Executive Summary

Overview:

The USLI Payload and Avionics was created to be used inside a rocket that was launched in a NASA competition. In this competition, a rocket is launched and reaches approximately 4700 feet at its peak, and then it lands within a 2500 foot radius of the launch pad, all within two minutes. It is the responsibility of the Avionics technology to track flight data, such as altitude and GPS location, and to provide signals for when to eject each of the parachutes inside the rocket. The entire landing space is broken up into a square grid with 400 sections. Each grid space is 250 by 250 feet, and these make up the 20 rows and 20 columns of the larger grid. The Payload is a separate system from the Avionics technology, and its responsibility is to autonomously calculate which of the 400 grid squares the rocket has landed inside without the use of GPS. Once the grid square is calculated, it is transmitted to the home station. A fully successful Payload and Avionics system would allow a competition rocket to be launched, deploy its two different parachutes at appropriate altitudes, store its actual landing location with the Avionics GPS, and correctly calculate and broadcast the landing location to the launch site with the payload technology.

Design Process:

The first phase of the project was to work at the drawing board to decide which payload design could effectively autonomously calculate the landing location. About 5 different designs were considered at the start. Our general decision for the calculation method involved polar coordinates, where distance and launch angle would be calculated separately and then combined to derive the landing square relative to the launch site. The first design was a drone that would eject from the rocket during descent. The drone would stabilize itself at a specific altitude above the landing site, and then it would circle around the rocket body while transmitting time of flight signals to the home station to get an average launch distance. Time of flight works by pinging a signal to another station and measuring the time to do so. Because RF signals travel at the speed of light, a distance between the two stations can be derived from the time of flight method. A camera on board the drone would identify a landmark in the surrounding area. The specific landmark we were planning on using for the competition was a mountain that was located directly south of the launch site, and once it would be identified, a launch angle would be calculated relative to the mountain direction.

However it became apparent that the drone design would not be something that the team could realistically implement and have it perform successfully from a mechanical and programming standpoint. Halfway through the design process there was a major redesign that removed the drone from the design, changing the payload to be a system that remained entirely within the rocket. Time of Flight was still used to calculate the distance. However because the rocket could not rotate and observe its surroundings the same as the drone, more cameras were added inside the payload bay of the rocket so that all surroundings could be observed at all times; four cameras would be equally spaced inside the rocket with holes cut in the body so the outside would be observed. The landmark was also changed to a tent structure that would have a unique vibrant fabric on each of its four sides. The goal of the camera system was to identify the tent near the launch site and observe what percentage of each fabric color was captured in a given image. For example, if green fabric on the tent faced directly north and if purple fabric faced east, an image that captured 50% green and 50% purple would indicate the rocket is directly northeast of the structure. The last image taken during descent that included the tent would be analyzed for this calculation.

After many hardware revisions and field tests, the team began to believe that this design could be successful in the competition. The time of flight hardware could measure distances accurately enough for the competition. The four Cameras in the payload could take images where each of the four fabric colors could be identified out of a larger background. The team worked long hours to implement this new design to make up the lost hours put into the original design. Ultimately in April the rocket was launched in Brothers, OR. Unfortunately there was a software timeout approximately 19 seconds into the flight that caused the landing position to start being calculated when the rocket was near its apex. However, up until this point the hardware in the rocket functioned as intended.

