Spring Proposal

Future Plans for Spring Semester

Team 10

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Abstract

The Marsupial Deployment and Engagement computer design and analysis is coming to an end, as well as the fall semester. The next half of the project is outlined in the form of a report to present future goals, deadlines, and the paths to be taken to complete the project.

It is the intention of the team to develop and test various methods of engaging and disengaging the BomBot to the RMAX helicopter in order to provide the customer with a fully functional, safe, and user friendly system which meets all of their design requirements. This is planned to be completed utilizing the ball and socket design as well as the swinging platform design. Both of these designs will be necessary in order to fully meet all requirements of the engagement and disengagement of the BomBot to the RMAX.

Tests will be set up to research the response of the BomBot to various engagement and deployment conditions. Analysis of the static and dynamic responses of the BomBot with its environment will be conducted as well. This research is important to understand if the BomBot is to be controlled by a computer based on simple programming logic.

These tests are necessary to create an autonomous engagement process by the end of the spring semester.

Introduction

AFRL expects a completed product by the end of the senior design project. This design must be fully tested in all situations to prove useful to the Air Force and safety of the RMAX in flight. A large portion of the mechanical design has been completed and little is left to meet the design requirements stated by AFRL. Briefly stated, the BomBot has to securely engage and disengage from the RMAX helicopter to be safely transported in flight between locations. To safely engage the RMAX the BomBot will make use of the Ball & Socket system along with the Swinging Platform.

The socket portion of the Ball and Socket system is mounted to the RMAX and the balls, of course, are on the BomBot. The male end, being the balls of the BomBot, will penetrate and align itself into the female portion, or the socket on the RMAX.

The swinging platform is to lower the camera and antenna based on specifications set by the team to create clearance allowing the BomBot to drive underneath the RMAX.

To promote creativity and give better understanding of the goals for the team the lower portion of the helicopter is being reproduced. A visualization of the helicopter will be implemented into our tests. A mock up is being promoted by faculty and sponsors.

The design process has involved simulation analysis, representation of ideas through professionally orchestrated presentations, and substantial communication between the team and the sponsors.

Unfinished design

Though most of the mechanical portions of the design are completed aspects of design are still left undone. The balls which are primarily used for alignment in the Ball and Socket system are not easily manufacturable so the design is deemed unfinished. A finished design of the ball portion will happen when the design can be easily manufactured. This will require sourcing real world parts that can be purchased to create a physical model from the CAD prototype. The balls can be seen in Figure 1.

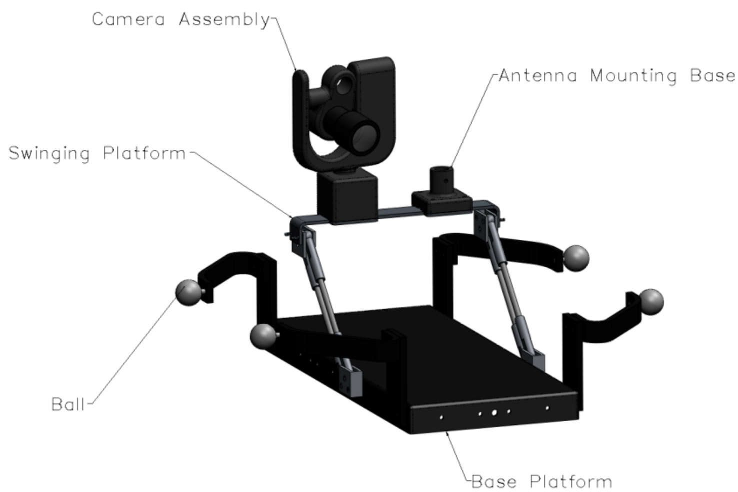


Figure 1: Base Platform

The position of the ball and socket is going to be based on the center of gravity of the RMAX. The BomBot, when secured, needs to have its center of gravity directly below the RMAX's center of gravity. To do this a mounting rack similar to the one in Figure 2 must be designed. The mounting rack depicted in figure 3 is pre-made by AFRL for mounting instruments to the RMAX but unfortunately does not allow clearance for our design. A new design will be based off the original design premade by AFRL. The new design will feature shorter flanges and less material in the rack portion. The flanges are the pieces that control the height of the rack relative the ground. The new design of the rack portion is going to be specifically designed for the ball and socket. Overall the only change to the design is removing material. This is good because the less material used the lighter our design. The RMAX is capable of lifting a 60 lb payload, but if the payload is drastically under requirements performance will be increased.

