Villanova University
Autonomous Surface Vehicle

Villanova University Autonomous Surface Vehicle Team
Villanova, Pennsylvania
http://www.students.villanova.edu/asv

Design Report

Abstract

Our team at Villanova University has designed and built a fully unmanned surface vehicle to compete in the AUVSI and ONR's 1st International Autonomous Surface Vehicle Competition. This ASV, named Hot Box*, is capable of performing a number of tasks completely autonomously. Tasks include navigating through buoys, recognizing and knocking over targets, rescuing a mannequin, and returning to its original starting point. It has a dry weight of 110lbs. and dimensions of 64x25x32". The vehicle is the result of the combined knowledge and experience of the members of the Villanova University Team that results in the most effective ASV given the limited amount of time allotted.*

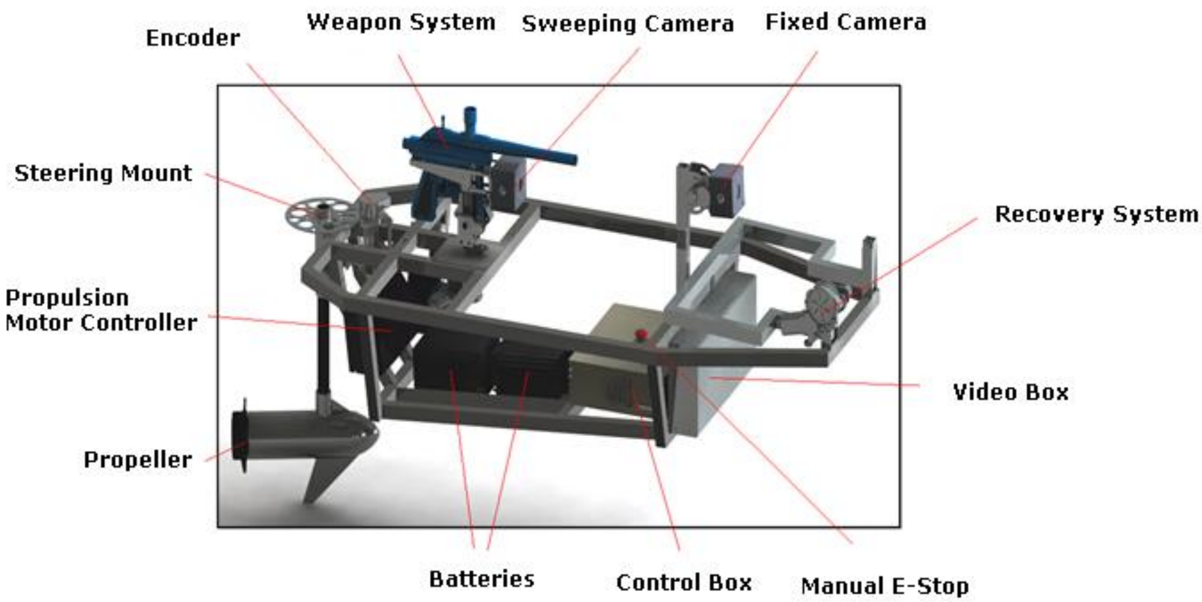


Figure 1: Rendering of complete assembly

MISSON

The 2008 ASV Competition is located at the Space and Naval Warfare Systems Center, TRANSDEC Facility in San Diego, CA from August 7-9. Each team must submit a fully autonomous surface vehicle that has a total of thirty-five minutes to complete three tasks and return to the starting position. The starting gate is comprised of two white poles spaced 10' apart no more than 100' away from the first set of buoys. The first task is to navigate through six sets of buoys. A buoy set is comprised of one red buoy on the right and one green buoy on the left. The distance between each is 6' and the distance between each set can range from 3-15' with a maximum angle of 45°. Once this is accomplished the second mission is to shoot down lit targets while avoiding unlit ones. Red LED lights distinguish the lit targets from those that are unlit. Lastly, the ASV must rescue a mannequin and return him to the starting gate. The mannequin is covered in Velcro and stands upon a platform that is 1' above the waterline. The ASV must be able to dock inside this platform, rescue the mannequin, and then proceed to back out of the dock and return successfully through the starting gate. Additionally, the ASV must meet a number of requirements including size, weight, max speed, power supply, and safety features. Maximum size is constrained to a 6x3x3' box. The weight cannot be anymore than 140 lbs, but bonus points are awarded if the ASV is less than 70 lbs. Maximum speed is at 10 knots and all ASVs must have both a manual and a wireless emergency stop switch in case of safety issues.

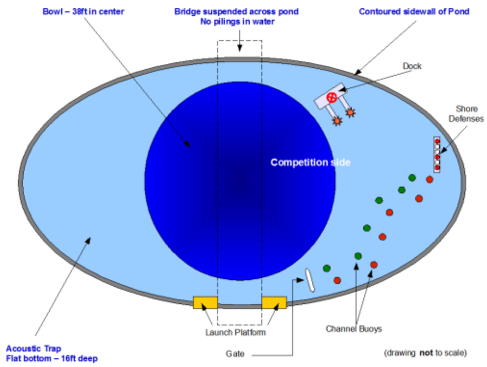


Figure 2: Mission Layout

MECHANICAL SYSTEMS

Hull and Frame

Given the size and weight requirements, along with the specific tasks the boat must perform for the competition, a *Thule 682 Sidekick* cargo carrier was chosen as the hull of the ASV. The main reason this was selected was because of its lightweight, buoyancy, hydrodynamics, and size. The main requirement for the cargo carrier was that it had to stay afloat given the weight restriction of 110 lbs. Buoyancy equations were used to determine if the cargo carrier would float; knowing the volume that the cargo carrier would displace in water and also the approximate weight of the boat.

Buoyancy Calculation:

Thule 682 Sidekick:
- Dimensions = 4.5 x 2.1 x 1.3'
- Weight (max) = 110 lb
- Density H_2O = 62.28 lb/ft^3

$110 = l \times w \times h \times \textit{Density of water}$

$110 = 4.5 \times 2.1 \times 62.28 \times h$

$h = 0.187$ ft ← Height of submerged Thule

$0.187 \text{ ft} < 1.3 \text{ ft}$ therefore it floats

The large length and depth of the cargo carrier made it ideal for storing the control box and two Jet Ski batteries. In addition there was also an ample amount of room for the gun and recovery systems; which were designed and installed after the hull was purchased. Preliminary flotation tests were done on the hull to determine where the center of gravity needed to be to keep the boat level. Test results showed the hull was very maneuverable and moved through the water well. The waterline was found to be about three inches when a weight of 85 pounds was placed in the center of the boat.

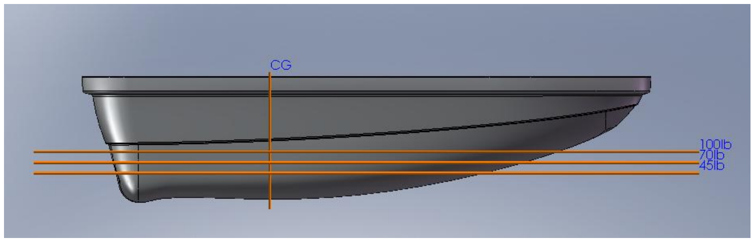


Figure 3: Center of Gravity and Waterline for Different Weight

However, since the hull was made of thin, lightweight plastic it was not rigid enough and the equipment could not easily be bonded to it. Due to these problems with the hull, it was decided that an internal frame was needed to make the boat rigid and also to mount the equipment. The frame consists of 1x1” aluminum tubing that is welded together in order to form a supportive structure.

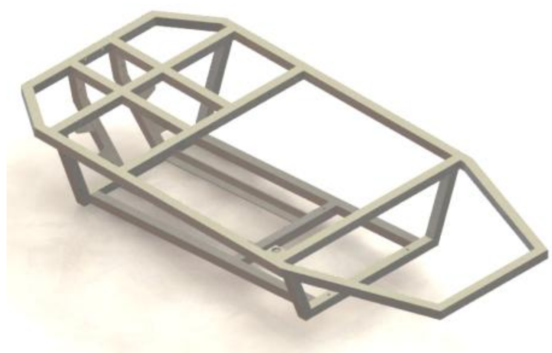


Figure 4: Frame

Aluminum was chosen due to its lightweight and resistance to corrosion. All systems are mounted onto the frame, using rivet nuts, in their designated areas to maximize their capabilities. The batteries were placed near the rear of the boat, on rails, so that they could slide to change the center of gravity as needed. Early in the design, it was determined that the frame would not be attached permanently to the hull. This would make the installation of electronic, cables, and other systems easy when transporting the boat. This also allows for better integration and expansion if new systems need to be added in the future. The frame and hull were attached using rivet nuts and screws that are located evenly around the top perimeter of the frame. Later on in the development of the hull and frame, it was found that when the frame had all the components attached, it pulled the hull down causing the bottom of it to deform. To fix the problem, Styrofoam spacers were made to fit between the bottom of the hull and the frame. In order to make the boat more water resistant, a custom fiberglass cover was fabricated. Holes were then strategically cut out to allow a clear outside view for the camera, recovery, defense, emergency stop and steering systems. Lastly, a plastic cleat was attached to the front of the hull in order to satisfy the towing requirement.

