Project IMUA Mission 12 FAR ARLISS

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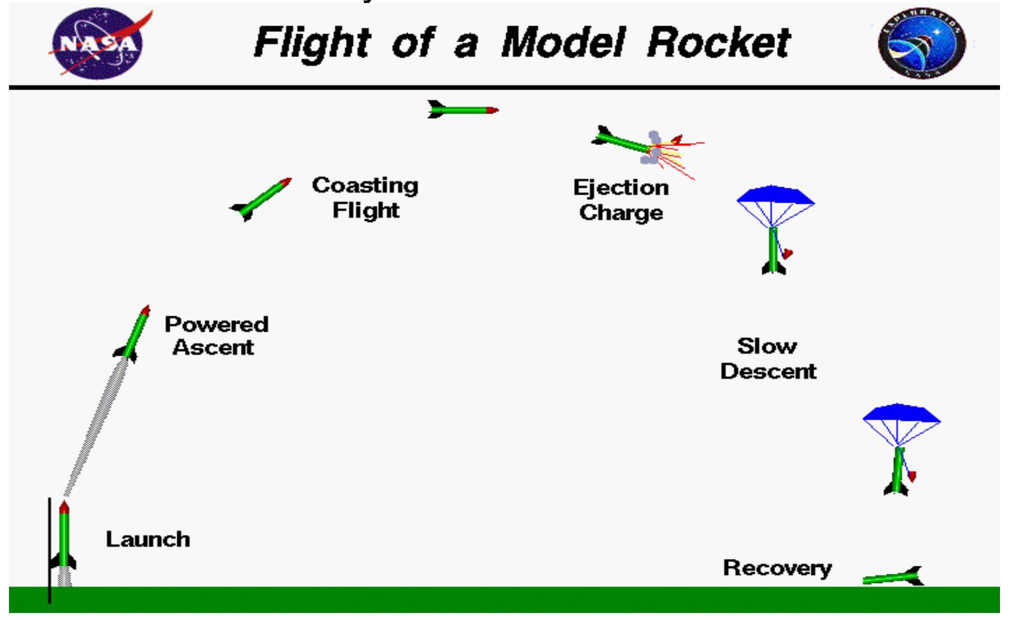
Mission Objective

Project Imua Mission 12 involves the participation in two separate but related rocket competitions. In June, UHCC students will travel to Mojave, CA with their mentor to enter the FAR's 10/25 competition—the challenge is to build a liquid bi-propellant rocket that attains an altitude of 15-20,000 feet and recovered safely and intact. The FAR's launch will serve a dual purpose: 1. advance Project Imua's experience with hybrid motors, and 2. test the payload (consisting of an autonomous rover with atmospheric sensors) that will be flown in the subsequent competition at Black Rock. Once field tested at FAR, an improved version of this payload will be launched by a solid rocket motor at the ARLISS Come-Back competition at Black Rock, NV. The opportunity to fly the same payload in two different competitions affords the team a chance to enhance the overall design of the autonomous rover for two different environments.

The FAR requirement that the ascent vehicle use a hybrid motor, while ARLISS requires a solid fueled propulsion, gives further opportunity to test the ground safety protocols that could be used for future static propulsion studies at WCC's Static Rocket Motor Test Facility.



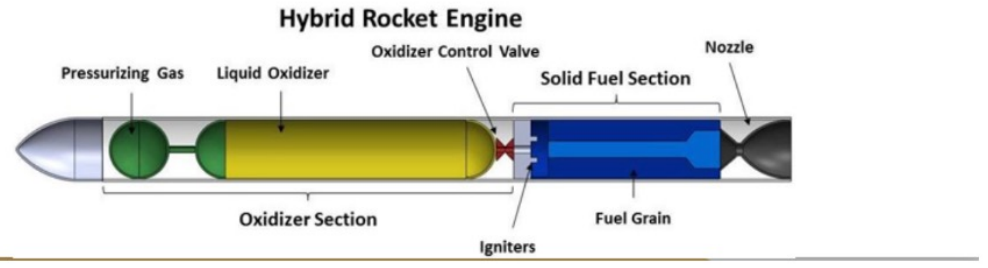
The Payload

In addition to the actual launch of the rocket, we will also need to find a way to have the payload reach the specified GPS location. While previous members of this team have designed their code, we plan to learn from their mistakes and improve on the different aspects that were unsuccessful during their launch. From the previous launch, the team used a microcontroller which is the technology that allows the payload/rover to move towards the designated location. An Arduino Nano Every is the specific microcontroller that was used. This microcontroller had stored the code that was written in the IDE Arduino 1.8.18 [4]