<u>Timeline:</u>

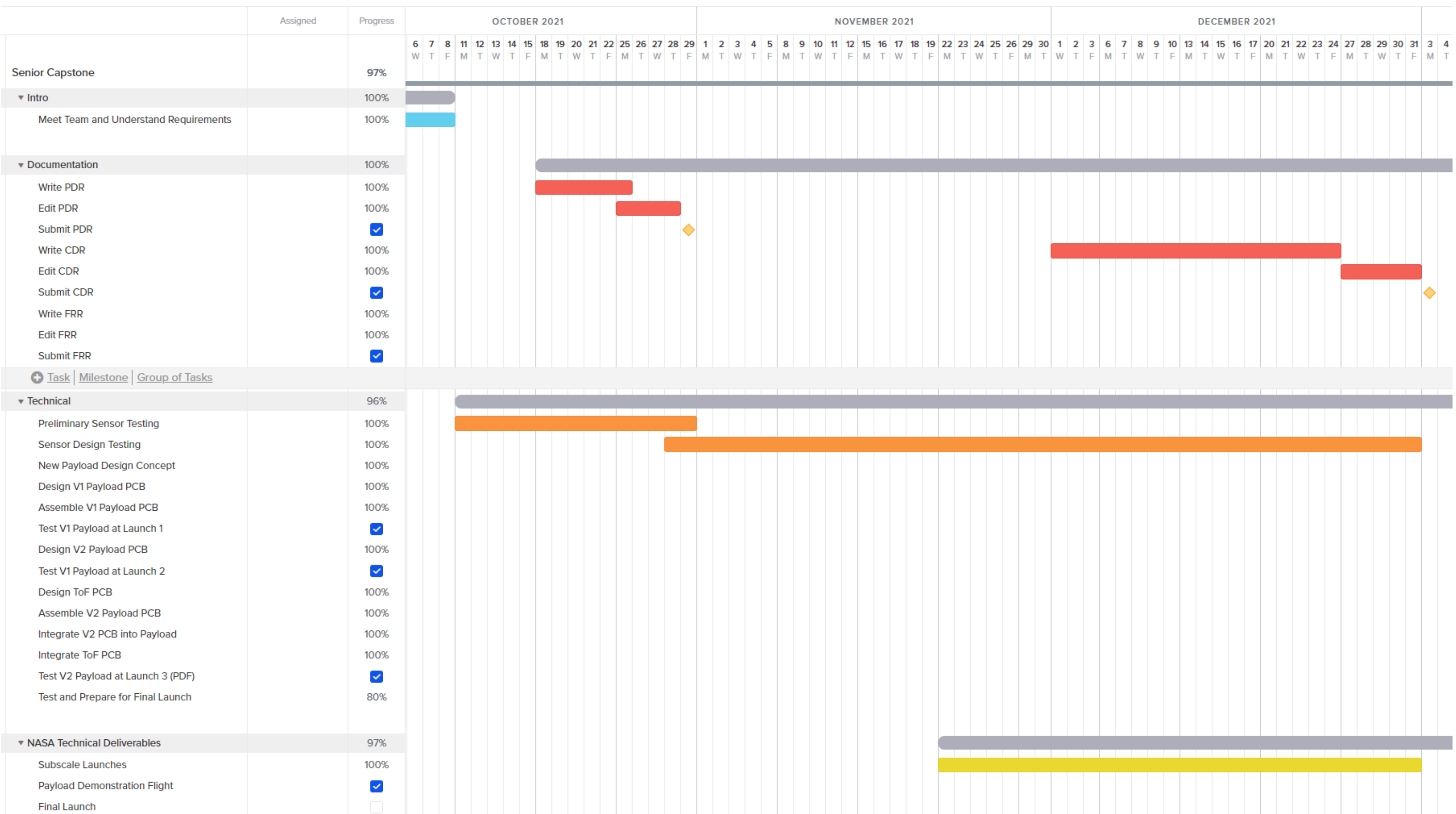

Figure 1: Team USLI Project Timeline I

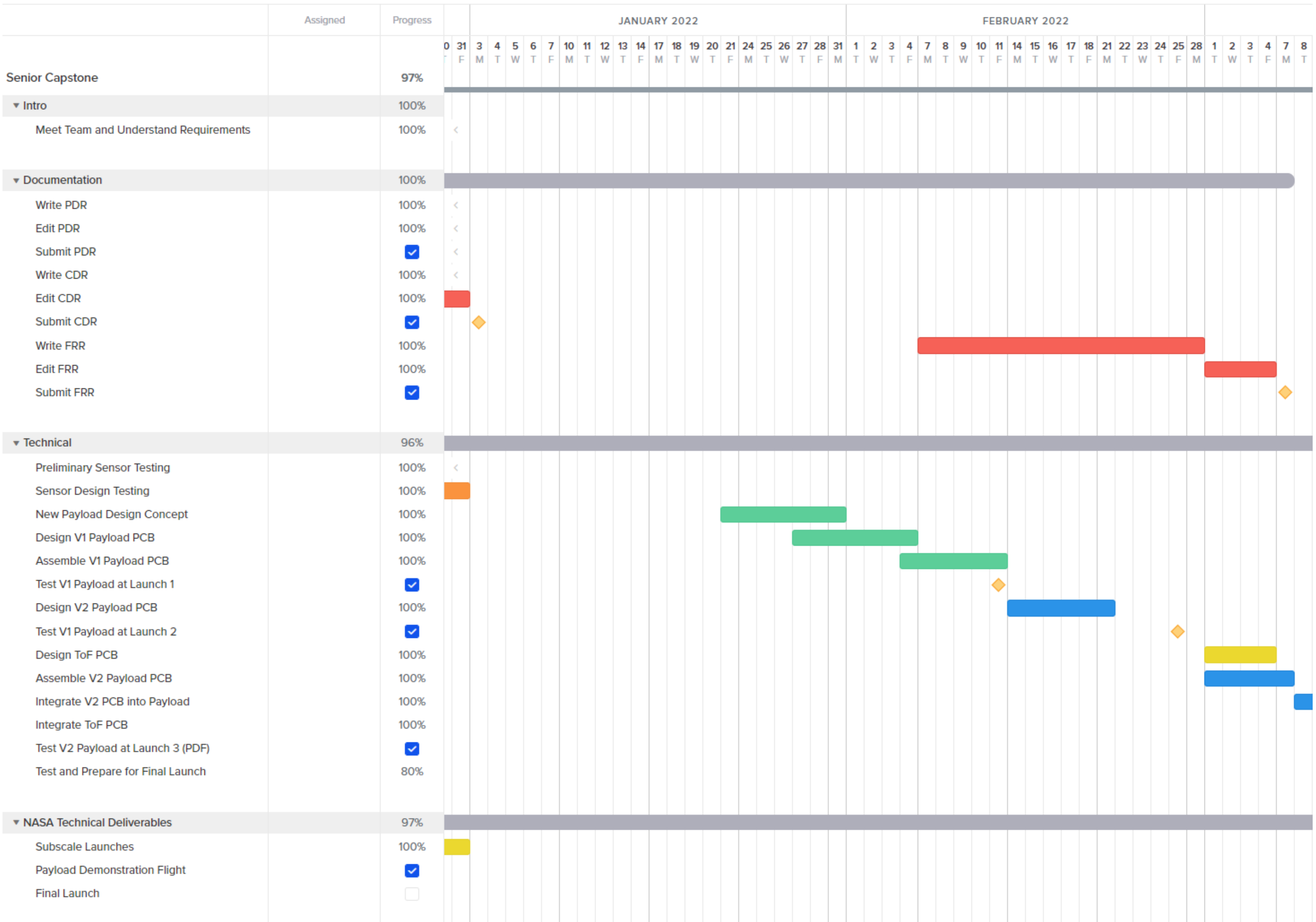

Figure 2: Team USLI Project Timeline II

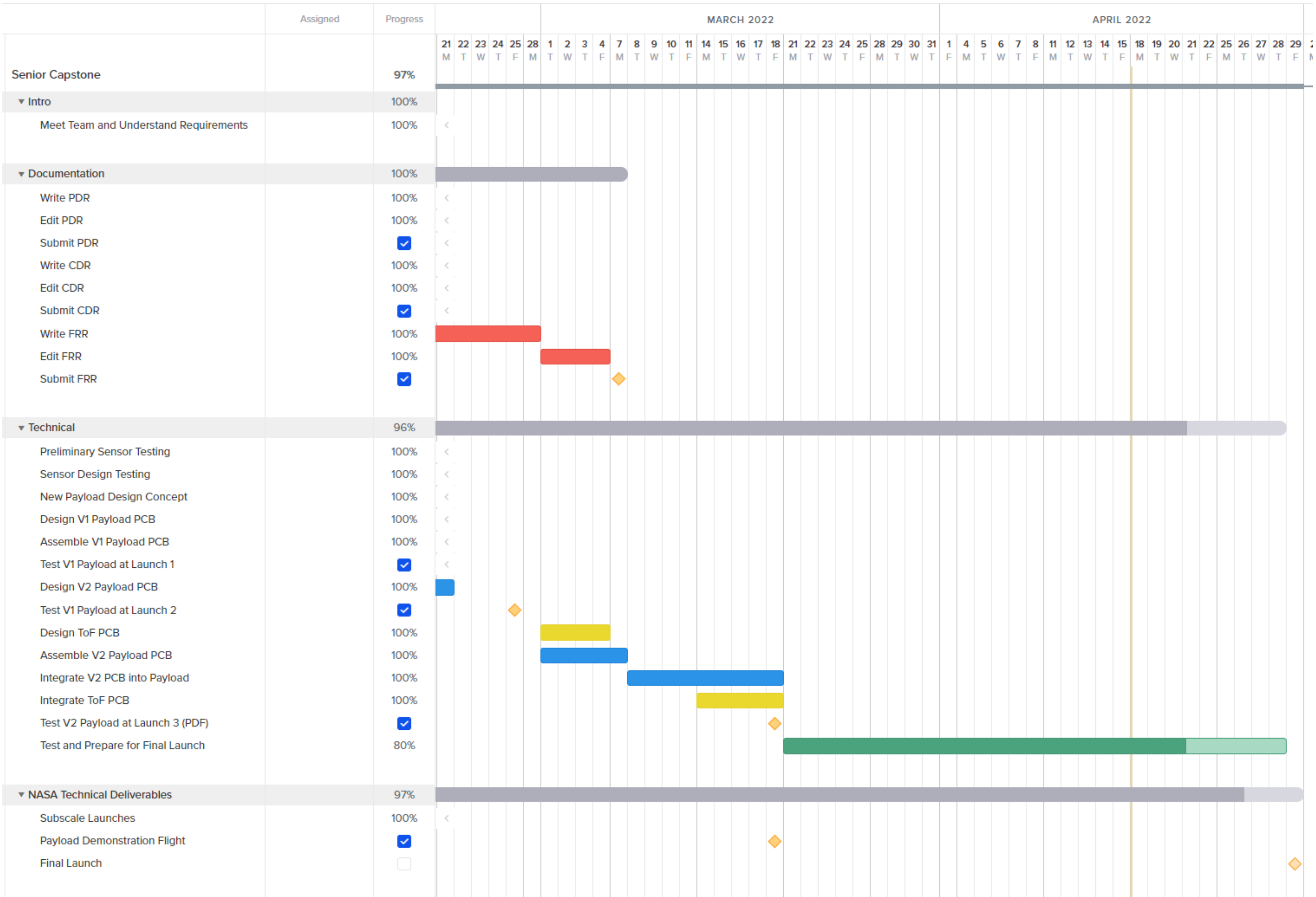

Figure 3: Team USLI Project Timeline II

Lessons Learned:

The biggest hurdle in this project was dealing with the major redesign halfway through the project. A main reason the original design was the focus for so long was because there was a lack of collaboration and communication between the payload team and the rest of the sub teams involved in the competition flight. For many months into the project, there had only been one dedicated meeting which discussed in detail the planned design for the payload. But this meeting had taken place too early for problems to arise and was too short for disagreements to be solved fully. At the end of the meeting, the decision was to continue with the current design, as a better design was not discussed during the meeting time. In hindsight it should have been clear from this meeting that more design changes were necessary. It would have been extremely helpful to have more regular meetings specifically dedicated to fleshing out the payload design. One of the biggest lessons learned