Association of Experimental Rocketry of the Pacific

TRIPOLI Rocketry Association, Inc. Prefecture No. 23

Volume 24 Issue 1

May 2018

AEROPAC Spring 2018 Newsletter

Photo by Phoenix 4, courtesy of Curt Von Delius

President's Pad

The playa is looking pretty good. We should have a normal flying season this year.

Our treasurer, Eric Kleinschmidt, has been called up for duty and won't be running the registration booth this year. William Walby will be handling Mudrock registration. We will likely need some help for the other 2 launches.

Waivers are - Mudrock— Daily to 60,000'. High altitude to 150,000' 2 hour windows on Friday starting at 13:00, Saturday and Sunday starting at 09:00. Aeronaut— Daily to 60,000'. High altitude to 150,000' 2 hour windows on Friday, Saturday and Sunday starting at 09:00. ARLISS/XPRS - Daily to 60,000'. High altitude to 150,000' 2 hour windows on Monday-Friday starting at 13:00, Saturday and Sunday starting at 09:00.

What's Inside

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Fin Fillets

Jim Green

The subject of fin filets comes up at some launches so I documented how I have been doing them lately.

This method is a combination of tips that I have received over the years.

First, I tack the fins on with CA while holding them with a fin alignment jig. When dry I remove the alignment jig and mark the fins and body tube 3/8" out from the fin slot. Then I lay down blue tape at the marks.

Photo courtesy of J. Green

I mix up some epoxy. I like West Systems 405 with the 206 slow hardener. It gives me a long pot life.

I thicken that epoxy with equal amounts of Tap Plastics Cab-O-Sil and Microspheres until it is about peanut butter consistency.

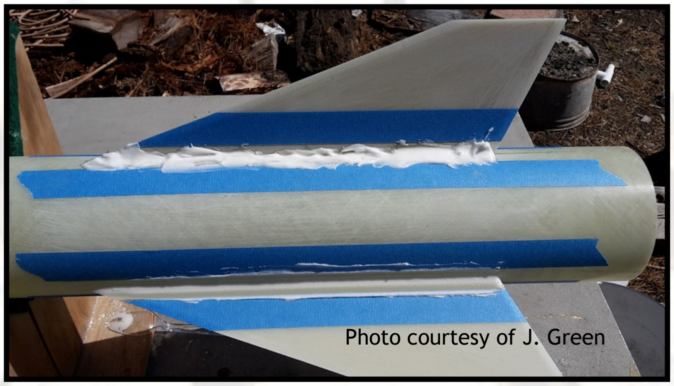
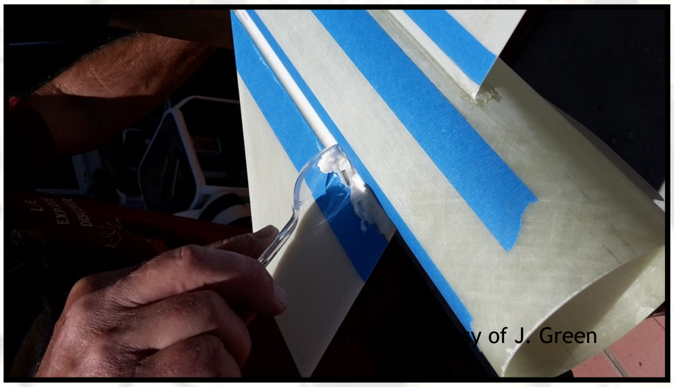


Photo courtesy of J. Green

I scoop and dab the epoxy into the filet area.

I use a plastic spoon and then a ½" copper pipe to form the filets.

I drag the spoon down the filet area so that the excess epoxy gets scooped into the bowl of the spoon. That forms a nice filet but in this case I want the filet a little smaller. The spoon's function is to catch the excess epoxy so I have less mess.



y of J. Green

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Fin Fillets

Jim Green

I take the copper pipe and hold it at a 45 degree angle so that just part of the tip is forming the filet. I drag the pipe at that angle down the length of the filet area.


Photo courtesy of J. Green

Check for trapped air pockets. In this picture you can see a small bump in the filet area about 2" from the end of the fin. That bump is trapped air. Dab at it until it breaks open.

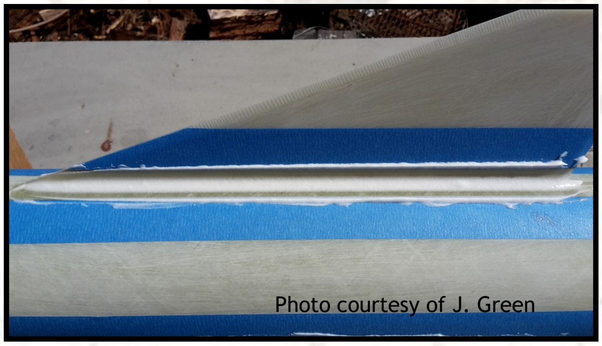
Photo courtesy of J. Green

Put a little epoxy in the hole to fill it back up and then run the copper pipe down the full length of the filet area.