Propulsion

The propulsion system for the ASV is responsible for providing motion to the boat. Its functional requirements are that it must move the boat forward and backwards and maintain a constant speed or adjust the ASV’s speed. The propulsion must be able to navigate the boat through the entire course in less than thirty minutes but cannot reach a speed above 10 knots. After considering these elements, a Minn Kota motor was chosen. This motor was not only readily available since it was used on the 2007 ASV Team's boat, but also because it was a submersive motor that possessed enough power to propel the ASV through the water. Two 12V lead-based sealed batteries were wired in series and sent to the motor controller. Minimum modification was needed in adapting the motor to the boat, but a tachometer was placed inside the motor housing which the propeller's shaft comes out of. This was implemented in order to be able to regulate the rotational speed that the propeller would be spinning at. The tachometer outputs a DC voltage directly proportional to the rotational speed of the motor. This signal subsequently feeds into the *Advanced Motion Controls* (*AMC*) motor drive. The motor drive simultaneously receives a voltage signal from the control box to obtain a constant speed for the boat. The difference between these two voltages creates a minimized feedback error resulting in a closed control loop. The maximum rotational speed that was achieved during testing was 1200 RPM.

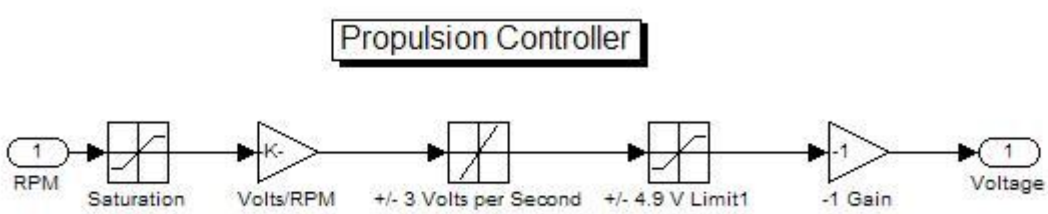


Figure 5: Propulsion Control Diagram

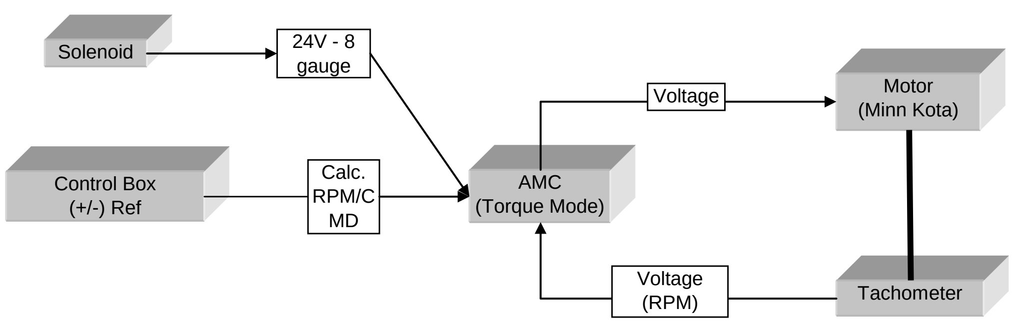


Figure 6: Propulsion Block Diagram

Steering

The steering system is responsible for maneuvering the vehicle. The motor mount steering assembly is a duel mounted system that constrains the motor but allows it to rotate freely in the left and right direction. The steering system is a wielded part consisting of a standard 13/8" outer diameter tube. The tube has two bushings to keep the motor in place, along with a 3/4" tube that is wielded on the outside of the lower mount. A U-channel was also crafted for the top mount. These two mounts are offset 1" from each other. The inner piece of the mounting assembly was crafted out of steel and acts as a sleeve around the motor shaft, due to the fact that the motor shaft is made of plastic. A needle roller bearing is used to control the axial direction and is fitted with a shaft seal. This part is then bolted on the top and bottom of the mount to the motor shaft.

The steering system is able to obtain and maintain a steady calculated course in a desired direction. A 12V 88 in-lb gear-motor controls this system. The main reason behind choosing this is that once obtaining a certain position, it does not require any additional voltage to stay there. In addition, it has a compact design and high torque capability. A 15 tooth, quarter-inch pitch sprocket and optical incremental encoder attaches to the window motor's custom-made shaft. The sprocket controls the direction of the boat's motor using a 90-tooth, quarter-inch pitch sprocket that attaches to the propulsion motor. A chain connects the two gears and creates a drive gear-chain system with a 6:1 ratio. The ratio was chosen based on the window motor's speed when given the lowest voltage required to spin the motor. This ratio results in high torque and low speeds for the steering of the propeller, which is between 0-85° per second. This allows for high angle accuracy without sacrificing steering speed. The encoder then communicates with the control box to implement the exact angle of the steering system.

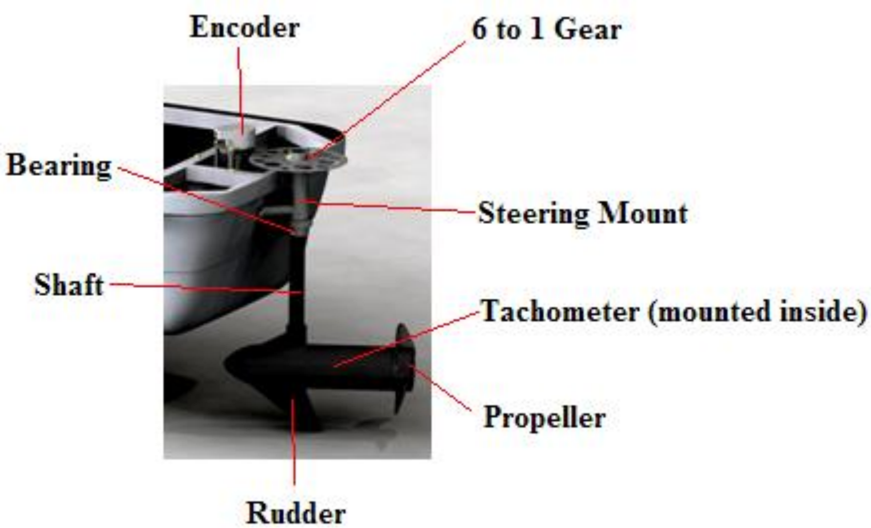


Figure 7: Motor Mount and Steering System

The software for the steering assembly communicates with the *AMC* motor controller in order to position the motor at a desired angle specified by the navigation system. The encoder will relate the position of the motor to the *AMC* controller via the control box to close the steering algorithm loop. The angle the boat needs to turn is sent from the video card to the control box via a user datagram protocol (UDP) packet. It is formatted in the following way:

{[Distance to Buoys],[Angle to center of buoys],[Normal angle to buoys],[# buoys past]}

This angle is then used in a proportional integral derivative (PID) control scheme to control the offset of a set point from a pre-established zero position. The gains are set to the following: a proportional gain of 2, an integral gain of 0.012 and a derivative gain of 0.3.

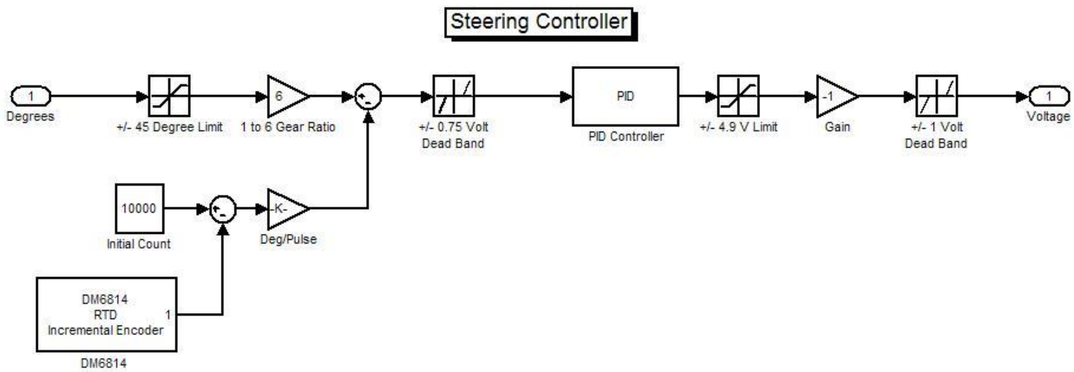


Figure 8: Steering Control Diagram

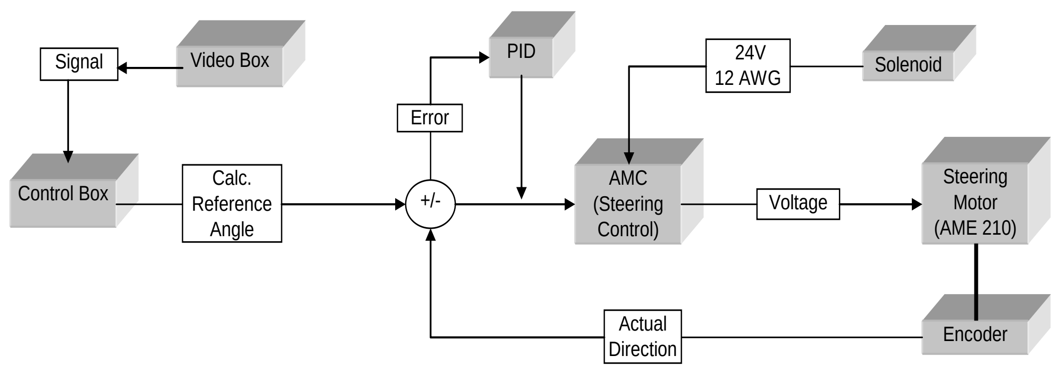


Figure 9: Steering Block Flow Diagram

Weapon System

The ASV is equipped with a gun system capable of locating shore batteries that are lit with red LED lights while avoiding unlit targets. The targets occupy a 3x3" square and each target is 4" away from each other, therefore making the need for accuracy important. In designing the gun, many functional requirements had to be met. Since there are three targets, the gun must be able to fire multiple shoots while on the water. It must also be able to shoot rapidly on command when it receives this signal. Finally, in order to locate and distinguish between lit and unlit LED lights, the gun must implement a vision system. In working within these elements, an automatic reload paintball gun was decided upon. The gun's automatic trigger allows for multiple rapid executions once signaled to fire. In addition, since the paintballs will be released from the gun at such a high momentum, any wind factor that could otherwise bend the course of projection can be ignored.