throughout this project was the importance of fullying thinking through how a particular design will be implemented. In the case of the drone idea, there were many problems which should have been obvious from very early on, but there was a feeling that those problems will be dealt with at a later date. This turned out to be a very poor way of going about the engineering design process. Instead it would have been advantageous if our team spent more time, slowly working through all of the implications of our design and attempting to find as many problems as possible for each design. This would have resulted in a slower initial design, but it would have ended up saving the team months of time in the long run because we could have selected a design that was not riddled with unforeseen problems.

Over the duration of the project, there were many lessons learned regarding the way in which engineers view projects. The modular design process is a much more effective method for accomplishing a project than it would originally seem. As long as a block is well defined for its inputs and outputs, it is possible to break up the project between many different people and trust that the other blocks will function as described. This allows for each individual person to take up a particular responsibility and focus on that block. A block diagram should be one of the first steps when starting a project. Spending a significant amount of time on the block diagram may cause the initial steps of the project to appear slower, but in the long run, dedicating more time to creating a well organized and very detailed block diagram plan helped to avoid countless issues in the implementation of the designs. A well organized block diagram is another tool in the investigation into the viability of a particular design. If a block is created in which the team members do not have knowledge of how that block will be accomplished, this will more easily illuminate previously vague problems which may need to be addressed.

A positive lesson learned is that it is rewarding to see the culmination of everyone's work displayed in a competition. There were many times the team resented coming into campus on weekends to work on the project, however, there was always excitement during the test launches throughout the year. The launches were a positive reminder that our work is worthwhile. As engineers who will likely work on more team projects in the future, it's possible that we will have similar experiences to look forward to.