Within the actual payload unit, a GPS system will be crucial in the success of reaching the specific location. The GPS information gained from this system is what will be needed in order to run through the functional PID (Proportional, Integral, Derivative). This PID system takes a specific goal or in this case a specified coordinate, then adjusts the current location to minimize the distance between its current location and the target.

Our payload, "Roberr" was initially designed by the previous Project Imua team members. We plan on making adjustments based on inconsistencies that had been encountered in the past. This payload will need to fit within the volume constraints required within the top portion of the forward section of the rocket. Additionally, Roberr will likely have to traverse through dry and uneven terrain on its way to the GPS location.

Hybrid Rocket and Equations

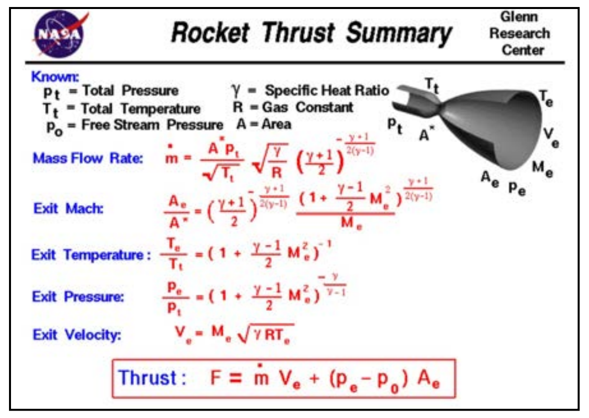


Pros:

- Less complex
- Safe
- Throttle Capabilities
- Restart Capability

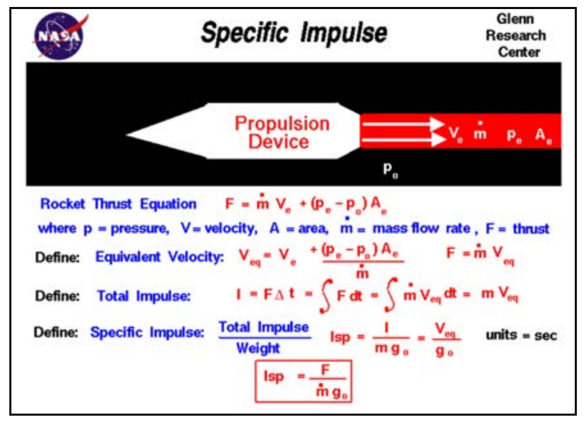
Cons:

- Some complexity
- Regressive thrust curve
- Restart is theoretical and is yet to be done in practice



Thrust Summary:

In a rocket engine, stored fuel and stored oxidizer are ignited in a combustion chamber. In this case, our oxidizer is N_2O and our propellant is acrylic based. The combustion produces great amounts of exhaust gas at high temperature and pressure. The hot exhaust is passed through a nozzle which accelerates the flow [2].



Specific Impulse:
It gives us a quick way to determine the thrust of a rocket, if we know the weight flow rate through the nozzle. Second, it is an indication of engine efficiency. Third, it simplifies our mathematical analysis of rocket thermodynamics. Fourth, it gives us an easy way to "size" an engine during preliminary analysis. The result of our thermodynamic analysis is a certain value of specific impulse [3].

$$\text{Thrust} = A_T P_C \gamma R \sqrt{\frac{2T_T T_C}{\gamma-1}\left(\frac{2}{\gamma+1}\right)^{\frac{1}{\gamma-1}}\left[1-\left(\frac{P_e}{P_C}\right)^{\frac{\gamma-1}{\gamma}}\right]}$$

