<u>Team 12: REEF Subsonic Articulating Robotic Arm</u>

Deliverable Title: Restated Project Definition and Scope/Project Plan

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Faculty Advisors:	Sponsors:
Dr. Gupta	Michael Sytsma
Dr. Kumar	Ken Blackburn

REEF Subsonic WT Articulating Robotic Arm

The Team:

Jacob Kraft - Team Lead:
Jacob is a FSU student from Stuart, FL. He has not claimed a specialty but has studied design and aerodynamics. He is a member of ASME (American Society of Mechanical Engineers) as well as a teaching assistant at the college.

Andrew Baldwin – Treasurer:
Andrew is a FSU student native to Tallahassee, FL. His area of concentration is aeronautics. He is a member of both Tau Beta Pi Engineering Honor Society and Pi Tau Sigma Mechanical Engineering Society. He also participates in Seminole Sound and is a former member of the FSU Marching Chiefs.

Justin Broomall – Secretary:
Justin is a FSU student from a small town in central Florida named St. Cloud. Growing up just sixty miles from the Kennedy space center, his childhood was filled with dreams of the final frontier. This drove him to pursue a mechanical engineering degree with a specialization in aeronautics.

Caitlan Scheanwald – Media:
Caitlan is a FSU student originally from Richmond, Va. She specializes in control systems and various programming languages. She plans to take her FE exam prior to graduation and pursue PE and PMP certifications. Currently, she works for the Department of Economic Opportunity as a project manager in software development.

Sponsor:

Dr. Michael J. Sytsma:
Dr. Michael J. Sytsma was born on March 15th 1982 in Homestead, Florida. He received his Bachelors degree (2004) in Aerospace Engineering with a Business minor from the University of Florida. Michael continued on to receive his Masters of Science in Aerospace Engineering from UF in 2006 studying Micro Air Vehicles. He began work at the Air Force SEEK EAGLE Office in 2006 as a loads engineer, and moved to the Air Force Research Laboratory in 2009 as a research scientist.

Acknowledgements

Team 12 would like to recognized sponsor Dr. Michael Sytsma and Dr. Kumar for exceptional guidance throughout the design phase of this project. The team is grateful for Dr. Sytsma's contributions and for allowing the team to visit the REEF center. Dr. Kumar has provided the team with a lot of help in regards to technical analysis of the system needed to finish he design process. Team 12 would also like to recognize the teacher Dr. Gupta for continued guidance throughout the semester.

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Abstract

The Aerodynamic Characterization Facility (ACF) of the Research and Engineering Education Facility (REEF) has requested a mounting and actuating mechanism in order to continue testing. This facility hosts an open subsonic wind tunnel with a maximum wind speed of 22 m/s . The design must be able to adjust pitch (-5° to +30°) and yaw (-10° to +10°) while the tunnel is in operation and maintain the specimen in the center of the air flow. The design features 105 degrees of a 25 inch radial arc with a square shaped cross-section. The circular arc will be mounted in two locations in order to stabilize it during wind tunnel operation. Roller bearings with rubber coating will be used to reduce friction and help dampen vibrations. This arc will be actuated through the use of a flexible gear track fixed to the underside and a turn table as its base. A sting mount will be utilized to hold specimens. Procurement for the motor, drive train, and materials is underway and a prototype is expected by the first week in March.

I. Introduction

Due the removal of the current model mounting system, the Air Force Research Lab has requested the production of an articulating robot arm to be used in a subsonic wind tunnel. The arm would allow research conducted at the facility to continue and will enable the researchers to manipulate the pitch and yaw of aircraft models in an active flow. The articulation of the robotic arm will be dictated by a stepper control unit that will be linked to a remote user interface. The pitch and yaw movements of the arm will be carried out through the use of two separate stepper motors and attached encoders. Any specimens held by the arm will be mounted utilizing a sting. The wind tunnel that the robot arm will be placed into is an open test section and is located at the Aerodynamic Characterization Facility (ACF) of the Research and Engineering Education Facility (REEF). The wind tunnel as the ability to generate wind speeds that can reach up to 22 m/s or approximately 50 mph. The inlet of the wind tunnel has a square cross-sectional area that is 42 in by 42 in.