In deciding on how to execute the defense system, a "drive-by" system was chosen. Since the boat will pass the dock steadily, the gun system will have to be able to move within at least one degree of horizontal freedom. Conversely, it was figured that the system should be able to move freely in a second degree of vertical freedom in order to overcome any movement from the rocking water or the different distances the targets will be from the actual ASV. These notions were implemented using two 12V 88in-lb gear motors. These were chosen for their high torque, which was needed for the gun's relatively heavy weight, and steady programmable speeds. These gear motors also have the ability to hold an angle without drawing any current once the desired angle is obtained. The first gear motor is positioned underneath the gun, below its mounting plate. This one rotates the entire gun system in a left to right manor. The second gear motor is located on the left side of the gun mount which regulates the angle of elevation the gun's barrel makes with the horizontal. A custom made gun rest holds the gun upward and a camera mount located right underneath the paintball gun's barrel allows it to have accurate vision.

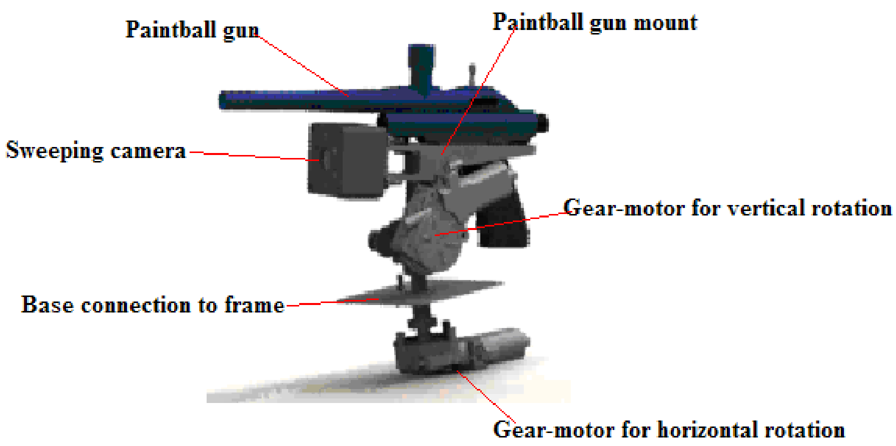


Figure 10: Weapon System

Through the camera, the gun's two gear motors will align it correctly with each lit target. The camera used is a 40° Vision Technologies shipboard camera. The camera will then proceed to find the center of the target by placing the LED light in the center of the 3x3" white target square. Each gear motor will adjust accordingly until the camera finds the center of the target, but within some degree of leniency as to factor in that the gun barrel is a couple inches higher than the actual camera lens.

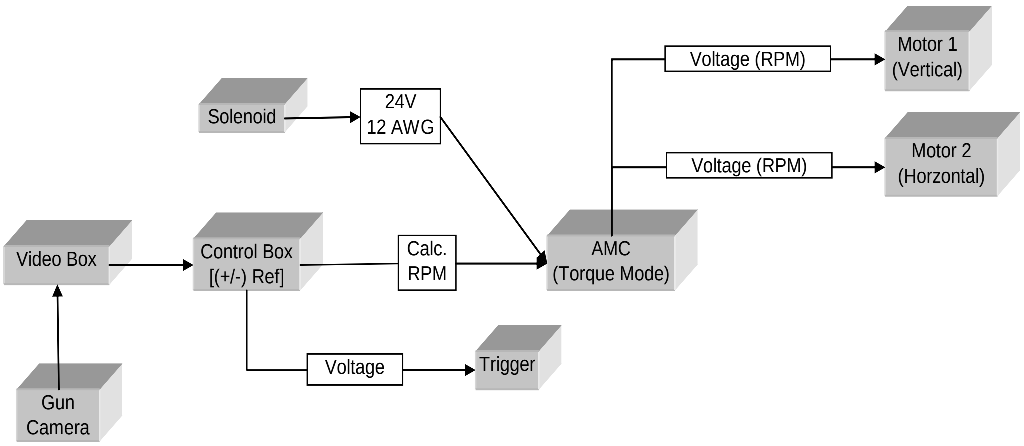


Figure 11: Defense System Block Diagram

To acquire essential accuracy, two potentiometers were used to provide necessary feedback that controls the position of the gun. The potentiometers are attached inside the window motors. All of this information is continuously fed back into two *AMC* controllers, one to control each degree of freedom, which output an analog voltage signal that controls the motors to minimize error.

Figure 12: Weapon System mounted in frame

Recovery

The recovery system also needed to be designed in order to comply with an array of functional requirements. The ASV must recognize and approach a Velcro mannequin without knocking him into the water. The mannequin will be standing upon a dock that is 1’ above the water’s surface. Therefore, the recovery system must be able to reach this height. On top of this, the mannequin is 6” high so there is additional height requirements to observe. When placed into the water, the ASV’s top is approximately 6” above the surface of the water. Because of all of this, the recovery has a range of 6-12”above the cover of the boat to work between. In addition, after capturing the mannequin, the recovery system must be able to hold onto and bring it back to the starting position. This makes a need for a resting place for the mannequin.

To compensate for the height difference, an L-shaped retrieval box-arm was designed. The shorter leg of the “L” stands vertically and attaches to the rotational axis. The longer leg of the “L” lays horizontal, parallel with the top of the hull.

Figure 13: Recovery Arm Closed

A 12V 88in-lb gear motor is attached to one side of the recovery box and when activated rotates the entire system around a horizontal axis. A Velcro net fills the hollow inside of the retrieval box arm and is loosely hung between each corner. As the arm flips over, it will knock over the mannequin doll and it will be retrieved as the Velcro catches. Once this happens, the retrieval arm will rotate back and the mannequin will rest upon this on its way back to the starting gate.

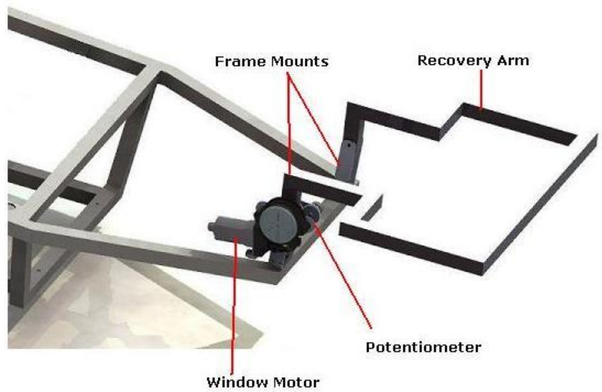


Figure 14: Recovery System Open

A passive range marker, consisting of a red outlined square around a blue circle is located above the mannequin. By using the 40º stationary camera, the direction and approach to the mannequin can be found. The boat will understand to stop moving forward once it has obtained a desired distance away from the dock by computing the distance it senses between the red square's sides and the blue circle. After the retrieval system has performed its task the ASV will back out of the dock and head to the starting gate.

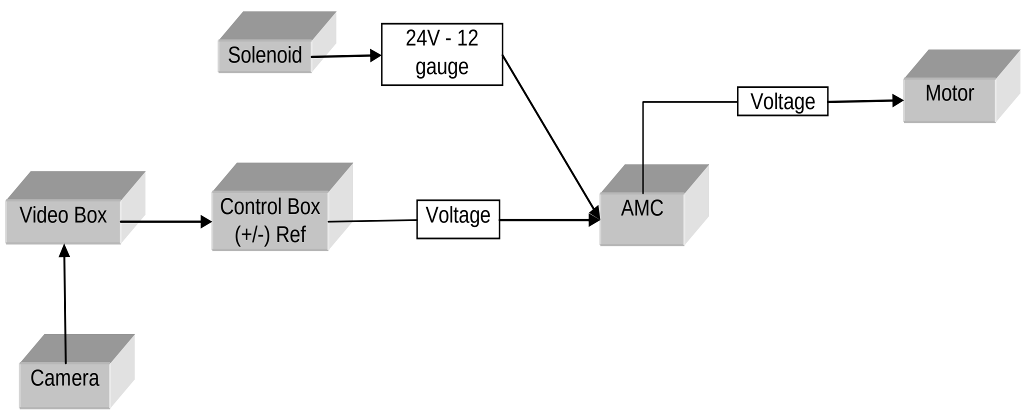


Figure 15: Recovery System Block Diagram

Hardware Assembly

Each component of the hardware and its corresponding software system were mounted onto the aluminum frame in an area which was deemed most productive for its tasks. The batteries sit on the bottom of the frame in order to make the center of gravity very low and towards the back of the ASV. The recovery system is mounted onto the front bar of the frame. This was done because in order for the recovery system to work properly, nothing could be in its path as it gets flipped around. The first camera, a stationary one is held up by aluminum tubing about 6" off the cover of the boat. This allows for an unobstructed view of what is in front of it. Behind this is the weapon system. The gun is able to rotate from left to right because of the gear motors so that the camera that is fixed to this set up is able to get a sweeping view of that ASV's location. In this way, targets and buoys that are located to the side of the boat can be seen. The video box and control box are both located in the lower part of the ASV towards the front. The control box's centralized location allows for its access to the many subsystems found onboard. The video card's location was decided because more weight was needed in the front of the boat in order to maintain a steady center of gravity. Also, it could be easily connected to both cameras and the control box when mounted here. A fuse box, solenoid, and the emergency stop reset hardware are all located along the sides of the lower part of the frame. These were placed to disperse weight evenly throughout the hull as well.

