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G.A. CubeSat Team

ME486C – 2

1) Did the team complete the Purpose and Goals stated in the Team Charter?

- F: Our stated team goal in the charter differs from our overall goal moving forward with our project. At the beginning of ME476C, the team stated the goal was to build a CubeSat while the team's goal now is to build a mounting fixture to test different CubeSats with differing payloads
- S: Another goal the team had was to have a successful project/high quality project, this goal is still being achieved and as a team is on the correct path to meeting that
- S: The charter states that one of the goals of the team was to regularly contact and update both our capstone professor and clients on the progress of the project. Throughout last semester these meetings with the clients and professor ensured that the end goal of the project was still being reached and that all problems with the design were being addressed
- S: Each team member executed their role as stated in the team charter. At the beginning of the project, each member was given a role: project manager, client contact, budget liaison, documents manager and website developer. The team members performed their roles exceptionally throughout the duration of ME476C.

2) Were the Ground Rules and Coping Strategies stated in the Team Charter followed? What worked and what did not?

- S: One of the best dynamics in our team is having open discussions about an idea and evaluating it for its merit.
  - F: A bad thing about this is we sometimes have side discussions.
- S: Another team rule that is helping us out a lot is preparing explicit actions/plans before we move forward with the project. After each meeting, we have a list of items that need to be done before the next meeting.
- S/F: Another thing the team made as a ground rule that has been successful is keeping everyone up to date on the tasks that each individual is completing. The team has a group chat where everyone updates one another, and then at the beginning of every meeting people discuss what they have accomplished. This team behavior fell off after spring break but major player in this was the COVID-19 responses. We expect to improve on this by creating d

3) Which aspects of project performance (time management, product quality, manuf. Cost, etc.) were most positive?

- S: The team as a whole submitted quality memos and reports which adequately and successfully conveyed the progress of the design to our capstone professor. Each team member made a fair contribution to these assignments which positively effected the team as a whole.
- S: Another project performance that was successful was the team developing unique and interesting design options. The team as a whole had creative sessions where each member would bounce ideas of each other. Together the team was able to develop the design option that we are continuing with

S: Communication with the client was also successful. The team had bi-weekly meetings with the client and updated them also through emails. Each time we had a meeting the clients would provide constructive feedback, and the team would ask questions. Overall, what the client is asking the team for, has been what the team has been completing.

4) Which aspects of project performance were most negative?

- F: The team did experience some difficulty in making a final decision regarding which type of motor to use in the design. Too much deliberation occurred on the feasibility of using electrical motors and which path to move forward on regarding the alternative options.
- F: Determining the cost of our final design was doable with a bill of materials. However, the team never determined the actual budget given to us by GA.

5) Which tools, methodologies and practices contributed to positive (or negative) aspects of performance?

- S: In person meetings helped contribute to the overall success of our team pre-COVID. Afterwards, the team utilized Microsoft Teams and Zoom to try and replicate these in person meetings since they were so effective in coming up with ideas and overall working on reports or other assignments.
- S: Also meeting with the client as often as we did and sharing all of the relevant information to them, as well as being open and honest about where we at in the design process and getting all of our questions answered helped.
- F: One thing that the team do as a whole was not having the best time management skills. A lot of the times the reports or presentations would be worked on until the very last minute. This is something the team is going to work hard on starting tasks early.

What problems did the team encounter?

- F: As stated before, the team did experience some road bumps due to the transition to online classes for the rest of Spring semester. While the team did put out quality material with regards to the design of the project and team reports, we do believe that had the semester continued as planned, some of the drawbacks to isolated group work would have been a nonfactor.
- F: Originally, the team encountered problems of understanding exactly what the design was supposed to accomplish, and what exactly the device that the team was supposed to be developing. But with asking the client questions we were able to grasp what was needed.
- F: Another problem that the team encountered was running into design issues. One major part of the device is to relocate the center of gravity of the entire system and the team wanted to accomplish this by using motors. However, the device had to be completely nonmagnetic, meaning that the magnetic field produced by motors was not allowed.
- Available materials and off-the-shelf items because of material restrictions
- Designing for the stretch goals was something we all wanted to do and felt like it was in our capacity. When we started making decisions and doing calculations, it became aware to us that it was easier to design for the minimum requirements and not the stretch goal. I feel like we should have entertained the idea more.

What specific organizational actions can be taken to improve performance?