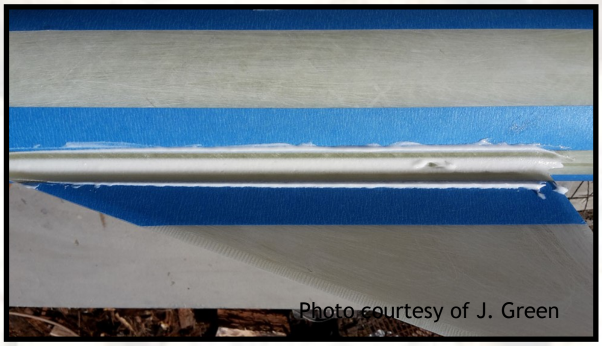
Photo courtesy of J. Green

Now you can carefully remove the tape while the epoxy is still wet and let these 2 filets harden for an hour or 2. Position the filets face up so they don't sag during the cure. Once it is hard enough to not sag you can turn the rocket and work on the next 2 filets.

You will have very little sanding to do once all of the filets have hardened.

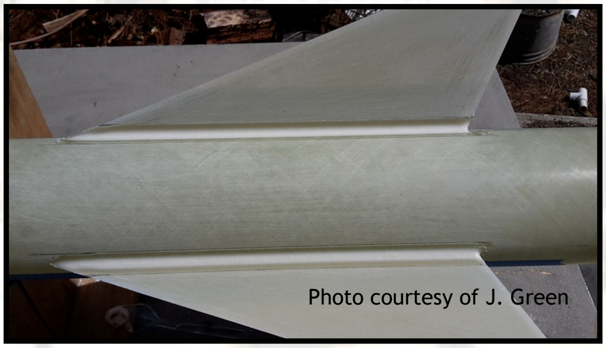
Photo courtesy of J. Green

Rising Data

Lauren Novatne

Rising Data is a NASA funded project for Rocketry and California Community Colleges

As always, our own Dr. Lynn Cominsky is still busy with educational outreach in rocketry. She was recently involved with a project funded by NASA to work with and train California Community College Instructors to develop curriculum for community college classes. Ten community colleges participated in the project, from the SF Bay area to southern California. The pilot team developed the material and trained the participating college instructors how to build rockets, payloads and quadcopters, and how to analyze the data acquired during a rocket launch. Dr. Cominsky, Dr. Greg Kriehn from CSU Fresno, Dr. Erin Quealy from Napa Valley College, and Lauren Novatne from Reedley College made up the pilot team. And of course, nothing could have happened without Tony Alcocer helping everyone with the rockets, making a video of how to build the modified Estes Big Daddys, and making all the modification kits.

In July of 2016, the pilot team and two participating college instructors met at SSU for a week of training. They learned how to build the Estes Big Daddy rockets, an electronic payload to acquire data during the rocket flight, a quadcopter and how to program the electronic payload. After the intense four-day workshop, the team launched their rockets and flew their quadcopters. Some data was recorded by the payload, which was then downloaded to a computer for analysis. Only four rockets ended up in trees or places that were hard to reach, and Tony was able to retrieve all but one of them (mine). Without Tony's help, the rocket portion of the project would not have been nearly as successful as it was.

Photo courtesy of L. Cominsky

Dr. Cominsky and the author, Lauren Novatne at Snow Ranch

In addition to learning how to build, fly and acquire data, the pilot team also developed materials for use in community college classes for STEM majors. The first classes were taught by Lauren Novatne at Reedley College and Dr. Quealy at Napa Valley College in the Spring of 2017. The students built a rocket, quadcopter and electronic payload. They programmed the payloads to acquire data on altitude, acceleration, magnetic fields, pressure and temperature.

Photo courtesy of L. Cominsky

The July 2016 Rising Data Class at SSU on flight day

In late spring, the student rockets were launched at the Snow Ranch site east of Stockton, CA.


Photo courtesy of L. Cominsky

Napa Valley students and instructor at Snow Ranch


Photo courtesy of L. Cominsky

Reedley College students and instructor at Snow Ranch

The summer of 2017 had the pilot team hosting a training workshop at CSU Fresno to train several other community college instructors. The instructors built their rockets, payloads and quadcopters, then flew them successfully – this time at the Tripoli Central California club site. During the second year of the grant the colleges: Rio Hondo, Merced, Contra Costa, Fresno City, San Mateo, Irvine Valley, and Los Angeles City joined Napa Valley and Reedley College in teaching the class to STEM majors. For a successful grade in these classes, the students had to build their own rockets and quadcopters, build and program their electronic payloads and successfully fly both their rockets and quadcopters, as well as acquire and analyze the payload data.

The Community College students learned some essential building skills like soldering, basic tool use, and programming to construct the rockets, quadcopters and electronic payloads, just like the instructors had.


Photo courtesy of L. Cominsky

Tony Alcocer and a Reedley College student at the 2017 Tripoli October Skies Event

The students from the Reedley College class launched their rockets at the 2017 October Skies event at the Tripoli site. Tony Alcocer helped again, and the students enjoyed his expertise and patience. The data acquired by this launch led to some very insightful understandings, in both scientific and technical applications. Student feedback was overwhelmingly positive, they loved the class and learned more than they thought they could. Some of these students have caught the rocket bug!

The final rocket flights occurred at Napa Valley College as the Snow Ranch May date was cancelled due to fire danger. Students from Contra Costa, Napa Valley and San Mateo joined Dr. Cominsky and Tony to launch rockets near the Napa River. All rockets and payloads were retrieved successfully, which was a fitting end to the Rising Data project.

Reedley College students and Instructor at the 2017 Tripoli October Skies event

Some students got even more out of the experience. The NASA grant also provided that one student from each college got a paid summer internship at either SSU, CSU Fresno, NASA Ames in the Bay area or NASA Armstrong Flight Research Center in Southern CA.