The Oberth Equation relates the thermodynamic conditions in the combustion chamber and nozzle to the overall thrust of the rocket motor.

$$\dot{r} = aP_C^n$$

$$\dot{r}(x) = ax^m\left[G_o + 4\int_0^x \rho\frac{\dot{r}(x)}{D_H}dt\right]^n$$

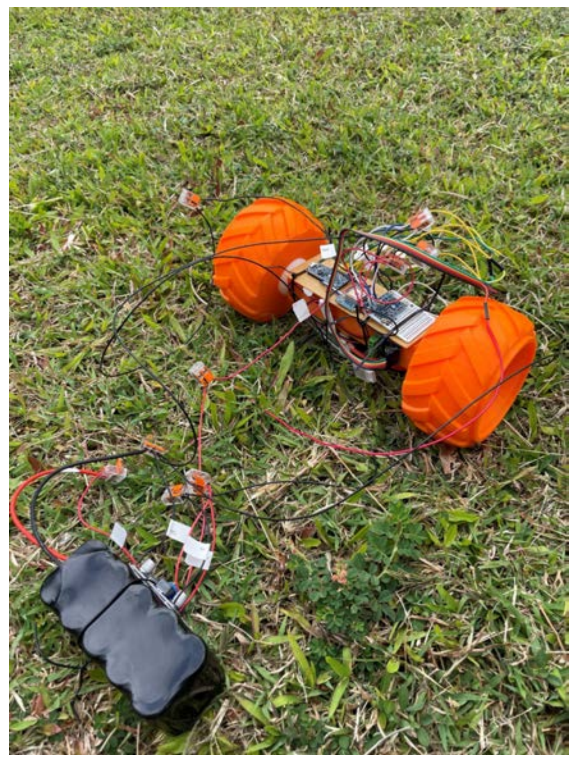
$$\dot{r} = aG^n x^m \quad \text{(m = -1/5, n = 4/5)}$$

$$\dot{r}_{ave} = aG_{ave}^n L_p^m$$

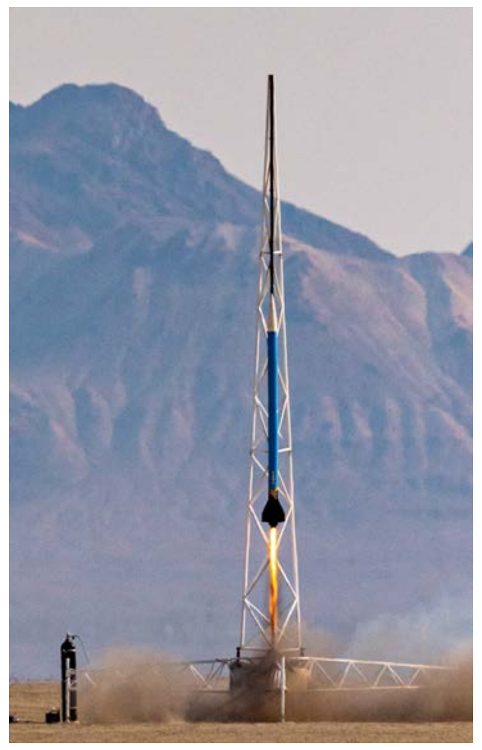
The burning surface of a rocket propellant grain recedes in a direction perpendicular to this burning surface. The rate of regression, typically measured in inches per second (or mm per second), is termed *burning rate* (or *burn rate*). This rate can differ significantly for different propellants, or for one particular propellant, depending on various operating conditions as well as formulation. Knowing *quantitatively* the burning rate of a propellant, and how it changes under various conditions, is of fundamental importance in the successful design of a solid rocket motor [7].

Previous Launches

Apophis at touch-down



Roberr the Rover



Apophis at lift-off

References

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[5] *Friends of Amateur Rocketry, Inc. – Serving the Amateur Rocketry Community*. friendsofamateurrocketry.org/.

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[7] "Richard Nakka's Experimental Rocketry Site." *Nakka-Rocketry.net*, nakka-rocketry.net/burnrate.html

Acknowledgments

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