The funnel clip on the Ball & Socket system will carry the BomBot securely but a latch on each of the funnel clips strategically located will secure it in place. The latch will be operated by a linear spring. The spring will be used to keep the gate open and closed. For this to be done a clever positioning of the spring will need to be a must. The design is not yet finalized but instead just a conceptual idea that will soon be drawn.

Currently the swinging does not have a means of operation. Brainstorming has created many ideas and the two that seemed the most plausible are a spring and a motor. A spring would be used to keep the swinging platform in its upright position through linear force. The act of driving the BomBot underneath the helicopter would allow two sturdy surfaces to come in contact with each other and lower the swinging platform. This action would cause the spring to stretch. The second plausible choice was the use of a motor which would be actuated by a second onboard computer. The decision the team faces is choosing the design that would create the least amount problems down the road and the least amount of problems immediately. Each of the concepts, based on how well they are designed and manufactured can trump one another. To solve this dilemma both concepts will be designed and then compared based on importance factors such as maintainability, electronically controlled, simplicity, and price.

Simulation

The Ball and Socket system can utilize many profiles for the track as seen in Figure 2.

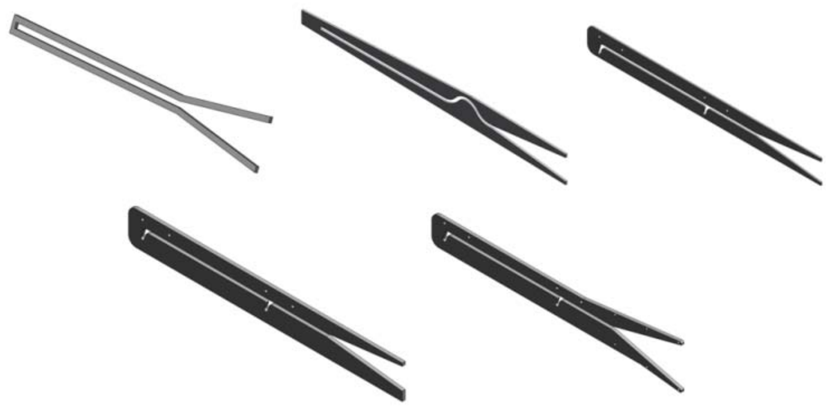


Figure 2: Profiles in order from least to most efficient

The best type of profile will be based on results from simulations in the fall. These simulations must meet the performance requirements of AFRL to qualify for actual testing using the RMAX helicopter.

BomBot characteristics must be studied in static and dynamic simulations. The research derived from these tests will prove useful when choosing electronics. To program the BomBot there must be a strong understanding of its handle-ability and the electronics of the system.

Mock RMAX Test Bench

To best design the ball and socket system for use with the RMAX a test bench simulating the RMAX must be created. The test bench will be avisually pleasing representation of the legs and skids of the helicopter while accurately providing mounting locations of the skids. The final result will closely depict the design in Figure 3.