- The team can rely on the Gantt chart more moving forwards in terms of getting things done and making sure everything is done on time and on schedule.
- The team can also communicate more effectively whether that is through the group chat or more meetings where we can discuss ideas for the remainder of the project.
- Starting tasks early and breaking down each report/presentation early. So that presentations could be practiced, as well as everything being turned in is organized.
- 8) Meet with a faculty bi-weekly to discuss a specific task or function. It would be great to hear input of some pros.
- Especially in this semester, we might find benefit in assigning sub-functions to members of a team and having them be the expert on that sub but still have inclusion for all sub-functions.

What specific technical lessons did you learn?

- One of the lessons learned early on was assessing magnetic fields. Our device must close to non-magnetic so understanding what effects magnetic components have was a great skill to have and gave us a chance to broaden available materials.
- For some modeling we did, we used engineering drawings of GA components and devices so we have replicas to use in our design. The skill of reading detail from a busy drawing and transforming a 2D drawing into a 3D model was developed.
- The team learned how to calculate the magnetic field generated by electric motors and the effects they have on the onboard systems of the CubeSat.
- The team learned how to calculate the center of gravity based on the geometries of the 3U, 6U and 12U CubeSats
- The team had more developmental practice with 3D modeling a design in SolidWorks
- The team also learned more about Fluids, and how pneumatic systems work. Along with the pressures needed, what the system has inside, how to utilize one within a design, and different aspects about that
- The team gained experience in how to utilize Arduino sensors and programming to calculate the center of gravity for the CubeSat. Kind of but it still counts amen

## 1.0 Introduction (Jacob)

The CubeSat capstone team is a four-member group composed of all mechanical engineering majors. Our customer is General Atomics who is an advanced technologies company with military, laboratory, and aerospace applications. One of GA's applications is satellite technology, the CubeSat. A CubeSat is a compact, low orbit, space satellite. Before commissioning these devices into orbit, they must be tested on the ground. To mimic zero-gravity, the CubeSat is tested on an air bearing test stand to achieve a low friction environment. A convex, smooth semi-circle fixture is the interface between the test stand and CubeSat. Our team is tasked with designing a new fixture for the CubeSat to interface with the test stand.

In orbit, the CubeSat is affected by Earth's magnetic and gravity fields, so it is vital to simulate that environment. The satellite is free to rotate about its center of mass (COM) while in orbit. The fixture must reposition the assembly COM to the COM of the CubeSat alone. This is a priority requirement for our design. The CubeSat's instruments are sensitive so the design must not contribute to "noise" in data capture. The device must not contain any magnetic components or

induced effects from electric current. This is another priority design requirement for the device. Other requirements of the design consider the limitations of the air-bearing test fixture: degrees of freedom and maximum weight.

Last semester, the CubeSat team created a critical design for the fixture. This team project offers unique experiences considering world events, but our team charter helps mitigate team dynamics. Our team recognizes many successes throughout the project but have also identified areas we need to improve. This document reflects on the team performance and evaluates the progress of the CubeSat fixture.

## 2.0 Project Successes

### 2.0.1 Team Charter (1,2) Jackie

To reflect on one aspect of the overall project successes, the team met up to reflect on what was written within the team charter and to see which sections were completed vs which were missed. The first part of the team charter that was reflected on was the section based on the team's purpose and goals created for the year. Most of the goals that the team created were reached. The first goal that was accomplished was to have regular meetings to update both the capstone professor and the client of the project on the progress of the design. Throughout last semester the team met with the professor every week, and the client every other week. During these meetings the team was prepared with updates of the project, any questions they had, and addressed problems that arose. These meetings will be continued for this semester moving forward, and the team will continue to make the meetings constructive for the team, professor and client. Another goal that is continuing to be met, is that the team wanted to have a high-quality successful project at the end of the year. The progress that the team accomplished last semester is assuring that this goal is being met at the end of this semester.

The other section of the team charter that the team reflected on was the section discussing the ground rules and coping strategies. The team last semester had a good dynamic of working together and figuring out everything as a team. The team did not have any big issues occurred where the team needed to use the coping strategies section. Due to the team having a good dynamic from the beginning allowed for the conversations to be open and honest. This allowed for the team to have deep discussions about ideas about the project and evaluating each idea. Another good thing that the team had a success in, is everyone taking responsibilities that their given role acquires. Each team member performed their roles exceptionally throughout last semester and is continuing to do so.