ELECTRICAL SYSTEMS

Electrical System

The electrical system functions as the supplier and distributor of power to all systems on the ASV. Power is supplied by two 12 Volt *Odyssey* batteries. This was chosen because the ASV's motor controllers work off a 24 Volt power supply that can be obtained when these batteries are wired in series. In addition, the batteries were already waterproofed. Two DC/DC converters- a 5 and 12 Volt- hook up to the electrical system in order to give the systems the correct amount of voltage. The video processor, GPS, INS, encoder, and compass connect to the 5 Volt regulator, while the control box and the cameras connect to the 12 Volt regulator. In order to turn the boat on, both manual and wireless emergency stop switches need to be set in the on position. The reset button then has to be held for 2 seconds. This triggers a simple latch relay which in turn provides power to the coil of the solenoid. The solenoid then allows power to flow from the batteries to the motor controllers and the remaining components.

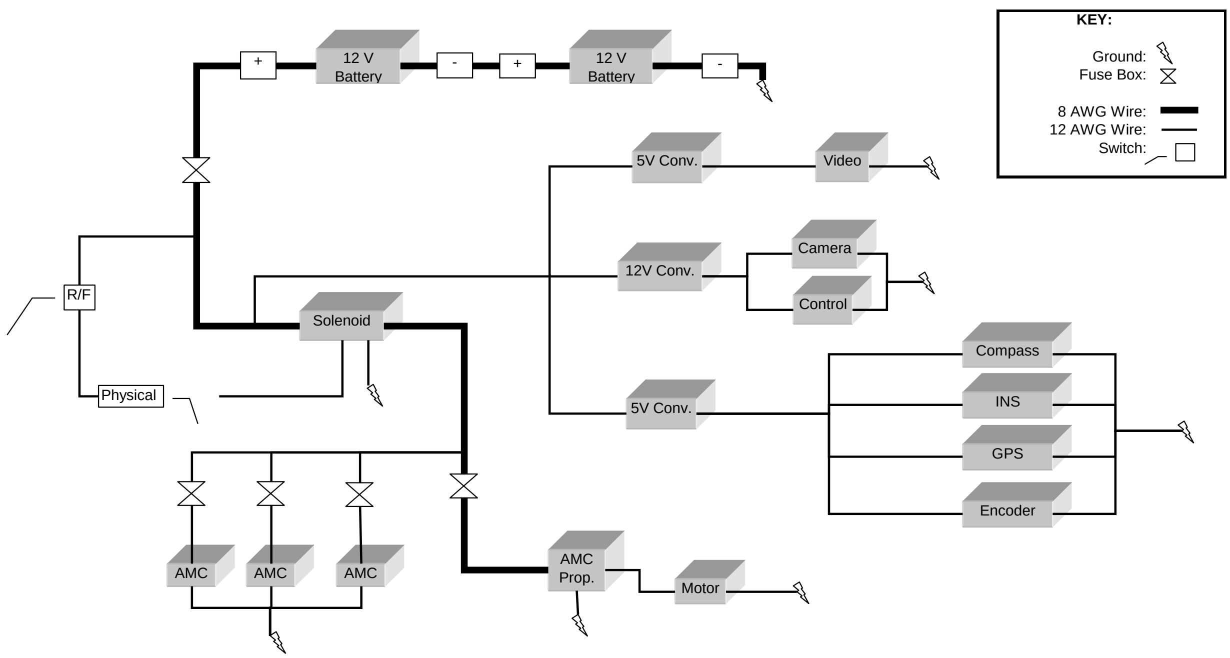


Figure 16: Electrical System Block Diagram

Emergency Stop

The emergency stop system, or E-Stop, is responsible for the complete halt of all power supplied for each system at any time during the ASV's activity. There are two ways to engage the E-Stop. The first is a wireless signal from a remote controller. The second way is the physical E-stop, a large red button found on top of the boat's frame. The power supply will shut down and remain off until a reset button present in the hull is switched on. This succeeds because the E-Stop employs a solenoid to control the power supply for the boat. When the E-stop is activated, the solenoid coil loses power, thus turning off power to the rest of the systems on the boat.

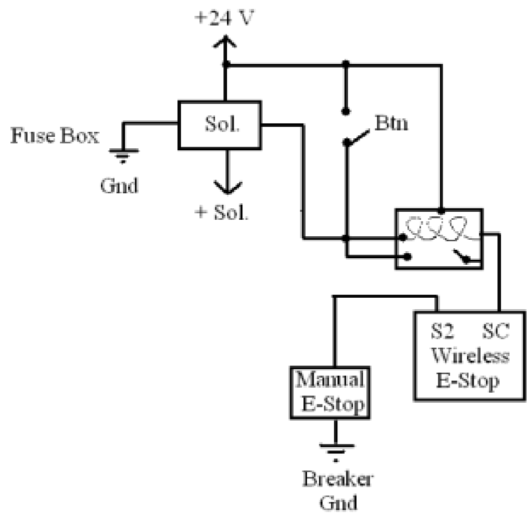


Figure 17: E-Stop Wiring Diagram

Control System

The control system is responsible for overall control of the mission and mission planning. It is comprised of two things, the main hardware of the control box and its associated software. The control box itself is a custom made Pelican 104 made by Pathway Technologies Inc. The Pelican 104 is a small industrial PC based on the PC/104 specification that runs xPC Target 3.3 as an operating system. Internally to the control box there are five PC/104 cards that interface internally with the main PC/104 control bus and externally through the use of a 50 pin D-Sub connection. There are two Diamond Systems Diamond MM-16-AT analog input/output cards. Also from Diamond Systems, we installed the Emerald EMM-XT card which has four RS-232 ports. The last two cards were made by RTD Embedded Technologies, Inc. They are the RTD DM6804 and the RTD DM6814.

Table 1: Internal PC/104 cards within control box

Name	Manufacturer	Function	Quantity
DM6804	Real Time Devices	Captures and measures a pulse width modulated signal.	1
DM6814	Real Time Devices	Counter timer card. Allows one to keep track of an encoders position	1
Diamond 16-AT	Diamond Systems	Provides digital and analog voltage I/O.	2
Emerald MM-XT	Diamond Systems	Provides 4 RS-232 I/O ports for serial communication.	1

Table 2: External components connected to control box

System	Function	Interface
GPS	Gives the latitude, longitude and ground speed of the ASV	RS-232
INS	Gives the x, y, and z accelerations in gravity in relation to the ASV	RS-232
Compass	Gives the degrees off of true north	RS-232
Encoder	Gives the position of the steering relative to the starting position	Custom 50 pin I/O
Video Card	Processes a video stream from a camera	Ethernet

The control box is interfaced with a number of components and sensors including five Advanced Motion Control motor controllers, an encoder, four potentiometers, a TI C6000 video processing card, a GPS, an INS and a compass. The five AMC motor controllers, the encoder and the four potentiometers are interfaced with the Diamond MM-16-AT cards. An analog voltage is sent to the motor controllers which turn the desired motor. The potentiometers are used on all but one of the motors. Their voltage output is sent back into the box to be processed. This keeps track on how far the motor shaft has turned. The only motor that does not use a potentiometer is the propulsion motor. However its output is monitored through a tachometer mounted inside the motor housing. It is used in order to monitor the current being fed into the motor. The tachometer outputs a voltage proportional to the amperage being used by the motor. This keeps the motor turning at a constant RPM. On the steering shaft a potentiometer and an encoder are used. The potentiometer zeroes the shaft to make sure the ASV drives straight. After this is accomplished, the encoder takes over due to its higher level of accuracy. The accuracy obtained is upwards of a tenth of a degree. The output of the encoder is fed into a control loop which uses a proportional integral derivative controller to obtain this high level of accuracy. The video card connects to the Pelican 104 simply through the use of a cross over cable. It sends UDP packets which are obtained by the software and processed. The three sensors, GPS, INS and compass, connect to the Emerald MM-XT card via a custom made 50 pin D-Sub connection. There outputs are fed into our navigation algorithm that enables the ability to control the boats motion and positioning in the water.