a) Goals and Objectives

The goal of the project given to Senior Design Group #12 is the design and production of a cost effective mechanism that would hold and adjust the orientation of a specimen being tested in a subsonic wind tunnel. The sponsor of the project presented a set of objectives to be achieved by the robotic arm. The arm must be structural sound enough to withstand the maximum forces generated by the wind tunnel, 22 m/s. The arm must also be able to manipulate the orientation of the mounted specimen while the tunnel is operating at maximum velocity. During the manipulation of the specimen, the position of the specimen (center of mass) must not change. The two aspects of the specimen's orientation that will be adjusted are the pitch (angle of attack) and the yaw (side slip). The pitch of the specimen should be able to be adjusted to any position between -5° below center and 30° above center. The yaw of the model should be able to adjust 10° left or right of center position. The final objective set forth is that when the model is in the desired position the model must not move. The programming goal to be installed at the end of the mechanical fabrication is to create a user interface that will accept static inputs and move the arc to the desired location.

Objectives list

- Arm able to withstand maximum force generated by wind tunnel
- Arm able to operate at maximum tunnel velocity
- Center of mass of specimen must not change
- Adjustable pitch range of -5° to +30°
- Adjustable yaw range of ±10°
- Model must not move when in set position
- User interface to control motion of arc

b) Constraints

While attempting to meet the objectives set forth by the sponsor multiple constraints had to be considered. The sponsor has requested that the user interface that will operate the robot arm will be run by a LabVIEW program. LabVIEW offers the opportunity to create an easy to use system, as well as having the ability for the system to report the angle that is actually at in comparison to the requested position. A second constraint in regards to the operation of the arm requires that the orientation of the arm should be within 0.25° of the requested orientation. When at any position the sting has the potential to deflect, the maximum deflection that is allowable is 0.25”. To ensure validity of any results taken while using the system in addition to the structural integrity, the sponsor has required a factor of safety of 5. The final major constraint of the project is the operating budget; the team has been allotted $2,000 to complete the project. To assist with limitations of the budget and overall design, some components have already been provided by the sponsor.

Constraints list

- User interface involves LabVIEW
- 0.25° orientation accuracy
- Maximum Deflection of 0.25”
- Factor of Safety of 5
- $2,000 budget

II. Procurement

With the design process in its final stages the group has begun to place purchase orders for raw materials to be machined and stock parts from manufacturers. A Tallahassee based metal supplier (acceptable FSU vendor) has provided the team a quote approximately $400 for the aluminum 6061 required for the arc and housing. The machining of the arc will be done by the High-Performance Material Institute (HPMI) located in Innovation Park.

The rest of the components needed for the design will not require extra machining or major alteration to be implemented. To achieve arc translation, a flexible gear track is being added to backside of the arc which will mesh with gears. The flexible track will be purchased from Stock Drive Products and will be $70. The gears that will comprise drive train will cost $105. The stepper motor/encoder/driver that will drive the gear train will be approximately $500, ordered from Anaheim Automation. The numerous roller, bearings and metal rods required are being ordered from McMaster, the purchase order is to be placed this week totaling $200.

The mechanical pieces for the mechanism total $1,275; leaving at least $725 for the electrical components, a LabView license and any other necessary items. The current budget breakdown is shown in Table 1.