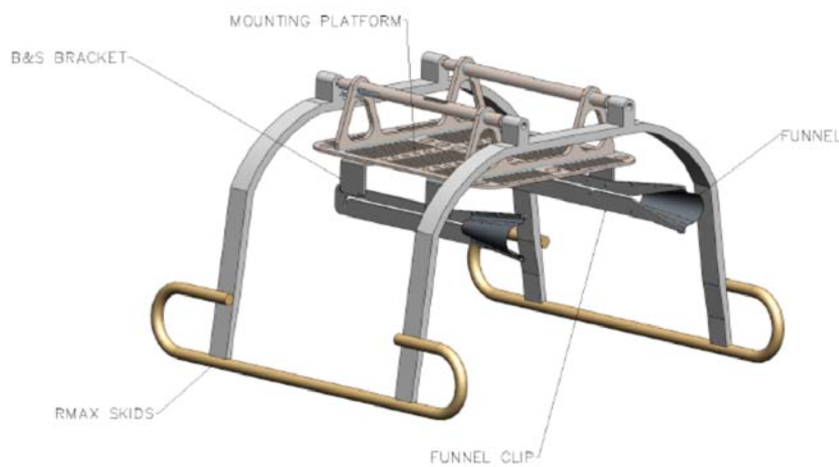


Figure 3: RMAX Test Bench

The legs are going to be Aluminum Alloy 3003. To get the desired shape as well as the mounting locations they will be created using an OMAX water jet. The B&S bracket is going to have slots instead of holes to provide adjustability of the ball and socket system in the vertical and longitudinal direction. Manufacturing of the brackets will be an easy task when using the OMAX water jet to create the general shape.

The test bench will feature handles for users on either side of the test bench to raise and lower the test bench. Raising and lowering the test bench will simulate take off and landing of the helicopter. Raising and lowering of the test bench using human handles will not create a questionable simulation of takeoff and landing. This is because a helicopter will take off in random ways every time, though stable, the vertical, lateral, and longitudinal movement is unpredictable.

All of the tests run with the test bench are going to be similar to one another but will off important information for various design scenarios. Many different terrains and angles of takeoff and landing will be tested to give important information about the performance of a certain funnel clip profile.

The uneven terrain test will verify the ability of alignment at various different angles of roll. The angle test will verify the ability to align the BomBot when entering the socket with different heading angles relative to the RMAX. This test will be performed on wet and dry ground. The wet ground is to create instability of the BomBot and not translation of the test bench. In all tests the test bench will remain fixed until take off.

With the latch implemented onto the Ball & Socket take off and landing will be conducted on soft ground. This test should be conducted with the selected wheels that will be in the final product. This test will make sure the latch system does its job. To pass the test the latch should open the gate allowing the robot to deploy from the RMAX. The test will be failed if the latch requires too much force to open and the BomBot is pushed into the soft ground instead of being able to disengage. This test should be conducted with smaller tires as opposed to large tires. Larger tires will give a larger contact patch below the tires. Assuming the surface pressure is constant over the area of the tire contact patch more force can be applied without the BomBot sinking into the ground. Smaller tires will create the worst case example. The large tires on the BomBot can be seen in Figure 4.

Figure 4: Large Tires

Quick and slow landings and take offs may create unwanted results for the latch. Large accelerations can cause fatigue on the system and even failure.

To test security of the BomBot in flight the test bench will simulate exaggerated turbulence. In reality the BomBot will not experience conditions that will be found in this test, but this is engineering for the worst. The exaggerated turbulence will be simulated by violently shaking the test bench.

BomBot Research

To better understand the way the BomBot handles and performs tests must be conducted. The BomBot must be predictable based on two degrees of freedom, steering and throttle. To better understand how these degrees of freedom affect the BomBot certain tests must be made.

The BomBot must be able to steer itself at slow speeds. Currently the BomBot fashions extra large tires. These tires grip the ground extremely well and the high friction makes it difficult for the steering motor. The BomBot cannot steer the current tires at low speeds because the motor does not create enough torque to overcome the friction. The faster the BomBot moves the easier it is for the motor to steer the wheels. Smaller tires are going to be purchased and a static steering test will be conducted. Ideally the BomBot should be able to fully turn the wheels left and right with the smaller tires. This test should be conducted on dirt, pavement, concrete, and grass

If the latter test fails a secondary test should be performed. The velocity at which the tires can be steered by can be found through trial and error. The car will be given an initial constant velocity and the maximum steering angle will be inputted to the remote controller. The maximum steering angle with zero friction yields a maximum steering angle. The maximum steering angle is defined as the angle between the tire centerline as viewed from the top down view and the vehicle heading direction. This secondary steering test will determine the minimum speed required to reach the maximum steering angle.

Electrical Research

The electrical scheme of the BomBot is extremely important to understand. To be controlled it must first be understood. The goal of doing electrical research is is able to control the steering and driving motors using the onboard computer. The electrical equipment that will be used in the following tests will be a digital power supply, analog multimeter, digital multimeter, connectors, alligator clips, breadbox, resistors, and a variable resistor box if necessary.