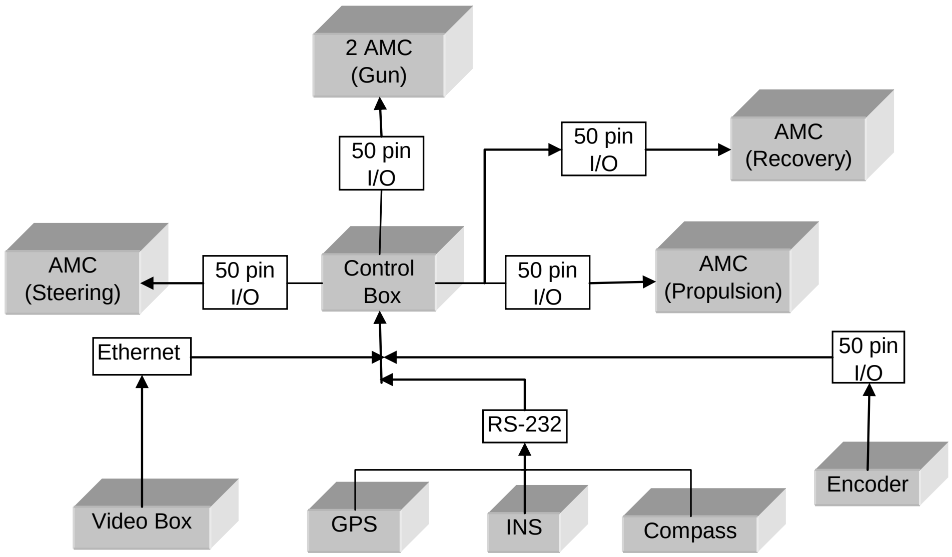


Figure 18: External Control Box Block Diagram

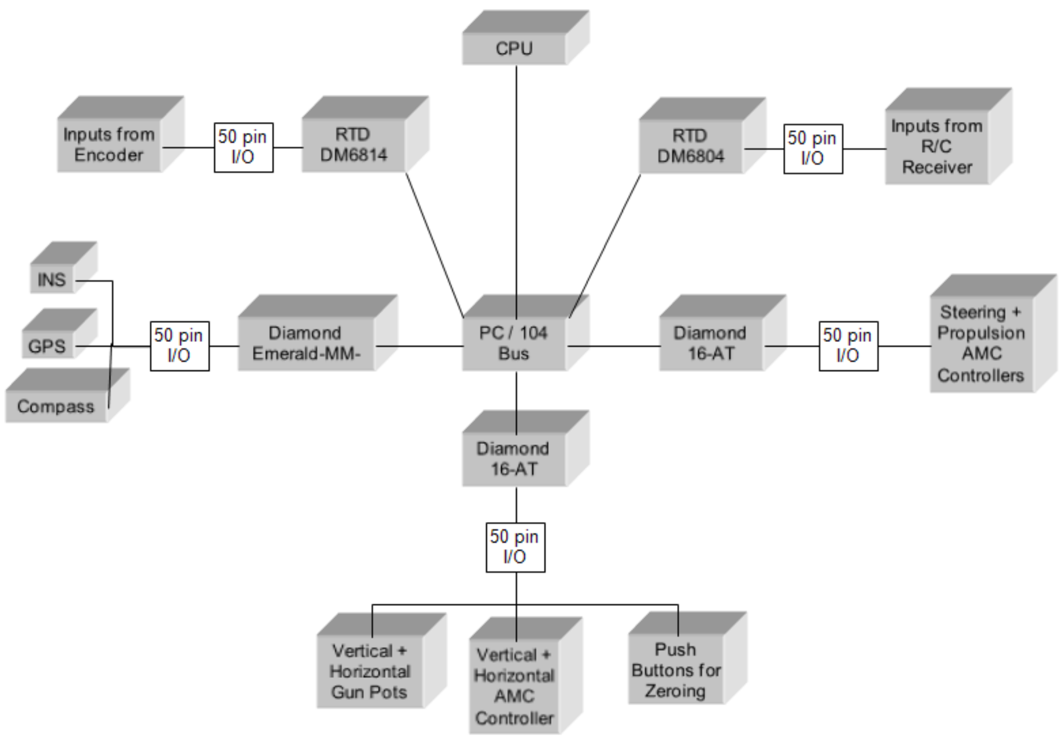


Figure 19: Internal Control Box Block Diagram

All of the control systems are written in Matlab and Simulink. The entire program then is embedded onto the boat so it will start when the boat is turned on. There is one main control loop that controls the entirety of the mission. Each objective is placed into a smaller triggered subsystem. This assures the completion of the first objective before the boat attempts to accomplish the second objective. As stated previously, all of the sensory data from the external instruments and cameras are fed into these subsystems and provide appropriate positioning data.

All of this data is logged and extracted after the fact so it can be viewed in order to analyze the run to troubleshoot any problems that occurred.

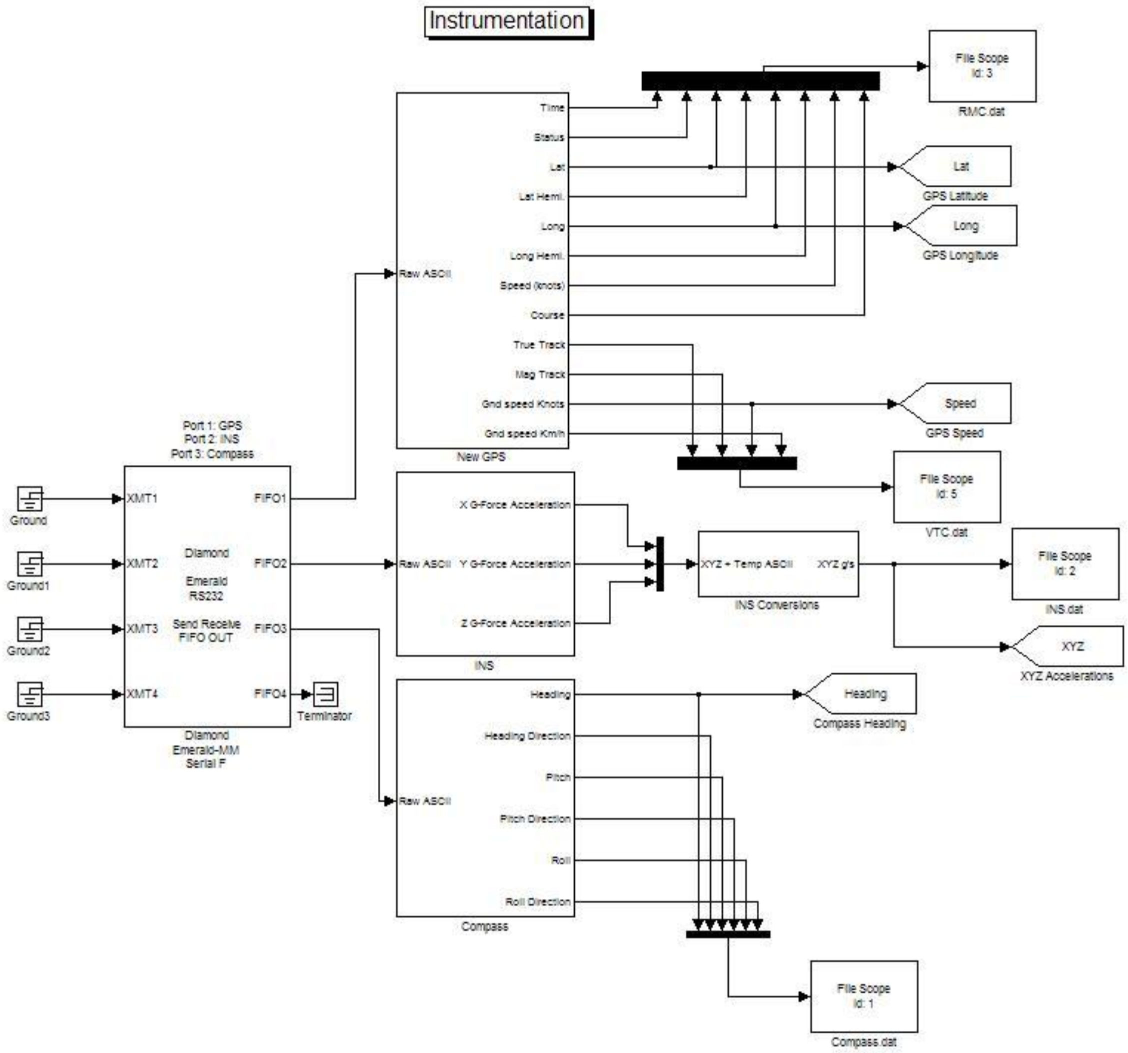


Figure 20: Instrumentation System

Navigation System

The boat's navigation is based on input from the cameras. Matlab and Simulink were used once again in parallel with our Digital Signal Processing (DSP) video card. The captured video is sent from the cameras, fed into the card and subsequently processed by custom video processing algorithms. A single subsystem is allocated to each of the objectives and triggered at the appropriate time. This is accomplished by intercommunication between the DSP video card and the control box. Once an objective is specified, the corresponding subsystem is triggered and the card begins to send UDP packets to the control box to communicate the closest objective's position relative to the boat. The control box stores this value in its memory and estimates the relative location. Then, through the use of the GPS, INS, and compass along with a continued feed of UDP packets about the objectives location, the boat chooses a proper course, sets a heading and navigates to that objective. A heading control algorithm is used in order to keep the boat in line with this objective. When an objective has been cleared, a UDP packet is sent from the control box back to the card in order to stop execution of the current subsystem and to trigger the next subsystem.

The ASV has three major subsystems that it goes through during the mission. The first thing that occurs is the initialization routine. This assures that there is no bad data being output by any of the instrumentation. During this time, the system undergoes zeroing of the propeller. After this is accomplished, the ASV proceeds to process the incoming image stream to navigate itself through the pairs of buoys. First the stationary camera looks for red and green buoys that are closest to this. It distinguishes the closest set of buoys by deeming the ones at the bottom of the screen the closest. After that, the camera looks for if there is a complete set of red and green buoys in the picture. If this is so, the boat makes a heading to the center of this pair. If only a red or a green buoy is present in the camera's field of view, it inserts the missing pair on the appropriate side 6' away (red being on the right and green being on the left. The ASV will then navigate to the center of this. The boat continues this until it has either successfully navigated through six sets of buoys or this subsystem times out. A time out analog is implemented for each subsystem so that the ASV does not get stuck in one mode and can continue onto the next mission even if the previous one is not fully completed.