Table 1: Updated Budget

Component	Price (Estimated)
Aluminum Plates	$400
Motor/Encoder/Driver	$500
Gear Track/Drive Train Components	$175
Rollers/Bearings/Rods	$200
Total	**$1,275**

III. Project Updates

During the fall semester, the major focus was upon completion of the mechanical design and procurement for the mechanical devices. The mounting system, sting, drive train, and follower were all designed during the fall semester. This semester's focus will be on construction, programming, and troubleshooting the device.

a) Semester Specific Goals and Objectives

This semester's focus will be on construction, programming, and troubleshooting. Procurement is underway and purchase orders are being sent out the week of January 12th, 2015. The project prototype is expected to be complete in the first week of March (3/2/2015). The final product is expected to be completed the week of 4/6/2015. The following is expected to be completed by then:

- Delivery of raw metal, drive train materials, bearings, rollers, motor, driver, encoder
- Machining of parts
- Programming of motor, driver, and encoder
- Construction of prototype
- User interface testing and troubleshooting
- Out of tunnel testing and troubleshooting
- In tunnel testing and troubleshooting
- Operation Manual

IV. Gantt chart and Resources

a) Schedule

To help keep track of this project and the many design decisions that must be made in order to proceed, the team has formulated a Gantt chart displayed in Figure 1 accompanied by a detailed breakdown. This will enable the team to keep track of progress and make sure that we complete milestones in a timely manner. Keeping as close to these deadlines as possible will ensure the team completes the project on time. For the spring semester, the focus moves forward to fabrication and control system design. The Gantt chart is displayed on the next page.