With guidance and support from Tony and Dr. Cominsky, the seeds for rocketry were planted in multiple community colleges, and many students were introduced to this fun and informative hobby.

Costa Rica ARLISS Vets at UNISEC's Global Meeting

Costa Rica Team

After achieving first place in a Latin American region contest in October, 2017, our team of students from the Aerospace Engineering Group of the University of Costa Rica, participated as representatives in UNISEC's (University Space Engineering Consortium) Global Meeting held in the University of Sapienza in Rome during December, 2017. In the pre-Mission Idea Contest 5 final, we presented our CubeSat project called RETI-SAT. RETI-SAT is a 3U CubeSat designed to monitor and predict the Red Tide phenomena in the Central American region.


Photo courtesy of Costa Rica Team

Our team of students is composed of: Jose Ricardo Campos, Stephanie Rodriguez, Thamara Montero, Francisco Salazar, Olman Quiros, Gustavo Fonseca, Francisco Segura, and Robinson Cespedes; lead by Msc. Mariela Rojas. This was a valuable opportunity for our academic, professional, social and personal development.

Our team not only worked hard for months on the technical development of the project, but we started an intense campaign to raise funding required for this trip. To do so, we ran an internet crowdfunding campaign. In addition, we visited the classrooms of the main universities in Costa Rica to seek support from other students. Finally, the Fundevi organization of the University of Costa Rica contributed the remaining funds required. Our team would like to mention that having received the support of several people (including AeroPac members) was, in short, an incentive to continue working persistently. We would like to thank everyone for your monetary contributions.

During our time in Rome, we were able to participate in the variety of activities at the event: workshops, round-table group discussions in trending topics for the aerospace community, but more importantly for the CubeSat community and the benefits of the space usage in the humankind development. This event allowed us not only a chance to learn and improve, but also a chance of benchmarking with researchers and academics from universities and industries involved in the aerospace sector, bringing us many opportunities in the future. Also, we improved our team work, while developing the project, socializing and learned some other soft skills such as assertive communication.


Photo courtesy of Costa Rica Team

Our team also had the experience of visiting Rome for the first time. We were able to visit Rome's most iconic places like the Colosseum, the Vatican, the Catacombs , the Pantheon, Trevi Fountain and some major catholic churches. We also enjoyed the world-famous Italian cuisine.

Since Rome, our team has grown not only in quality, but also grew in numbers. All the feedback received by the experts, is now incorporated in the design, and the project keeps undergoing development. The GIA plans to develop the project together with other national organizations to become a reality, and become the first CubeSat of the University of Costa Rica.


Photo courtesy of Costa Rica Team

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Building and Flying a 1/24 Scale SpaceX Falcon 9

Or how hardware store engineering, junkyard engineering and some real engineering led to a pretty cool high power flying model of the epic, industry disrupting and prolific workhorse rocket of this era.

Juniper Slouber and Jonathan DuBose

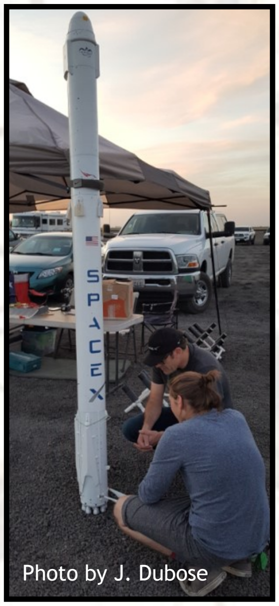


Photo by J. Dubose

Photo by J. Slouber

Photos by Nadine (c) 2018

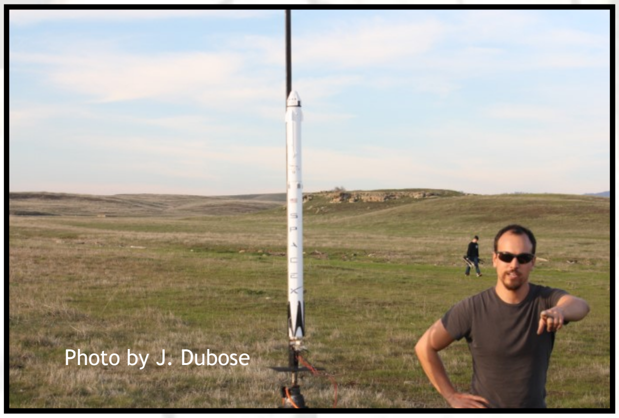
At LDRS XXXVII we launched our 1/24 scratch built scale Falcon 9. It went pretty well. This configuration had 5 motors - 4 Aerotech I140s with a central Aerotech J350. It was a very straight flight to 2000ft. The Dragon capsule popped off at apogee and came down on chute in perfect condition. The booster came down on chute and deployed landing legs at 400ft. It landed in a plowed up section and then fell over. Upon landing 3 of the legs broke - we should have reinforced them with carbon fiber. Two sub nominal items - we could not get the look down camera turned on so we missed the legs opening and the upper stage chute deployment failed.

Nevertheless, we considered the flight a success since it flew straight, the booster deployed the legs and got the capsule home safely. We can correct what didn't go right on future flights.

The backstory: In February, 2016 a little over a month after SpaceX successfully landed its first Falcon 9 booster, the LUNAR rocket club had a "Space Modeling" contest. One of the contestants was Matt Wise who had built a pretty detailed ~2 ft tall Falcon 9 with a "Crewed Dragon" capsule and which featured 9 A motors. A SpaceX fan for awhile, we (Dick Jackson and I) were pretty impressed. Yes, the legs and grid fins were not functional and it was only a single stage but nevertheless very cool and it immediately got the wheels spinning in our noggins. Maybe we could build a larger high power Falcon 9 that had functional legs, grid fins and a flying 2nd stage…it seemed like a very interesting and doable project.