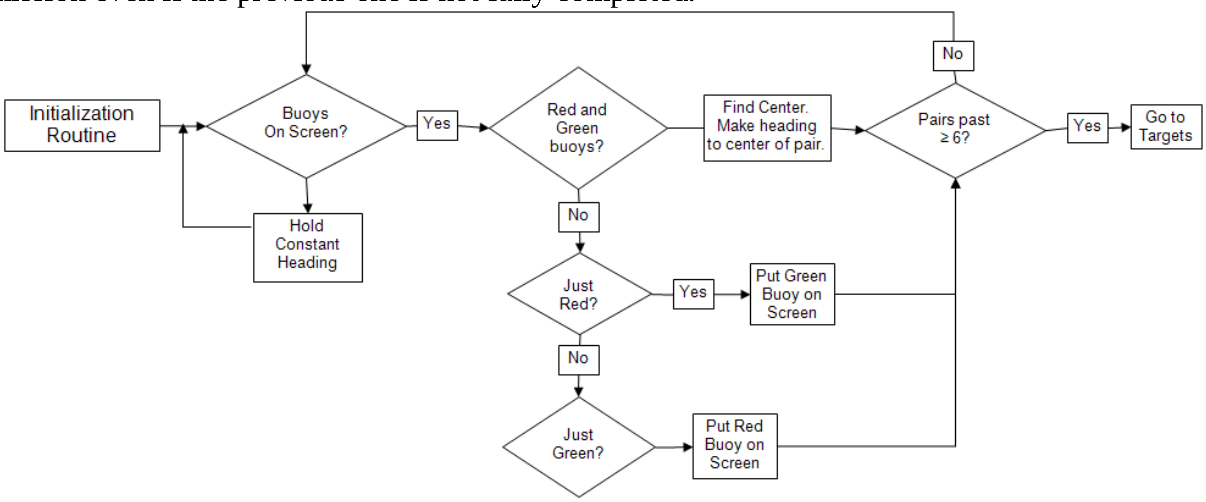


Figure 21: Buoy Navigation Routine

After the buoy routine, the ASV attempts to acquire targets. The sweeping camera becomes activated and attempts to locate the red LED lights. Once the boat is close enough to the targets, it will use the sensors in order to center the LED in the middle of the camera's view. This is accomplished by moving both the horizontal and vertical window motors. Once the LED is centered, the gun's trigger is activated. Similar to the buoy routine, when all three targets have been eliminated or the system has timed out, the ASV moves on to recovery.

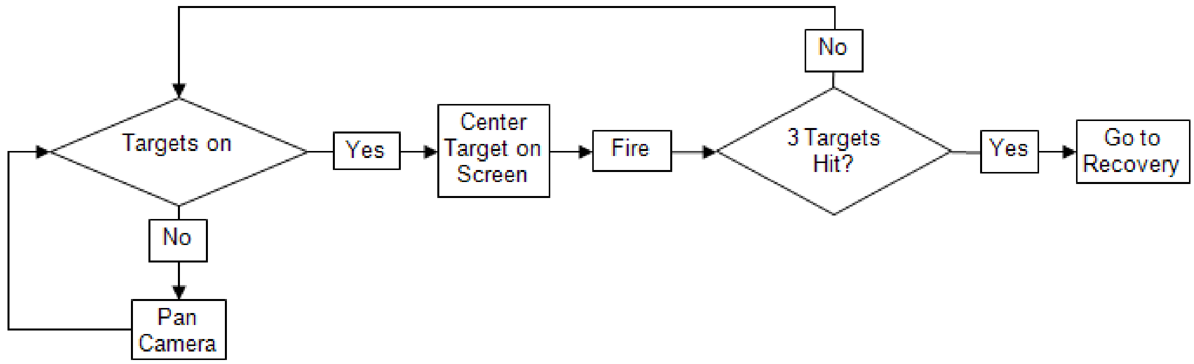


Figure 22: Targeting Routine

The final routine that the ASV runs is the recovery routine. Once the ASV completes the targeting routine it turns in the direction of the recovery dock and pans the sweeping camera in search of the strobe light. When this is found, the ASV moves closer to the recovery dock and begins searching for the passive range finder through the use of the fixed camera. The passive range finder enables the ASV to know how far away it is from the dock as well as enabling it to pull straight into a dock rather than an angle. The passive range finder is made up of a red box and a blue circle within it. Because the size of the box is known, the distance to the passive range finder can be calculated based on the number of pixels it takes up on screen. Also, the angle to the passive range finder with relation to the boat can be calculated and corrected by using logic that says the blue circle must always be in the center of the red square. Once close enough to the dock the recovery arm is lowered and raised back up in order to retrieve Agent James Velcro. Then the boat backs out of the dock and returns to the starting gate via a stored GPS data point.

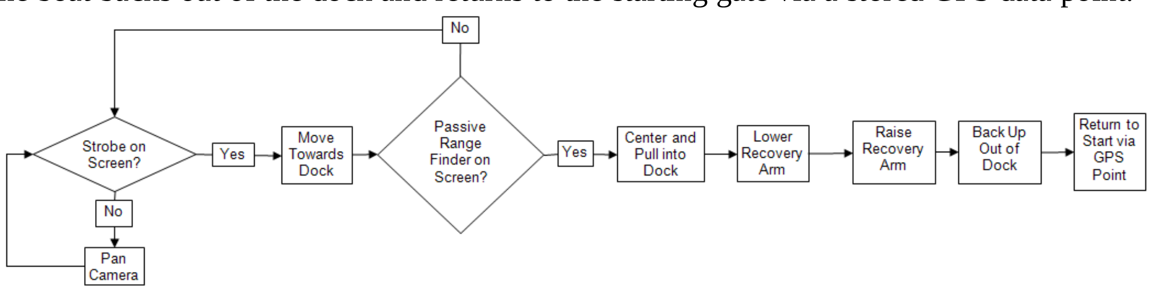


Figure 23: Recovery Routine

Video

The vision system is responsible for recognizing the dynamic and real-time video data that is pertinent to the system's primary tasks. The video processing was realized through a Texas Instrument DSP processor platform, using the Matlab and Simulink programming environment.

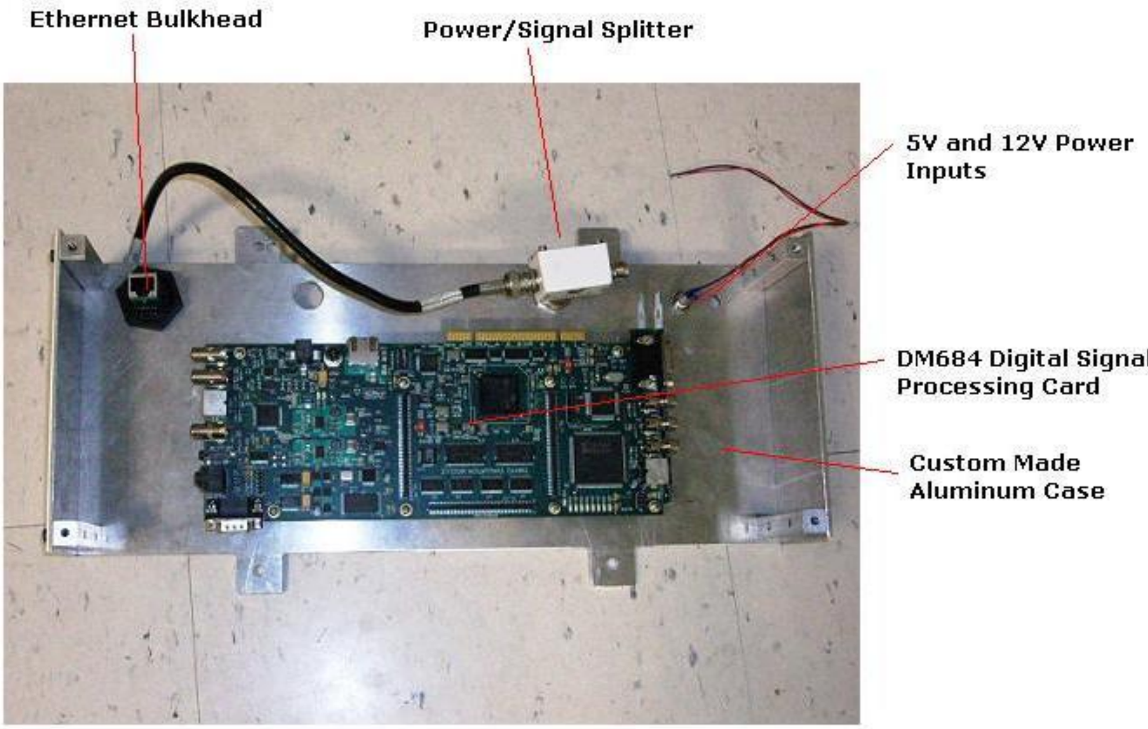
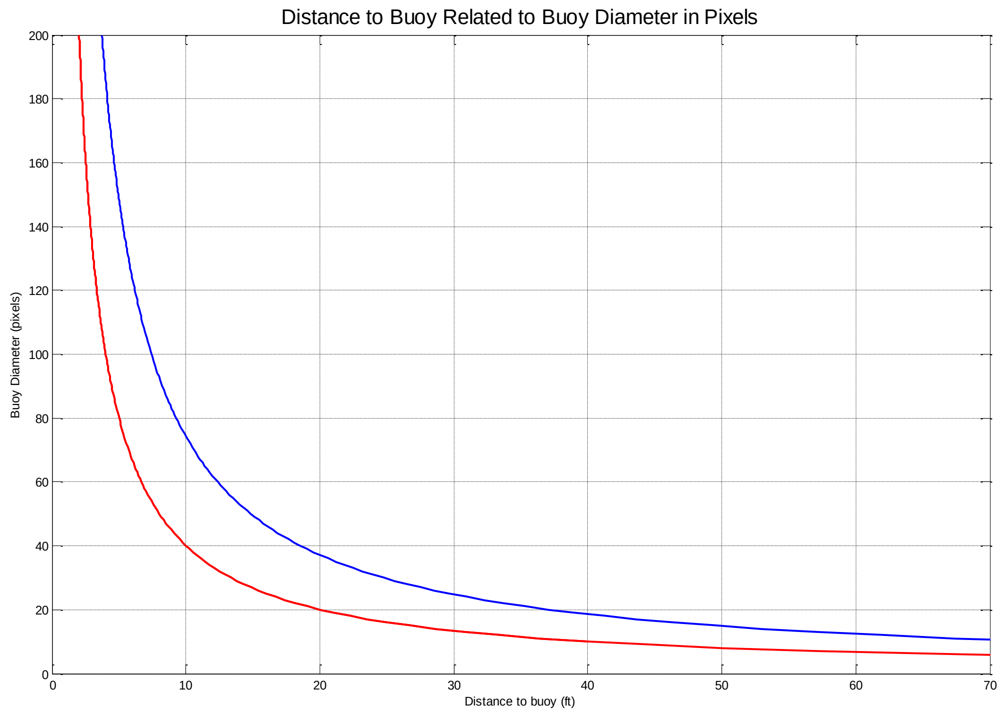