b) Gantt chart

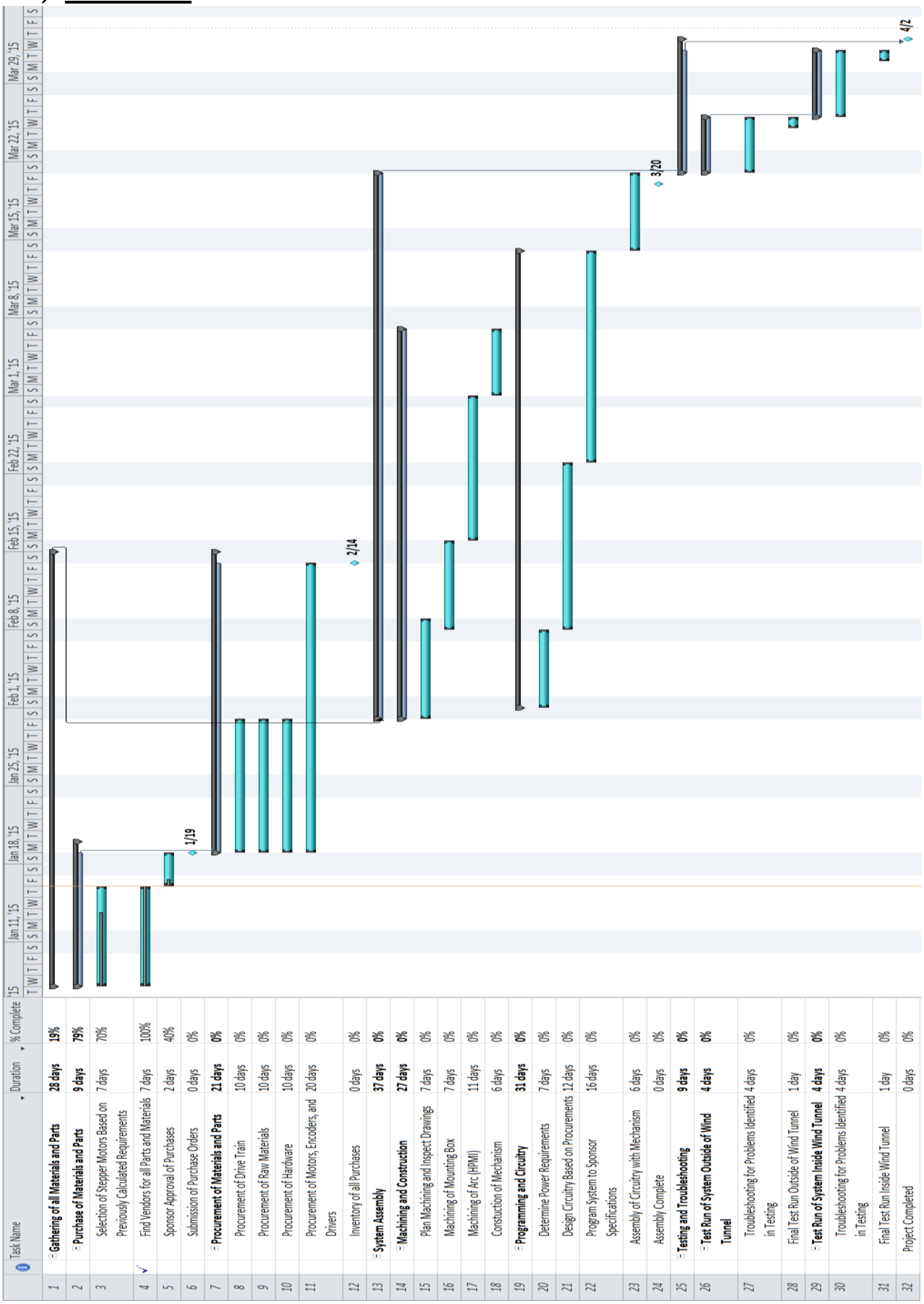

Figure 1: Gantt Chart

c) Resource Allocation

Design ideation was a team effort. All major design decisions are discussed by the team and each member contributes ideas to accomplish specifications within the project constraints while also being aware of possible problems that may occur with each idea or change. The team's Gantt chart displays the upcoming tasks that require completion for the project to move forward. Each team member has been assigned tasks based on their areas of expertise and has estimated the time they require to complete those tasks.

The fall semester focused on design selection and calculations, the spring semester focuses on assembly of the mechanism, circuitry, and controls. In many ways it will be much more difficult to lose track of time spent, as unforeseen challenges of fabrication arise. These challenges will be accounted for in troubleshooting weeks. The breakdown of how work will be allocated amongst the team is shown in table 2.

Table 2: Resource Allocation

Task	Member Responsible	Estimated time
Finalize CAD drawings	Justin Broomall	1 week
Finalize Motor selection	Jacob Kraft	1 week
Finalize purchase orders	Andrew Baldwin	1 week
Construct Mechanism	Justin, Jacob, Andrew	2 weeks
Build User Interface	Caitlan Scheanwald	2 weeks
Construct Full Prototype	Team	1 week
Testing without windtunnel	Team	1 week
Troubleshooting	Team	1/2 week
Testing with wind tunnel	Team	1 week
Troubleshooting	Team	1 week
Finalize and Make Ops manual	Team	2 weeks
Estimated Completion		12 weeks

The team is currently working on the completion of purchase orders for all parts required for the system. Our treasurer, Andrew Baldwin, is responsible for checking that the team stays within budget, and that the sponsor approves of all materials and parts selected by the team. Our team leader, Jacob Kraft, is currently re-running all calculations with the exact specifications of the parts and materials the team intends to purchase. This will ensure that no parts must be returned or replaced, which could threaten both the timeline and budget. Justin Broomall is formulating exact drawings to the specifications of our parts to ensure that all machining is properly planned and fabrication is as clear and simple as possible. These drawings will later be used as part of the system manual. Caitlan Scheanwald is currently researching and calculating all circuitry and programming needs based on the parts the team intends to purchase. She will be responsible for combining the circuitry with the mechanism and coding the LabView program for the user interface.

As shown on the team's Gantt chart, it is intended that all purchases are completed within the next 3 days. This also means that calculations and tests being run to check the parts must be completed by that time. Drawings will need to be completed in approximately 2 weeks. By then, the team will have received most of the raw materials necessary for machining. Circuitry and programming will not need to be completed for another 2 months. However, the team intends to have it fully planned and broken down in the next month.

Primarily, this group intends to function as a team. While we have assigned specific responsibilities to each member, we also recognize that it is beneficial to work together, especially when certain portions of the design process may be heavier on one team member than on another. Team 12 will work together to complete this design and its fabrication to the satisfaction of the sponsors and advisors.

V. References

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