### 2.0.2 Project Performance (3, 4) Zack

In order to accurately assess the team's performance over the duration of ME476C, the team met to discuss positive and negative aspects of performance. The team created successful memos, reports and presentations to accurately convey our progress as the semester went on to both our professor and clients at General Atomics. Each team member contributed equally to these documents which created a good work atmosphere amongst the team. Each of the team members wanted to contribute equally which helps the team get things done to a high level. The team also came up with multiple unique design ideas and alternatives. This was achieved by having productive team meetings both in person and remotely by utilizing Zoom and Microsoft Teams. The team also utilized design software (Solidworks) to create these alternatives by 3-D modeling. The team communicated with the clients at General Atomics exceptionally, we had bi-weekly meetings where we would present our progress to them and take any

questions they had about our design, thought processes, etc. The team also communicated with the client through email whenever a breakthrough was made or whenever the team thought the client needed to be updated on our project before our scheduled meeting. The team's communication with the client was solid throughout the semester. It was a good middle ground in communication, it worked well last semester and the team hopes to continue this communication for the remainder of the project.

### 2.0.3 Tools/Methodologies/Practices (5) Richard

Throughout the spring semester, the team kept a consistent and productive meeting schedule. During the team meetings, staff meetings, and client updates, the team found ways to move the projects forward despite whatever engineering problems or stretch goals that the team experienced. For instance, the collaborative nature of the initial meetings resulted in the team finding an engineering solution to the basic design problem relatively early on in the semester. Even after the suspension of in-person classes, and meetings due to COVID-19, the team still found ways to continue the flow of progress, by transitioning all meetings to virtual ones through the use of Microsoft Teams and Zoom. To emphasize on the client meetings, the team shared the progress and setbacks that was experienced throughout the semester in a clear and timely manner. This helped to reduce the potential errors that occur whenever miscommunications arise during the design process.

## 3.0 Areas of Improvement

### 3.0.1 Team Charter (1,2) Jackie

As mentioned above, the team had a lot of successes involving what was written in the team charter. However, there were some areas that could be improved upon moving forward. The first thing that could be improved is the focus of the team meetings. Since the team has a good dynamic and can have open conversations there is at times where the conversations go off topic. For the team meetings to be more beneficial the team is going to try and cut down on the side conversations, or off topic conversations and focus on the design. Another thing that the team can improve upon is having more communication on updates within the team. The team last semester created a group chat for the team to communicate through. In the beginning the team had many contacts about where everyone was at through the group chat. However, towards the end of the semester the team stopped communicating as often, and everyone was doing their own thing. The team wants to assure to bring back this mode of communication and to assure that everyone is keeping up to date on what is going on within the design. Overall, what the team wrote in the team charter has either been a success so far, or the team is making steps to accomplish the goals that were written.

### 3.0.2 Project Performance (3,4) Zack

While there were many positive aspects of our project last semester, there were also some areas for improvement. Figuring out the budget for the project was one of the main issues our team ran into. The team still is unsure on the exact budget for the project which makes building the design difficult. Also, the team experienced difficulties in choosing the type of motors to put into the final design. Overall, the team ended up choosing pneumatic motors since it gave us less conflict with our design restrictions. The reason the team was so conflicted on choosing motors was because pneumatic motors compromised the accuracy and precision of moving the counterweights while electric motors exhibited a high magnetic field which was against one of the design restrictions given at the beginning of the semester. Overall, the most negative aspect of our project from the spring was determining the budget. The team

was able to form a bill of materials from the final CAD model but the actual budget from General Atomics was never determined. Therefore, the team was unable to determine if we were within budget.

### 3.0.3 Tools/Methodologies/Practices (5) Richard

As what happens many times during extended projects, like capstone, as the project moves along, teammates feel more confident that presentations and reports will be completed before the submission time runs out. This of course did result in many submissions coming very close to not being submitted before the due dates. The team recognizes that this is not conducive to good time management or project planning. The team has concluded that one of the main causes of this is that the assignments were not started until a large amount of time had passed since receiving said assignments. To rectify this mistake for the fall semester of capstone, the team has agreed to outline and divide the work for the team assignments and presentations the day that they are assigned. This will help to ease the workload that the team has upon them.