After doing plenty of research of the motors used in the BomBot and analyzing the electrical wiring of the BomBot itself there is high confidence that we will be able to choose the appropriate wire to apply a signal voltage and get expected results out of the motors. The voltage will be provided using a digital power supply and alligator clips. The voltage across the motor will be measured using a digital multimeter. The resistance of the motor can be used to calculate the power needed to steer the motor at given instances for the steering motor and maybe the swinging platform motor if we were to go that direction.

To have a successful control of the BomBot the circuitry of the BomBot must be understood. To attempt to control any of the onboard motors the correct wire must be identified and a safe voltage must be applied. The voltage being applied to the wire may be a signal voltage, like with the drive motors, which will require minimal current or may not be a signal voltage and require more current that the controller may not be capable of.

Robotics

To successfully create an autonomous system for the BomBot a proper controller must be chosen. A controller will be a small computer that can be placed on board the robot. The controller will control various motors that will in turn lower the swinging platform, steer the BomBot left and right, and drive the BomBot forward and reverse. For the controller to be capable of guiding the BomBot autonomously it must have eyes to assess the situation. The controller also must have intelligence, artificial or not, to control the various motors that move the robot. The eyes that tell the robot what is going on will be appropriately sourced sensors that enable the robot to know its position and orientation relative to the RMAX. The artificial intelligence will be based on simple logical statements.

The controller we choose must have at least three outputs for each of the motors it controls. The controller must also have various inputs which should be split between analog and digital. The inputs are where the sensors are plugged into the controller. The analog inputs will be necessary for sensors that output multiple voltages. The computer will read the analog signal and be able to interpret its voltage into a unit of distance, temperature, force, flow, etc. Digital signals, such as limit switches, only have the ability to send two voltages. These voltages may be zero or 5 volts, or 2 or 8 depending on the type of sensor. These signals will interpret if a condition is met or not, such as on or off.

Controllers to consider are the Handy Board developed at MIT for botwars, the Orangutan, and the Baby Orangutan

Positioning

For the controller to control the motors it must be able to locate the position and orientation of the robot. Many types of local orientation methods have been used.

Dead Reckoning

Dead reckoning will follow the steps taken at every second along the way to determine the local position and orientation relative the starting point. This is similar to leaving a trail of bread crumbs that can be used to retrace steps.

By using incremental rotary encoders in a given wheel and a linear absolute encoder on the steering shaft paired with a high sampling rate the computer can calculate exactly where it is at relative to the starting location. In this case of the Marsupial project the starting location would be the RMAX. This type of system would require a fast computer. This method would prove highly inaccurate because it would require ideal physics based on many assumptions. These assumptions are, but not limited to, no wheel slip, no slip angle, no weight transfer, and constant tire radius.

Another dead reckoning method uses the Doppler Effect. The Doppler Effect can be used to measure ground velocity. The integral of velocity over time is distance. This is how an infrared mouse works. The Doppler Effect can be seen in Figure 5.

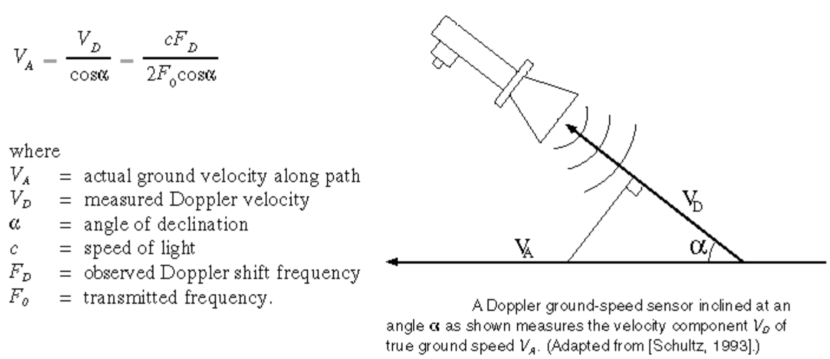


Figure 5: Doppler Effect

Active Beacons

Humans typically use beacons to navigate. The North Star is the most famous beacon used. Robots use beacons to navigate based on local position relative to an origin. These beacons generally use infrared, microwaves, RF waves, and sound (sonar). GPS is a common example of use of active beacons. Range finding sensors can simulate beacons.