Matt flew his Falcon, lit 8 of the motors and, I think, won the contest. We struck up a conversation with him and he turned us on to "Thingiverse" a website where folks archived their CAD designs as .stl files and which were "open source" to download and use for free. Matt had used a couple of these files to 3D print several features on his model and he also noted that SpaceX sold a model rocket Falcon 9 on their website and it had some good detail.

Since I already owned a 3D printer things were starting to take shape before we left Snow Ranch that day.



Matt Wise and his "crew" version of the SpaceX Falcon 9

Here are some of the highlights of our project which ended up taking 2 years.

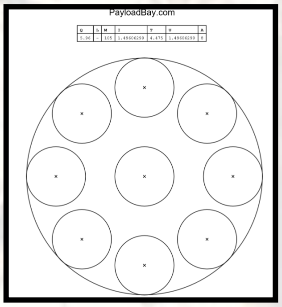
- The SpaceX Falcon 9 model rocket served as basis for upscaling and we used a factor of 3.6445 to reach a 6.15" OD airframe. The booster, interstage and 2nd stage, legs, grids fins, etc. are all based on the dimensions derived from the model.

- We utilized a leftover fiberglass Hawk Mountain airframe from previous ARLISS builds for the lower fincan.

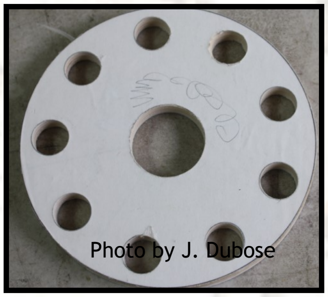
- We decided to build the ISS Commercial Resupply version with the Dragon capsule and trunk to facilitate reasonable standoffs for the launch lugs.

- The final build was 98" tall and almost 30 lbs.

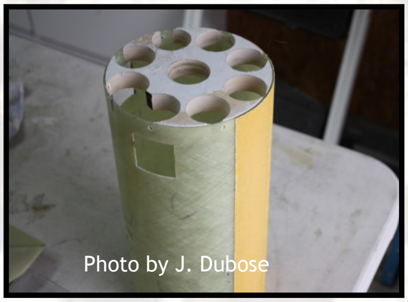
- PayloadBay.com was used to create the Falcon 9 "Octoweb" (motor mount) template. We printed the PDF, cut it out and pasted it onto a .75" thick Baltic Birch plywood 6" airframe bulkhead and used a 1.5" Forstner bit to bore 38mm motor slots.



Motor Mount Template



Thrust ring for I140s



Prototype fin can

The outer edge of 38mm slots actually allows a part of the motor thrust ring to contact the airframe insuring that the thrust of the 8 outer motors would be translated directly to the airframe and not just the motor mount.

- The upper section of the booster and the rest of the airframe would be 6" Blue Tube from Always Ready Rocketry which is strong enough, light and easy to work with.

At this point, the project sat for over a year. Jonathan had a high altitude two stage project in the works (M1419 to M650 to 55.3k' at XPRS 2015 and N1000 to M685 to 90k' in 2016 (FBLP, RIP - failed apogee recovery) and both Dick and Jonathan had sporadic and significant ongoing medical issues. Dick required knee replacement and missed the rest of the project.

In early 2017 several things happened to kick start the project.

- A 3D printer upgrade to a Flashforge Creator Pro which requires little maintenance and prints beautifully. Two key parts required printing in several pieces, due to their size, and then gluing together with CA glue, e.g. – the legs in 3 pieces and the Dragon in 6.

- Juniper Slouber (Jonathan's 17 yr old grandson), who had earned his Tripoli Mentoring Program (TMP) stripes the previous summer, got serious about the Falcon 9 project. He brought his significant CAD skills, rapidly expanding rocketry knowledge, considerable imagination, hard work and youthful enthusiasm to the project. See Spring and Fall 2017 AEROPAC newsletters for write-ups on Juni's awesome 54mm K motor project which flew to 26,939' (4th on Tripoli's K record page.)

- We were lucky enough to arrange a visit at SpaceX in Hawthorne, CA and this energized the project. Seeing real Falcon 9 and some Falcon Heavy components under construction was amazing. See Monica Daniels and Curt Von Delius' "SpaceX Trip Report" in Fall 2017 AEROPAC newsletter.

Progress came quickly when we could find time:

- Jonathan created an OpenRocket model, later heavily upgraded by Juni, and we constantly updated it to make sure it looked like our F9 could actually fly.
- Thingiverse and GrabCAD had some really good .stl files which were easily upscaled and printed. The two most important files were "DragonEasyPrint" by Prober https://www.thingiverse.com/thing:42488 and the landing legs from Lance Skelley https://grabcad.com/library/spacex-falcon9-1
- The Dragon was used without modifications and legs were modified by Juni to fit the struts we use.