Figure 24: Video card box

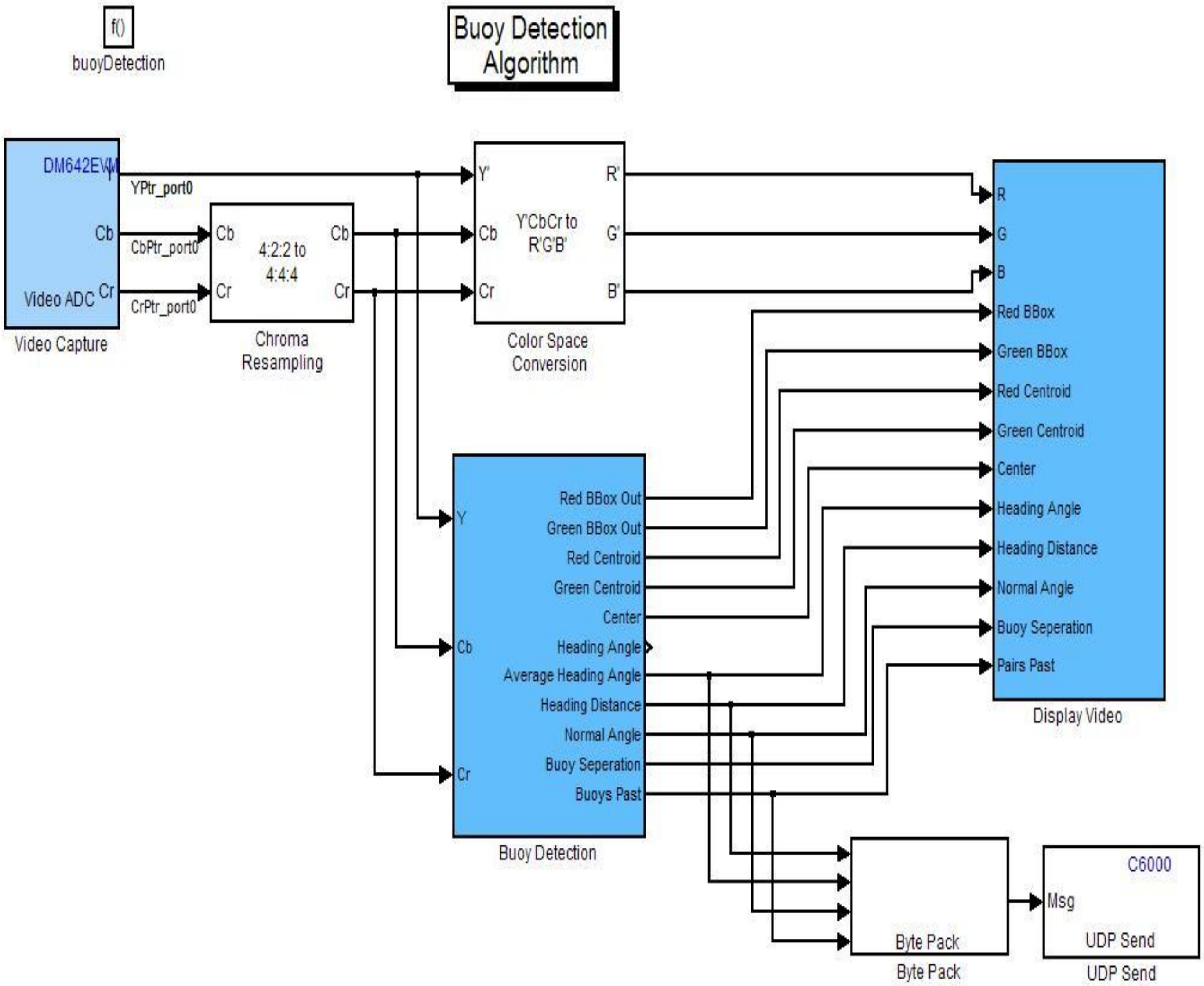
The information contained in the UDP packets was kept relatively simple in order to keep the packets small and to keep processing to a minimum on the control box. However, the actual video processing is relatively complex. First, in order to decrease problems resulting from reflections on the water, the bottom half of the image is disregarded. The remaining half is then processed using the YCrCb color space. Each pixel within this color space is made up of three values from the three matrices that make it up; one from Y, one from Cr, one from Cb. Since a specific color will have a distinct color combination within these three matrices, three separate processes are used to find where these values exist in a given matrix and these results are logically combined together. This successfully extracts the desired color from the given image. From this output, one can compute many different things. For example, because the size of the buoys is known, one can compute the distance to the buoy on the camera by using the number of pixels it takes up on the screen.



After this initial video processing, additional logic and computation takes place. The logic that executes depends on what objective is being sought after. For example if we are attempting to navigate the buoys, some of the buoys are excluded because they are too far away and the midpoint is calculated between the closest ones.

With respect to its primary tasks, this system is capable of recognizing channel buoys and any number of targets, in real-time, and outputting the necessary vital information to the control box that interprets this information.

During the first phase of the competition, the video processing card runs the buoy finder algorithm. It applies multiple color filters in order to locate the desired objects and compute the distance to the center point between these objects. The process outputs information to the control box so that the appropriate action can be realized.



During the second phase of the competition, the LED finder algorithm is used to distinguish between lit and unlit targets. The information is then fed into a PID controller that minimizes the distance between the centroid of the targets and the boundary lines of a specified region of interest, or ROI. This acts as an aiming instrument for the gun system. The region represents the area in the screen that corresponds to a likely hit from the gun system. Thus, when the target is aligned with the ROI, the fire command signal is sent to the gun system. The algorithm iterates this control process for however many targets it is able to locate.

Lastly, during the last phase of this competition, the Range finder algorithm is used to provide logistical information so that the ASV can dock properly in the U shaped dock and utilize its recovery system effectively before performing the sprint to the finish line.

