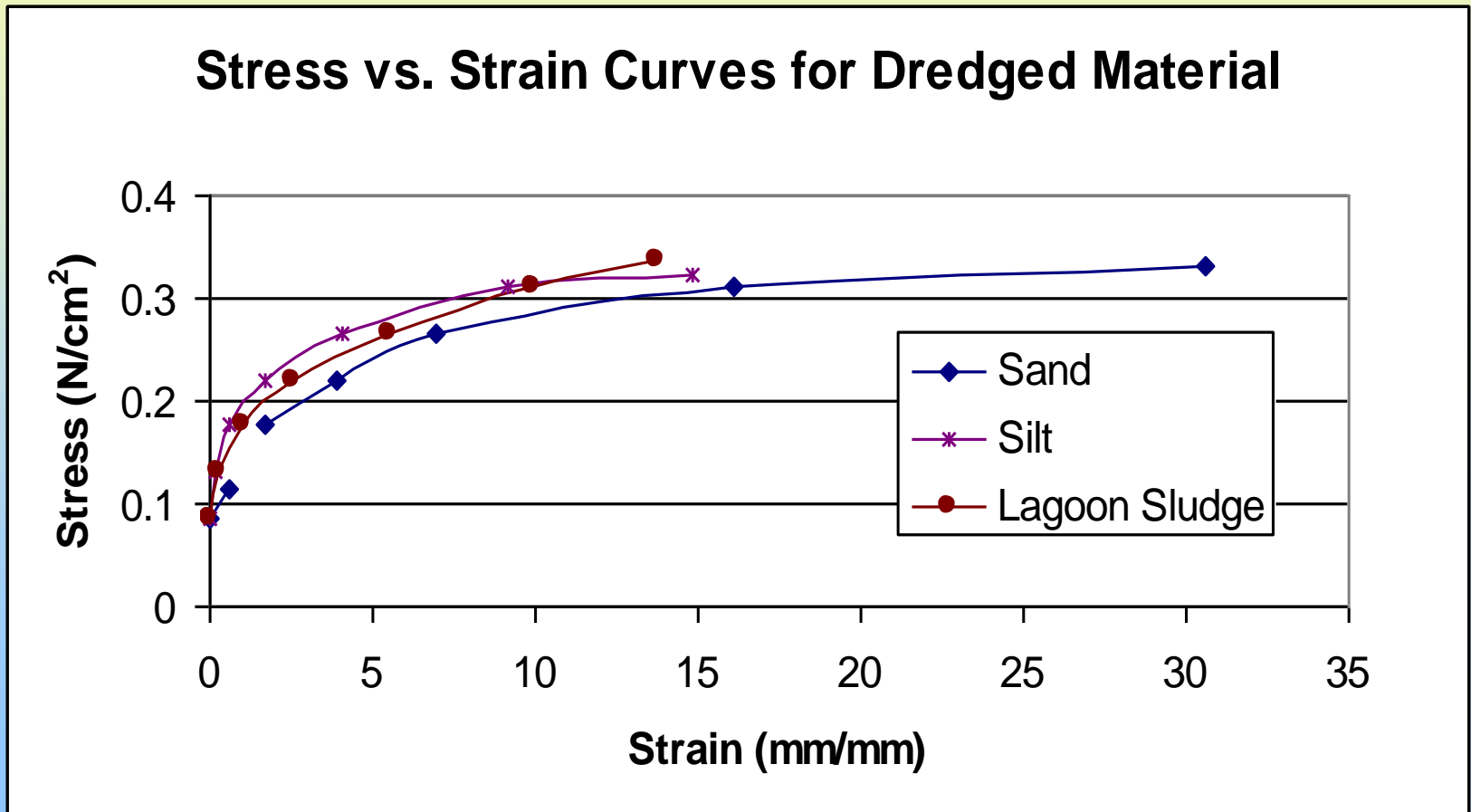
Purpose for test:

- Resistance on propulsion system
- Power required to “push” cutterhead through material



Testing of Materials

Shear Testing



Prototype Testing

Design

- Each design concept will be fabricated.
- 1/10 scale model of vessel
- Propulsion systems to a similar scale



Prototype Testing

Propulsion Testing

- Large tank with desired material on bottom used to simulate sediment
- Load cell attached to each propulsion system
- Measure the traction, resistance and/or the force to “drive” or propel through the material



Proposed Budget

Item	Amount Necessary	Purchase Date	Cost
Small submersible motors and mechanical parts for fabrication of models	various	2/1/2005	\$500
Metal for fabrication	various	2/1/2005	\$100
Rubber tracks	4	2/1/2005	\$100
Augers	4	2/1/2005	\$100
Tires	4	2/1/2005	\$100
Testing Tank	50 gallon	3/1/2005	\$100



Project Schedule



- Fall Semester:
 - Patent Search
 - Preliminary Testing
 - Design Concepts
- Spring Semester:
 - Order Parts
 - Model Fabrication
 - Model Testing
 - Final Recommendation



Thank You

We would like to thank:

- VMI
- the Biosystems Engineering department

A special thanks goes to:

- Cash Maitlen
- Dr. Paul Weckler
- Dr. Glen Brown
- Dr. Dani Bellmer
- Dr. Doug Hamilton



Questions