Tentative Schedule

A Gantt Chart has been attached to the end of this document to accurately show the steps that are to be taken in order to properly complete the project within the time allotted.

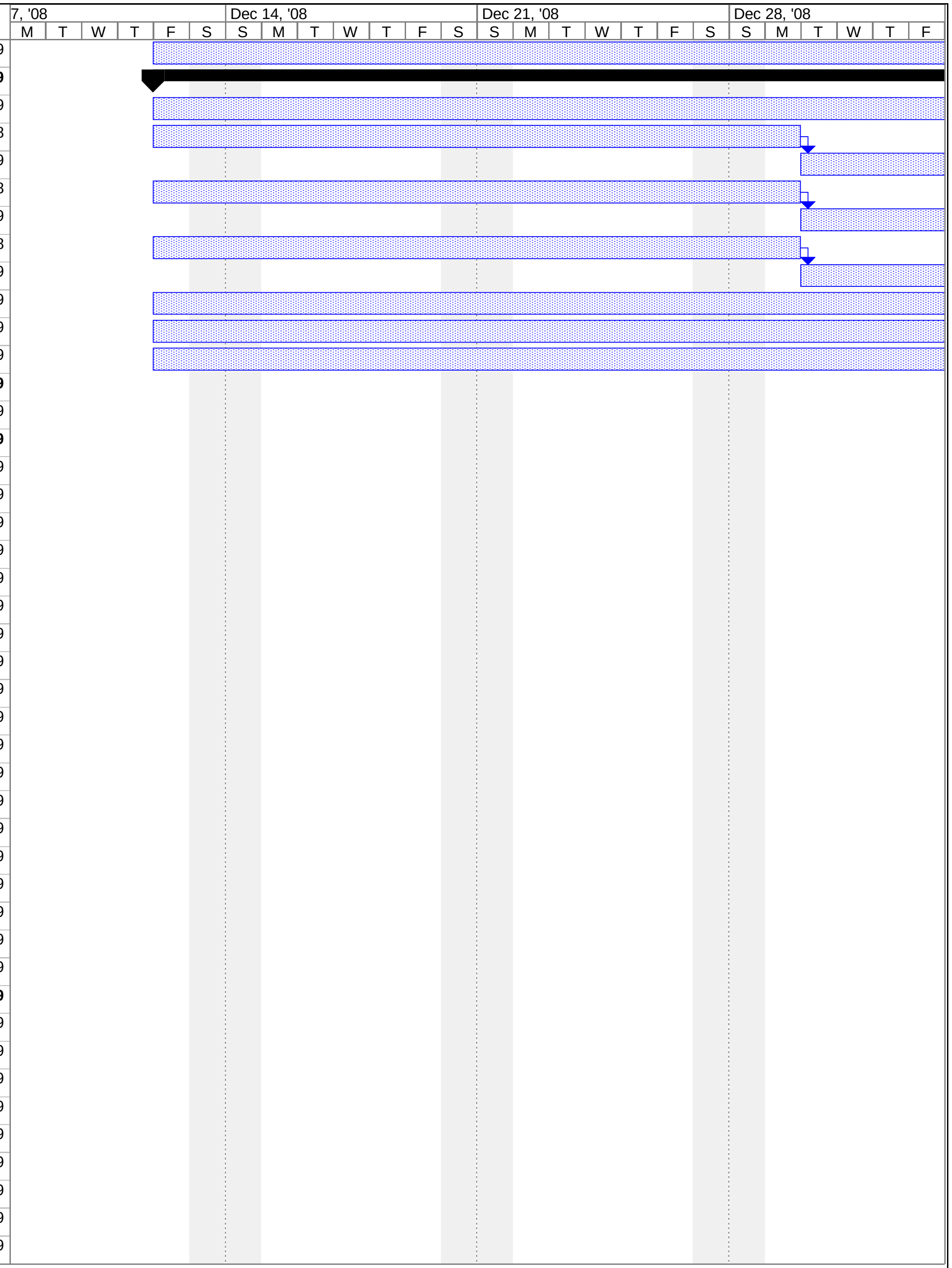
Conclusion

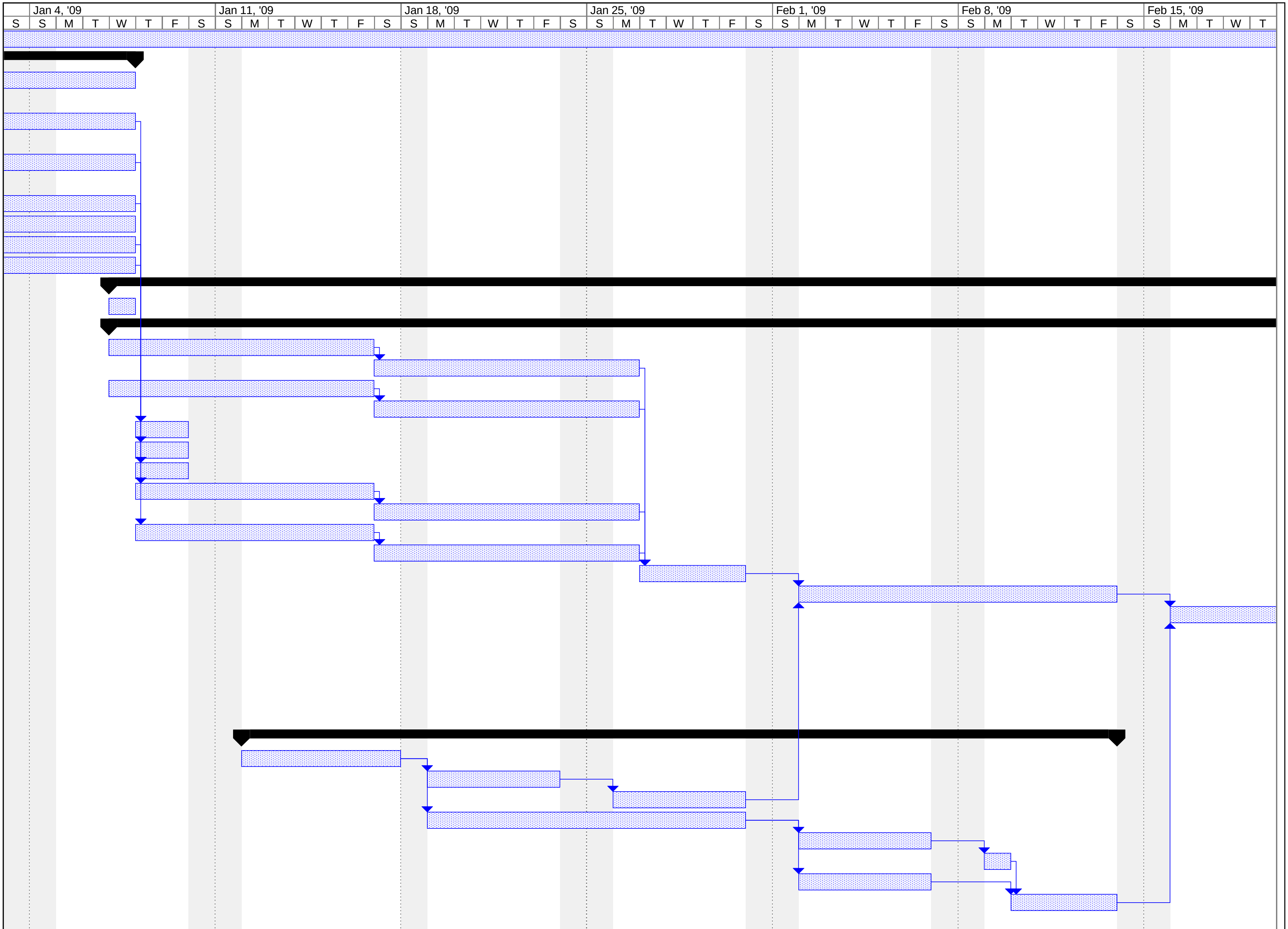
The intentions of the team have been clearly laid out. It is the intention of the team to provide the AFRL with a fully functional, safe, user friendly and secure mounting system that will allow the BomBot to mount to the underbelly of the RMAX helicopter. This will be completed using the aforementioned designs of the ball and socket, as well as the swinging platform.

The autonomous control of the BomBot while being a second priority is also planned for implementation. This will be accomplished using the active beacon methods as described above.