Dragon capsule and trunk. Printed early in the project with ABS filament

- Landing leg struts: ”gas springs” - the junkyard “engineering” part of the project was searching for workable units. The final version is from the glass lift gate on 1997-2002 Ford Expedition / Mercury Navigator ($7.50 each from Pick and Pull).
- Grid fins - Although we adapted parts of the fin .stl file from the web they were very modified and Juni designed the base and pivot point from photos. The pivots were designed to appear as close as possible to the real thing while maintaining functionality for the scaled size. The base mounts are designed to hold a Hitec HS-65MG servo mounted through the wall to facilitate the swiveling of the fin. The servos are controlled via an Arduino mounted about 8 inches below. The grid fins, as it stands, cannot activate in flight. We came up against our deadline and determined they were nonessential for our first flight.
- Decals were sourced from Stickershock23.com. Mark Hayes already had the basics and we just needed to give him the dimensions. The decals are very high quality vinyl “peel and apply” and really dress the rocket up.

Applying the decals with help from Jonathan’s father-in-law Ed.

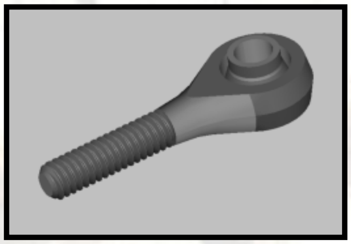
- For electronics 4 Featherweight Ravens and a Stratologger CF were used. The CF deployed the chute to land the Dragon after deployment from the 2nd stage by pyros fired by a Raven. Ravens were also used in the Booster to deploy the main chute and to fire the pyros to release the legs.
- Archetype cable cutters were used to cut zip ties that held the landing legs securely to the airframe. The cutter had to be prepped while fitted inside the 3D printed holder which would be secured to the inside of the airframe.


Archetype Cable Cutter with 3D printed holder

- Motor selection: For our first flight we chose 4 Aerotech I140 DMS motors with a central J350. Assuming we could light all 5 motors simultaneously that would result in a 16 to 1 thrust to weight ratio if the OpenRocket weights were accurate (and they were). The total impulse would end up being the equivalent of a mid range “L” motor pushing the 29.8lb rocket. The final altitude sim was 1800 but the actual was 2005ft (Raven).
- Motor Lighters: To insure the launch system would have enough juice to light all the motors we used 5 low current e-initators each surrounded by easy to light, cross drilled pellets of Aerotech Blue Thunder propellant. This method has worked perfectly to light the sustainer on Jonathan’s high power 2 stage rockets and it worked here as well.
- Fins: Lacking the ability to thrust vector the motors for stability we had clear plastic fins cut from 3/16 clear polycarbonate. Juni designed the fillets which would hold the fins to the airframe. “The

Plastics Guy" of Sacramento created perfect fins from Juni's file. The fins are barely visible in even close up photos.

- ~ 100 8-32 cup point set screws were used to assemble the rocket. Epoxy was used in only a couple of spots.
- Raptor PLA 3D print filament from Maker Geeks that was used for all 3D printed parts except the Dragon and Trunk which were printed very early with ABS. Raptor PLA is extremely strong, has high temperature tolerance and is anneallable which increases both the strength and temperature tolerance. All parts printed with a hexagon infill pattern at 60% density.
- 8/32 Ball Joint Rod Ends from McMaster-Carr. One of the critical points of the whole rocket was where the legs attached to the lower end of the booster. One of the modifications we made to the landing leg was to design # 8 screw holes to accept the Ball Joint Rod Ends. And since this was the thinnest part of the leg and also one that would take a lot of the stress we did a fiberglass sleeve layup over the very lower 4" of the legs.
- .STEP files from McMaster-Carr. Most parts in their online catalog have a CAD rendering which can be downloaded and inserted directly into CAD designs.
- Mistake: Jonathan decided, mainly for weight reasons, not to strengthen the legs with a carbon fiber layup. The CA glued legs seemed really strong and repeated attempts to break them at the joint required tremendous impact. This was a big mistake. As it turned out 3 of the legs broke upon landing under an 84" chute – the body section was about 20 lbs. The booster landed vertically and had we strengthened the legs we would probably have "stuck" the landing and, as it turned out, we did not have a weight / stability problem.

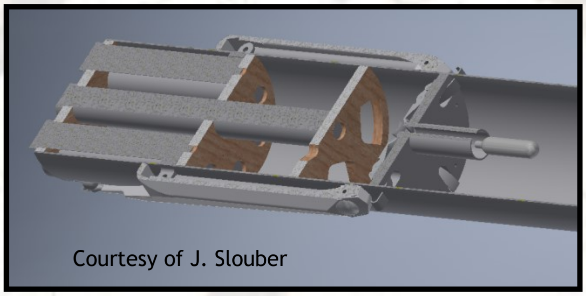


.step rendering of an 8-32 Ball Joint Rod End from McMaster– Carr online catalog

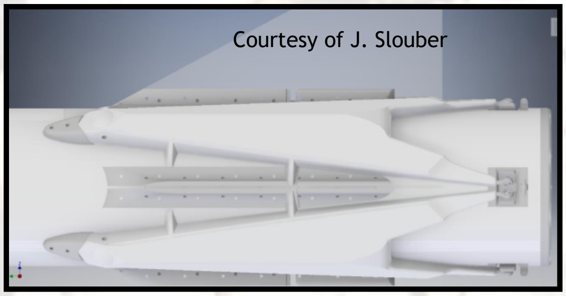
Extensive Use of Computer Aided Design (CAD)

This project was just not practical without the extensive use of Computer Aided Design done mostly by Juni. The most complex section of the rocket was, of course, the booster fin can. It would need to accommodate the 4 landing legs with anchors and pivots, mechanical struts to open and support the legs, at least 5 motors but slots for 9, the mechanism to release the legs and fins with fillets. That would be impossible without a precise drawing that showed how everything would fit together with precise dimensions to make any required cuts in the airframe.

