Imaginative Operational Processes

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I. Operational Procedures Overview

Across all of the years that the Sounding Rocketry Team (SRT) has been designing and building high power sounding rockets one aspects of the team that has had the most room for improvement was our reliability to meet a timed scheduled. With this in mind the current team (SRT4), saw the need to improve the way procedures were carried out to allow us to meet our scheduled times especially during testing of the engine and the launch of the rocket. This lead to the formation of the Flight Operations sub-team, whose task was to revise and improve previous procedure documents in terms of safety and efficiency as well as writing new procedures for any new systems that may be developed throughout the year.

Most of the previous procedure documents were written by the sub-teams that developed the systems themselves. Although logical in the beginning, it was later shown that the design, review, and construction process took a significant amount of time during the school year, leaving the particular sub-team with little time to write and update procedural documents relevant to their systems. This lead to rather inefficient procedures that slowed down operations and sometimes even led to instances where basic system assembly procedures were not documented at all.

The first factor that was addressed in the revisions was the time it took the team to complete a procedure. Whether it was an engine test, preparing for a launch, or doing a launch itself, these tasks often took from 5 to 10 hours to complete. Completion time was unpredictable and often lead to rushed tests that offered no useful data and team-members not performing to standard due to physical and mental exhaustion.

Due to the nature of the work being performed by the team, safety was of first concern when making the revisions to the procedures. The team met with a representative of the Society of Flight Test Engineers to discuss proper ways of determining and mitigating risks during operation of the rocket. The meeting led to the creation of a set of tables that outline the steps of a certain procedure, points of possible failure, the probability of failure, procedures for mitigating risk, and the resulting probability of failure after said mitigation procedures are implemented. These tables were created for each of the existing operating procedures as well as the stages of flight.

The first measure that was taken was to reduce the time spent between steps in the procedure caused by minor setbacks, like gas leaks, instrumentation errors, amongst others. Most of these problems were rather common and had happened before throughout the teams four years of existence, but the knowledge on how to identify the problems and fix them was merely anecdotal and was lost as members of the team graduated. To counter this, a database of setbacks was started. This sheet included the prominent signs or symptoms, the cause of the problem, and a list of times it has happened and how it was solved during each occurrence. Although it did not show a prominent effect on this year, it is a good basis for streamlining these situations in the years to come.

The second measure focused on reducing the time sub-teams were left to idle while waiting for another sub-team to complete part of the procedure. This was a large area for improvement during launches, as one sub-team would often be the bottleneck for the entire operation while others would wait, adding pressure that one sub-team and increasing frustration amongst others. To fix this, the workflow was reorganized and streamlined to allow for as much parallel working as possible. People were given specific roles at different stages of the operation so that everyone would be advancing the team at all times. This also helped the team know how many people were required to complete different tasks on launch day. To facilitate the communication of this information to the rest the team, a briefing is held the day before an event to let the team members know of their specific responsibilities and what tasks they will be performing during said procedure as well as mentioning all the safety precautions that must be taken to ensure a safe launch or test. Preparations for the event would also be done in the same day of the briefing for assemblies that did not require they be done on the day of said event, such as packing of the recovery system, or assembling the electronics bay.

These measures and modifications to procedures were tested during static engine and cold-flow tests. The cold-flow tests included all of the procedures corresponding to launch-day, including the briefings the day before, but excluded the ignition of the engine. Both types of tests were done multiple times, with each attempt using a slightly different order of operations and different amounts of people for each step. They were all timed and the data obtained from them was used to determine the optimum procedures method and order of operations for launch day and testing.

A specific example of these revisions is the modifications done to the filling procedures for the oxidizer used in the engine. The original procedure involved connecting the rockets run-tank to an external fill tank and opening the fill tank solenoid to allow for the oxidizer to enter the rocket. It should be noted that the run-tank is also connected to an external venting line that could be opened and closed on command. During this original procedure, the vent line was to remain closed until the engine was ignited, which limited the amount of oxidizer that could be introduced into the engine along with the loss of oxidizer during firing. After reviewing this procedure, it was modified so that the vent line would remain open during filling to maximize the amount of oxidizer being introduced into the tank, and then closed once the target weight was reached. The team would then wait a sufficient time to allow the oxidizer to expand and thus increase the pressure inside the run-tank before igniting the engine. This small change in procedures greatly increased the performance of the engine during testing.

After evaluating the results at the end of the academic year, the formation of the Flight Operations sub-team and the procedures implemented improved the fluidity of all large events led by the team. For improving time-efficiency, man-power usage, and most importantly safety, having a dedicated team to review the tasks proved to be an effective measure