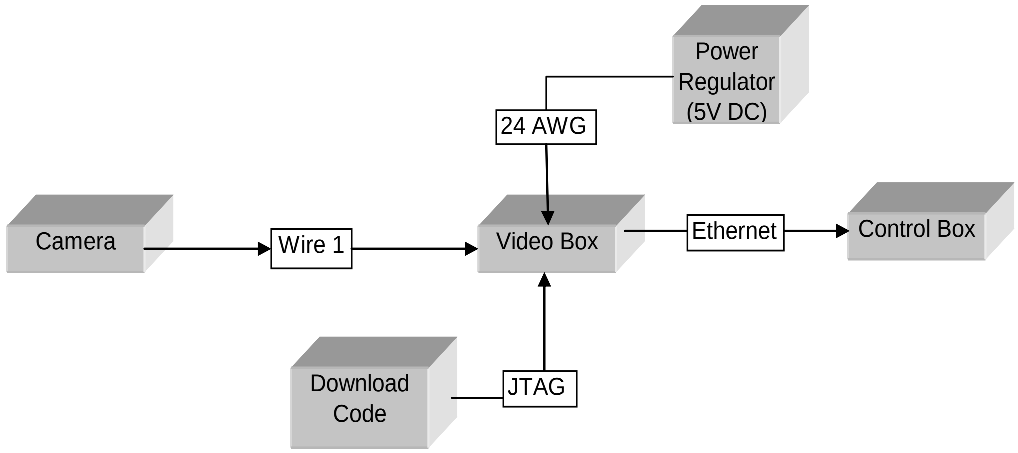


Figure 25: Video Block Diagram

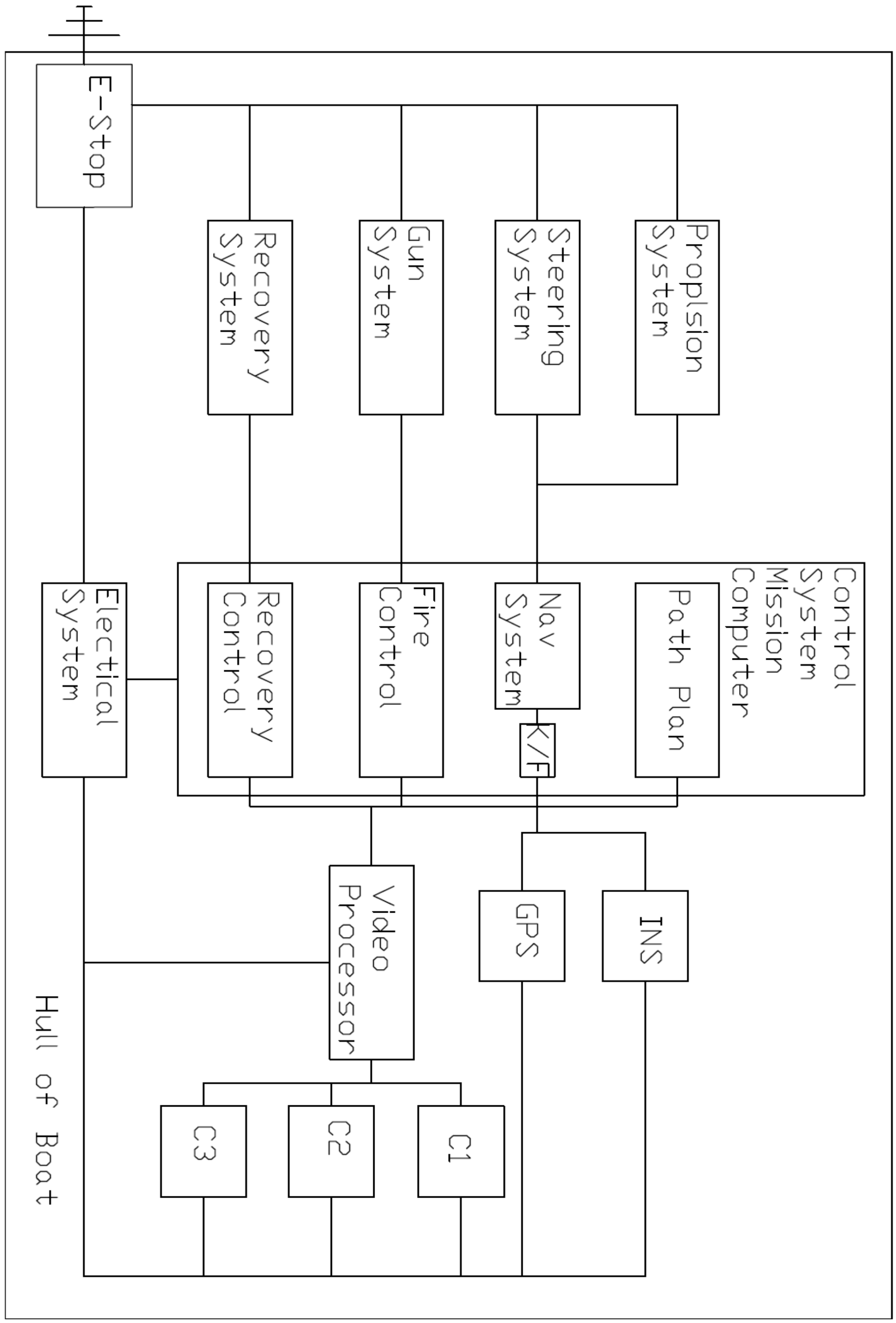
CONCLUSION

Hot Box is the accumulation of our team's experience and knowledge. We were able to adapt some of the 2007 team's models, software, and ideas. However, due to the extensive changes in the competition, we were left designing most of our ASV from new. Despite this, we believe that we have manufactured and programmed a respectable ASV capable of performing the tasks specified and are definite contenders in this year's autonomous surface vehicle competition.

Autonomous Surface Vehicle Team 2008

Jevon Avis- Mechanical Engineer Masters Student, team leader
Alex Baumer- Mechanical Engineer undergrad
Elizabeth DiBella- Mechanical Engineer undergrad
Fred Floyd- Mechanical Engineer undergrad
Mathew Goldsborough- Computer Engineer undergrad
Michael Matsushima- Mechanical Engineer undergrad
Nicholas Melgar- Mechanical Engineer undergrad
Daniel Morden- Mechanical Engineer undergrad

Appendix A: Complete Control System Layout



Appendix B: Hardware List

Equipment	Function	Part Number
Thule 682 Sidekick Rooftop Cargo Box	Hull for boat	
Diamond-MM-16-AT Autocal 16 bit 16ch Analog I/O PC/104 REV J	Analog I/O Card (internal to control box)	DMM-16-AT
Emerald-MM RS-232/422/485 XT PC/ 104 Module	RS-232 I/O Card (internal to control box)	EMM-XT
PC/104 Board, 2 CAN buses, with galvanic isolation	Control box and CAN card	CAN-AC2-104
Garmin GPS 18 5Hz Receiver	GPS	100032107
Propulsion Controller	AMC motor controller	120A10
Gun, Recovery, and Propulsion Motor Controllers	AMC motor controller	12A8
DM 642	Video card	TMDSEVM642
0.032" Thick Washer for 1-1/4" Shaft Diameter Steel Needle Thrust Bearing	Steering mount	5909K520
Steel Needle Thrust Bearing Cage Assembly for 1-1/4" Shaft Diameter, 1-15/16" OD	Steering mount	5909K380
Rulon Lr Sleeve Bearing Sleeve, for 1-1/4" Shaft Dia, 1-1/2 OD, 1" Length	Steering mount	6362K196
Shaft Seal	Steering mount	SKF-CR_16039
Alloy Steel 4130 Normalized Tube,1.25"x0.065"x1.12", 24"	Steering mount	7341
Mild Steel 1018 Cold Finish Round 3", Cut to 5"	Steering mount	7566
Alloy Steel 4130 Normalized Tube,1.25"x0.065"x1.12", 12"	Steering mount	10755
Mild Steel A36 Hot Rolled Square Tube 1"x0.065", Cut to 12"	Steering mount	10301
Odyssey Battery PC625	On board power	ODY-PC625
Nylon Machinable Bore Sprocket for #40 Chain, 1/2" Pitch, 10 teeth, 1/2" min Bore	steering mound	60425K163
Acetal Chain with Stainless Steel Side Plate ANSI #40, 1/2" Pitch, 0.312 Roller Dia, 3' Length	Steering mount	6228K133
Machinable Bore Flat Sprocket for 40# Chain, 1/2" Pitch, 60 teeth	Steering mount	2299K38
AME 210-series 12V 88in-lb RH gearmotor-shaft	Gear motor for gun and revovery	AME-210-1011
Hollow Bore Optical Encoder 500 CPR with index to fit 1/2" diameter shaft	Encoder for steering	HB6MD-500-500-IN
Tachometer Generator	Voltage monitor for motor	SA-740A-2
Gear for steering, pitch 0.25, teeth-90, 0.5" bore, dia 7.309"	Steering	A 6C 7-25090
Gear for steering, pitch 0.25, teeth-15, 0.25 bore, dia 0.875"	Steering	A 6C 7-25B15
Chain for Steering, Pitch 0.25", stainless Steel, tensile load 700 lbs	Steering	A 6Y 7-25
Single Beam Couplings, max bore dia 3/16", min bore dia 1/8", anodized Aluminum	Steering	87792495
Souriau JBX Push-Pul PLG SHELL 0 2P SLDR	Power connectors for video box	649-JBXFD0G02MSSDSR

Exxex White Rodgers 124-114111 DC Power Solenoid	Solenoid (main power 'switch')	124-114111
1W 10Kohms 20% ETI Systems Single Turn Conductive Plastic Potential	Gun and recover potentiometers	882-EUP1900-10K
Encoder Card	Encoder	
Brass Eagle 12-Gram Quick-Change Adapter	Adapter for CO2 cartridges	B001715ITO
Battleswitch 10A R/C Switch	Wireless E-STOP	0-BATTLSW1
6-BEAM ALUM COUPL 3/8 PIN HUB	Gun mount hardware	CO36A-1
Zinc-Plated Steel Open End Knurled Rivet Nut 6-32 Internal Thread, .020"-.080 material Thk	Misc hardware	95105A111
Zinc-Plated Steel Open End Knurled Rivet Nut 8-32 Internal Thread, 0.20-0.80 Material Thk	Misc hardware	9505A119
Zinc-Plated Steel Open End Knurled Rivet Nut 1/4"-20 Internal Thread, 0.027-.165 Material Thk	Misc hardware	95105A143
SAE 841 Bronze Sleeve Bearing for 1-1/4" Shaft Diameter, 1-1/2" OD, 1" Length	Recovery hardware	6391K295
Steel Ball Bearing--ABEC-1 Double Sealed, No. R10 for 5/8" Shaft Dia, 1-3/8" OD	Recovery hardware	60355K37