Juniper had been introduced to Autodesk Inventor in his high school engineering class and continued to hone his skills in his rocketry projects. Juni designed key parts in CAD and by using his model of the whole rocket insured they would actually fit correctly. More than once Juni would say after using the "interference" function in Inventor – "that won't work – not enough room" or the opposite…"that will work".

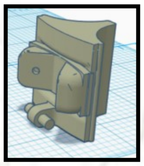


A prototype design (cutaway) showing a CD3 system which would open “draw latches” to release the legs. Elegant solution but didn’t work—latches kept hanging up

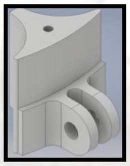


A final design with the fins and fillets

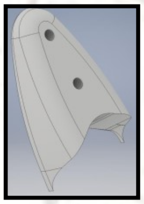
- Lower leg strut anchor / pivot CAD design / actual



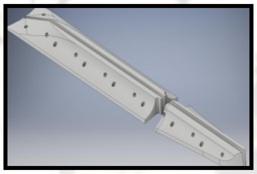
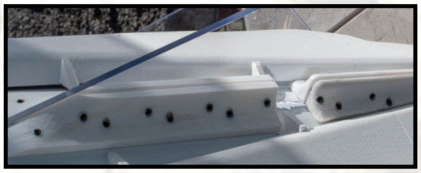

- Upper landing leg strut anchor CAD design / actual




- Landing leg latch cover CAD design / actual




- Booster fin fillets — CAD design / actual

Because of the precision of the design and the fact that parts are precision 3D printed the actual construction of this rocket was a lot like building a kit. Once the idea was designed and printed it usually fit perfectly and if it didn’t, it was changed and re-printed. In fact, by cutting the slots for the leg strut anchors evenly they actually snap into place and stay put. The lower anchors had nothing else holding them in the slot.

Future plans: We consider our first flight a success since the rocket flew straight (we were concerned about how the legs might affect the aerodynamics), the legs opened and we got everything back although the 2nd stage had some repairable damage. And since the Open Rocket simulations were very close to actual we feel that we can trust that model and go with some bigger motors, light the 2nd stage and with some reinforcement of the legs actually stick the landing on a calm day.

Longer range plans include functional grid fins that can actually steer the booster on descent, 4 motor air starts and a powered landing. We cornered members of the TRA leadership at LDRS and the consensus was as long as we manually control the lighting of the landing motor (it will need to be well away from the crowd) – go for it! Figuring out that problem will be interesting.

And of, of course, there will be a Block 5 version and eventually a Big Falcon Rocket (BFR). While the Falcon Heavy is beyond cool amazing we don't see it as a practical project for model rocketry.

AEROPAC Cleaning Party

Attendees:

Gene Engelgau

Darryl Paris

Michael Paris

Tom Fetter

Juniper Slouber

Jonathan DuBose

Evan Curtis

And thanks to Lynn Cominsky for hosting the party again!

Competing with a LUNAR launch on a prefect day, the cleaning party was understandably sparsely attended. But the crew got it done, had some pizza, ate some of Lynn's awesome brownies and then "Show and Tell" time for Juni and Jonathan's 1/24 scale Falcon 9


"We want to open up space for humanity, and in order to do that, space must be affordable."
- Elon Musk
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See the complete Q-Jet™ lineup and motor data at
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Ejection Cap
Ejection Charge
Delay Element
Composite Propellant
Propellant Core
18mm x 70 mm Motor Casing
FirstFire Micro™ Initiator
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Northern Nevada Rocket Clubs

Ron Swenson

I would like to introduce Sierra Rockets and ROCKONN. These are two rocket clubs that fly in the Reno/Sparks/Carson City area. Both clubs offer high power certifications (Level I and II).

Sierra Rockets

http://sierrarockets.org

This club is a hybrid club of both National Association of Rocketry (#728) and the Tripoli Rocketry Association (#145). Its primary launch site is Misfit Flats. It is a dry lake bed that is about 30 minutes east of Carson City NV. The waiver is for up to 10,500'. Overnight camping is available. For further details, please visit our web site.

2018 Launch dates:

NAR Launches: August 11, November 3

TRIPOLI Launches: June 2, October 6

Misfits Flats***

ROCKONN

http://www.rockonn.org/

This club is associated with the National Association of Rocketry (#735). Its primary launch site is Artesia Dry Lake. It is a dry lake bed slightly over 1 mile in diameter. It is almost always dry and soft for low-impact landings, but hard enough to drive out and get your rocket. The waiver is for up to 13,400'

It is about a 1.25 hour drive from Carson City NV. Overnight camping is available.

For further details, please visit our web site.

2018 Launch dates:

NAR Launches: June 16, August 18, September 15, October 20

Artesia Dry Lake

*****Misfits Flats? Some must read history:**

https://www.hcn.org/blogs/range/rants-from-the-hill-out-on-misfits-flat


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Association of Experimental Rocketry of the Pacific

TRIPOLI Rocketry Association, Inc. Prefecture No. 23

Volume 24 Issue 1

May 2018

S4 Rocket Design: Mach 1.5 Rocket Build

Musaiel - Moose

Mentor: Tony A.