Overall the team feels that it is well within their domain, as well as the scope of the project, to complete the production of a mounting system that the AFRL will be satisfied with. This will in turn allow for the implementation of this system whenever and however the Air Force pleases.

ID		Task Name	Duration	Start	Finish
1		AFRL Group 10 Spring	83 days	Fri 12/12/08	Mon 4/6/09
2		**Winter Break**	**19 days**	**Fri 12/12/08**	**Wed 1/7/09**
3		Bi-weekly email updates	19 days	Fri 12/12/08	Wed 1/7/09
4		AFRL Skid Manufacture	12 days	Fri 12/12/08	Mon 12/29/08
5		Receive Skids from AFRL	7 days	Tue 12/30/08	Wed 1/7/09
6		AFRL Funnell Manufacture	12 days	Fri 12/12/08	Mon 12/29/08
7		Receive Funnell from AFRL	7 days	Tue 12/30/08	Wed 1/7/09
8		AFRL Swinging Platform Manufacture	12 days	Fri 12/12/08	Mon 12/29/08
9		Receive Swinging Platform from AFRL	7 days	Tue 12/30/08	Wed 1/7/09
10		Order Tires for BomBot	19 days	Fri 12/12/08	Wed 1/7/09
11		Finish Mounting Rack Design	19 days	Fri 12/12/08	Wed 1/7/09
12		Finish Ball & Socket Design	19 days	Fri 12/12/08	Wed 1/7/09
13		**Spring Semester**	**64 days**	**Wed 1/7/09**	**Fri 4/3/09**
14		Team Recap Meeting	1 day	Wed 1/7/09	Wed 1/7/09
15		**Mechanical System**	**64 days**	**Wed 1/7/09**	**Fri 4/3/09**
16		Finish Control of Swinging Platform	8 days	Wed 1/7/09	Fri 1/16/09
17		Receive Swinging Platform from AFRL	7 days	Sat 1/17/09	Mon 1/26/09
18		Finish Design of Locking Mechanism	8 days	Wed 1/7/09	Fri 1/16/09
19		Receive Lock from AFRL	7 days	Sat 1/17/09	Mon 1/26/09
20		Assemble Skids	2 days	Thu 1/8/09	Fri 1/9/09
21		Assemble Funnell	2 days	Thu 1/8/09	Fri 1/9/09
22		Assemble Swinging Platform	2 days	Thu 1/8/09	Fri 1/9/09
23		AFRL Mounting Rack Manufacture	7 days	Thu 1/8/09	Fri 1/16/09
24		Receive Mounting Rack from AFRL	7 days	Sat 1/17/09	Mon 1/26/09
25		AFRL Ball Manufacture	7 days	Thu 1/8/09	Fri 1/16/09
26		Receive Balls from AFRL	7 days	Sat 1/17/09	Mon 1/26/09
27		Test Bench Testing I	4 days	Tue 1/27/09	Fri 1/30/09
28		Design Optimization I	10 days	Mon 2/2/09	Fri 2/13/09
29		Test Bench Testing II	5 days	Mon 2/16/09	Fri 2/20/09
30		Design Optimization II	10 days	Mon 2/23/09	Fri 3/6/09
31		Test Bench Testing III	5 days	Mon 3/9/09	Fri 3/13/09
32		AFRL Flight Test	5 days	Mon 3/16/09	Fri 3/20/09
33		AFRL Feedback Analysis	5 days	Mon 3/23/09	Fri 3/27/09
34		Design Optimization III	5 days	Mon 3/30/09	Fri 4/3/09
35		**Robot Controls**	**26 days**	**Mon 1/12/09**	**Fri 2/13/09**
36		Electrical Analysis of BomBot	6 days	Mon 1/12/09	Sat 1/17/09
37		Receive Swinging Platform Motor	5 days	Mon 1/19/09	Fri 1/23/09
38		Implement Swinging Platform Motor	5 days	Mon 1/26/09	Fri 1/30/09
39		Electrical Components Research	10 days	Mon 1/19/09	Fri 1/30/09
40		Receive Electrical Components	5 days	Mon 2/2/09	Fri 2/6/09
41		Assemble Electronics	1 day	Mon 2/9/09	Mon 2/9/09
42		Program Software	5 days	Mon 2/2/09	Fri 2/6/09
43		Test Autonomous System	4 days	Tue 2/10/09	Fri 2/13/09
44		Present Final Design to Sponsor and Class	1 day	Mon 4/6/09	Mon 4/6/09