### 3.0.4 Problems the team encountered (6) Jacob

At the beginning of the project, our team met with the customer gain background on the project and obtain a list of design requirements. These meetings were constructive but during a separate team meeting, we learned quickly that we each had a different understanding of the fixture. Without agreement on how the device works, we could not effectively break ground for the project. To correct this misunderstanding, we attempted to meet with GA for further questioning but did not yield positive results. After this attempt, we asked our customer if they could provide multi-media for a typical test. After several emails to follow up on this request, our team has not received media for the test. Our customer tried to explain the fixture to their best ability and sent us supporting documents. In reviewing the documents and speaking with the client, the CubeSat team was able to work through this setback as we each understand how the test stand works and the expectations of our mounting fixture.

One of the most problematic sub-functions in this project is relocating the COM. Our design uses a system of lead screws and motors to move counterweights which should displace the COM. An easy approach is to use simple motors to move the counterweights, but our material selection must adhere to the non-magnetic requirement, so this eliminates electric motors. Our team is pursuing pneumatic motors in the design but assessing accuracy and precision of these motors is difficult. In addition to performance, the lubrications required by pneumatic motors is not preferable in laboratory settings. We are currently benchmarking pneumatic motor technology for viable solutions.

### 3.1 Actions to lead to improvement (7) Zack

After sitting down and discussing our project from the spring, the team determined things we need to work on for the remainder of the project. The team's main goal is to stick to the Gantt chart and make sure each task is done on time. This chart is important for managing the project in terms of building, client communication as well as report deadlines and presentations. Another team goal is to communicate more effectively whether that is through our group chat or having multiple weekly meetings to make sure everyone is on the same page. Having to meet over Microsoft Teams has been effective since everyone went remote last semester and we plan to continue to utilize this for the fall.

The team also plans to start tasks early and break down each report and presentation. This allows for the team to practice the presentations and make sure everyone knows what is going on in the project. The team did a good job of this in the spring, we just want to make sure we don't forget about this

because it's very important to the communication with our clients as well as other faculty in the engineering department. Another goal is to meet with a faculty member biweekly to discuss the build of the design and get input on the positives and negatives to see if there is any room for improvement or things that are working well. Since this semester is building-focused, the team has explored the option of having team members work on different parts of the project. With being remote, the team determined that this might be the best option. After each team member has completed their part(s) of the project, we can come together as a whole in Flagstaff to build the final prototype. The team plans to work on these aspects and should lead to a successful final project.

## 4.0 Technical Lessons Learned (8) Jackie

Throughout the design process that the team has accomplished thus far, the team was able to learn a lot of technical lessons. The first and important lesson that the team learned was about assessing magnetic fields. One of the customer needs is for the device to be completely non-magnetic. The team had to compute how much of a magnetic field different types of motors would produce and then discuss whether that would be too much for the fixture. Overall, the team computed different numbers, but the magnetic fields were too large, for how close the fixture would be to the CubeSat. So, the team decided on utilizing a pneumatic system instead of electric motors to power the device. This is the next technical lesson that the team learned. The team learned about pneumatic systems. They figured out what exactly the components are, how to properly utilize one within the design, and the different components that must be thought about while using pneumatics.

Another lesson that was learned, was to calculate the center of gravity of the entire system based on different geometries using dynamics. The device must be able to relocate the center of gravity, and so the team had to figure out how to calculate and locate it first. Then the team must learn how to utilize Arduino sensors to locate the center of gravity as well. Initial experience has been gained in utilizing an Arduino system connected to pressure sensors. The last thing that the team practiced was 3D modeling using SolidWorks. Through the semester the team created a 3D model from 2D sections in SolidWorks to better show the client the design, and start understanding more of the full dimensions.

## 5.0 Conclusion (Richard)

With the design of the fixture nearly finalized, and with a clear end goal in mind, the CubeSat capstone believes that we are on the right course to finalize the project this semester. The current plan is to make prototypes of different components of the fixture in order to identify and fix any flaws that could be present in the current design. Once this is completed, the team can then redesign and manufacture the fixture and by the time that the semester ends, our design will be ready to be presented to our clients and our peers.

With that end goal in mind, the team believes that the significant progress made throughout the spring semester will be of significant benefit to us. With the trials and tribulations experienced throughout the world the team does anticipate setbacks during the rest of the design process. Hopefully any delays that could happen will be mitigated by the mistakes that were made and the lessons that were learned in the previous semester.