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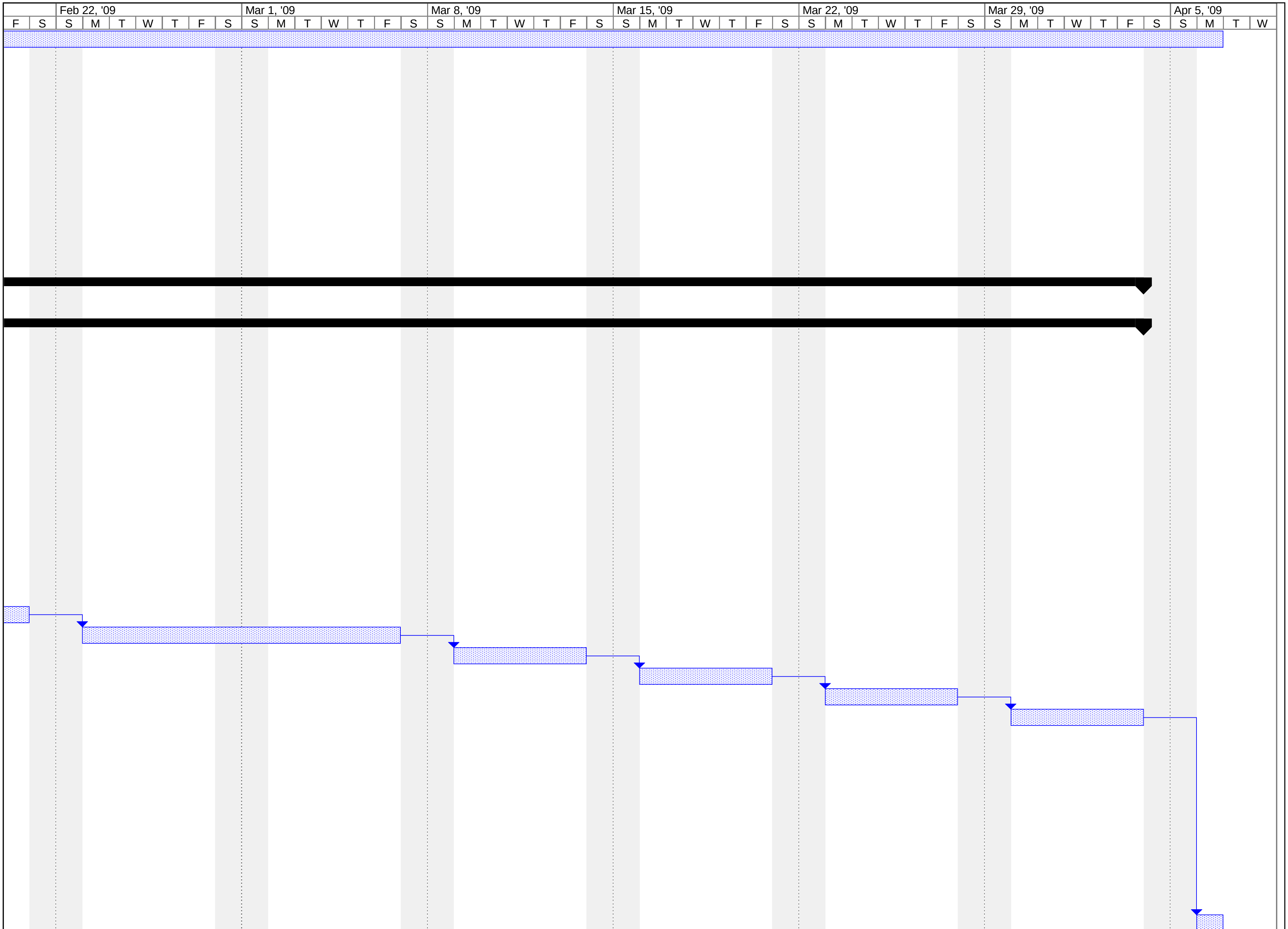
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