STEM Mentor: Kurt

Editor's Note: Another in the series "High Powered Young Rocketeers"

Goals:

- Design a rocket that achieves Mach 1.5 or faster
- To determine which type of paint can withstand a Mach 1.5 flight
- To be able to locate the rocket after launch using a GPS device

What is Mach?:

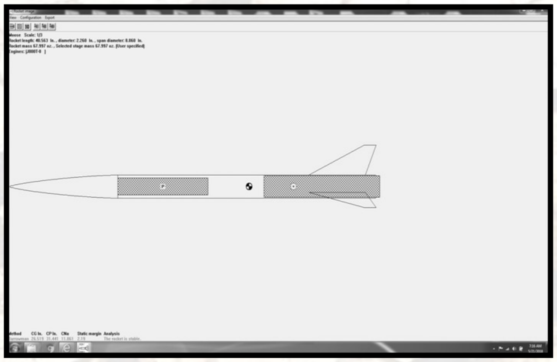
- A measurement of the speed of sound
- Mach 1 is the speed of sound
- Approximately 761.2 miles per hour

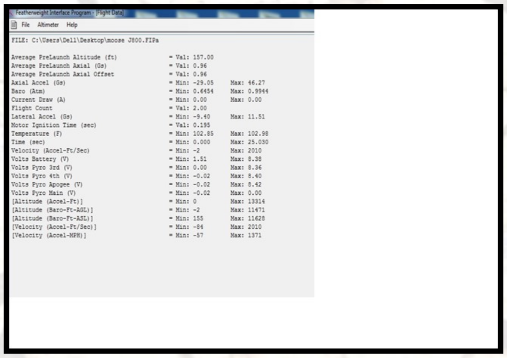
Significant Aspects of the Rocket:

- Must be lightweight
- Design of the fins needs to be aerodynamic as possible
  - Minimizes the coefficient of drag
- A motor that has enough thrust to accelerate the rocket quickly

RockSIM:

- A program that helps you design and engineer a rocket, and displays outputs of each motor





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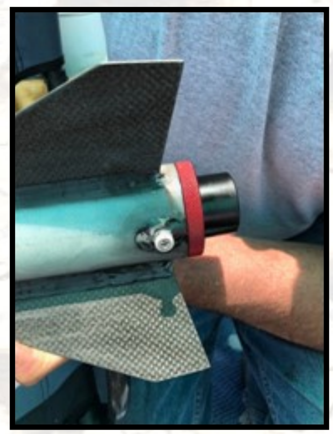
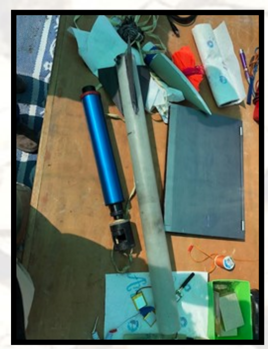
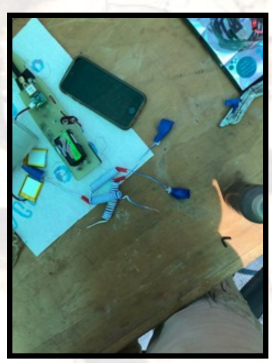
Rocket Motor:

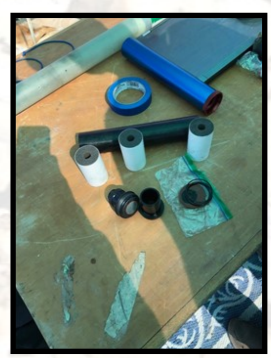
- Aerotech 54 mm J800 T Blue Thunder
  - Burns through 3 grains
  - Propellant weight 595 grams
  - Peak Thrust =180 lbs.

The Process:





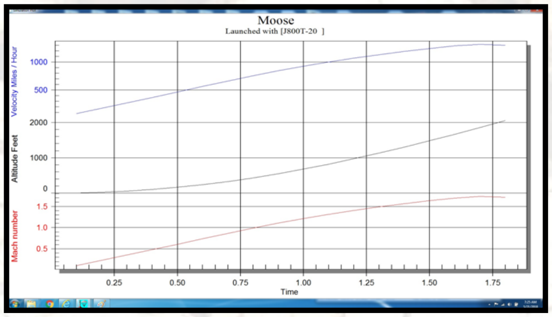


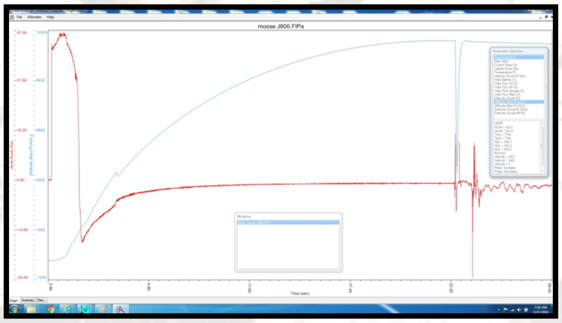


- Build body tube using fiberglass and mylar
- Apply epoxy on wraps of fiberglass on top of the mylar
- Covered with Peel Ply takes out excess epoxy and smooths everything out
- Cut out carbon fiber fins
- Attach fins
- Apply fillets with RocketPoxy
- Sand the fins
- Sand body tube
- Paint nose cone
- Connect shot cord to motor
- Apply rail buttons
- Insert parachute
- Install ejection charges for parachute

Data:

- **At 1.8 seconds, rocket is traveling at Mach 1.8 (1371 mph) and 1539 ft**
- **Coasted for 22 seconds**
- **Took 14 minutes to land**





Electronic Devices:

- Featherweight Raven altimeter
  Measures atmospheric pressure and altitude
  - Barometer knows when to supply power to the ematches

-

- Featherweight GPS
  - Allowed us to track the rocket with a phone
  - Able to track other rockets as well

Launch Videos:

https://www.youtube.com/watch?v=PCCMot7tRZE

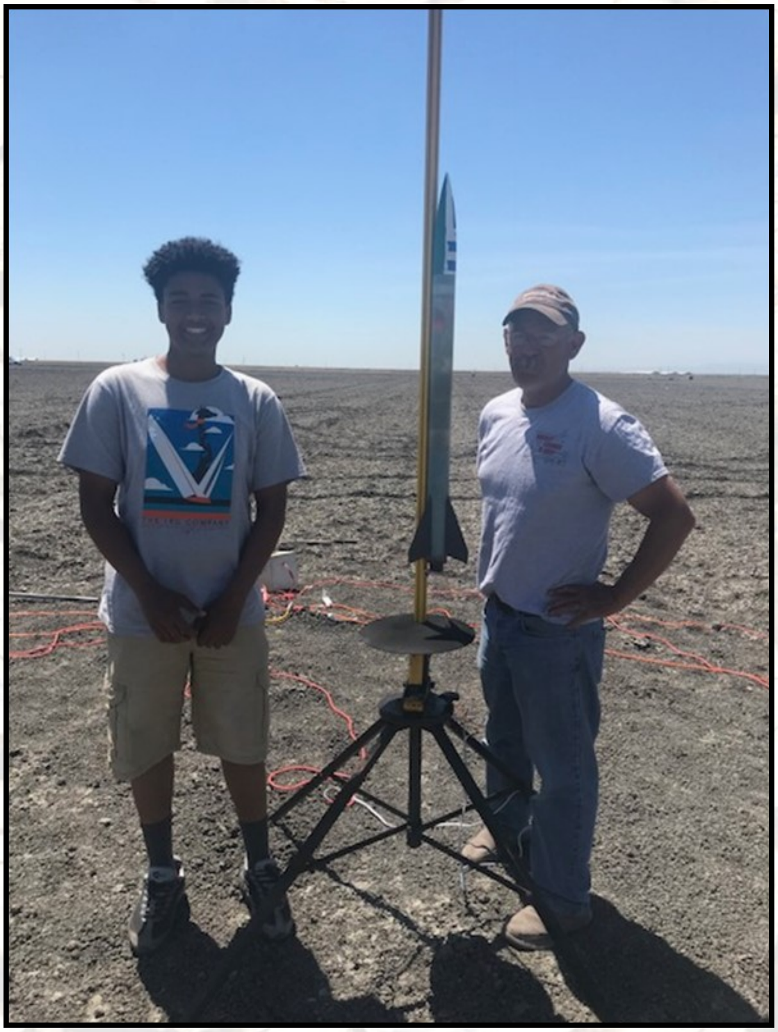
https://www.youtube.com/watch?v=ASQrJOXcdIM

Paint Results:

Before

Conclusion:

Overall, I was able to design a rocket that did not only fly at a speed of my desire, but exceeded my expectations as well. By doing this project, it allowed me to push myself and it sparked new interests in the field of engineering and design.



Association of Experimental Rocketry of the Pacific

TRIPOLI Rocketry Association, Inc. Prefecture No. 23

Volume 24 Issue 1

May 2018

Rocket Propellant Composition

Matthew

Mentor: Tony

STEM Mentor: Kurt

Editor's Note: Another in the series "High Powered Young Rocketeers"

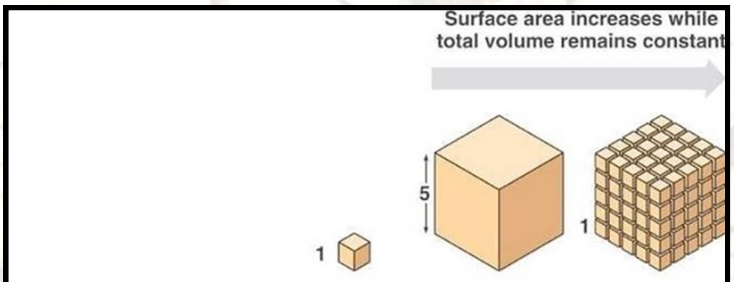
Question:

How does the particle size of Ammonium Perchlorate affect the burn rate of rocket propellant?

Rocket Propellant Chemicals	Purpose
• Aluminum	Fuel
• Ammonium Perchlorate(AP)	Oxidizer — sizes 90, 200, 400 micron
• HTPB(Hydroxyl-Terminated Polybutadiene)	Fuel/Binding Agent

Surface Area of the Particles :

- Changing the particle size of the AP changes the total surface area of the oxidizer
- Making the particle sizes smaller while keeping the same total volume increases the total surface area



Total surface area (height × width × number of sides × number of boxes)	6	150	750
Total volume (height × width × length × number of boxes)	1	125	125
Surface-to-volume ratio (surface area / volume)	6	1.2	6

Rocket Propellant Formulas:

Batch Mixing Worksheet — Basic Prospect

Density of this formula: 0.05900 | Slop factor %: 0.00% | Make Extra by weight: | Batch Weight (Grams): 1691.66 | Scale Starting Weight:

Ingredient	% of Total	Solid Y/N	Ingredient Weight	Running Weight	X
R45M HTPB	14.20%	N	240.22	240.22	
Dio Adi	3.00%	N	50.75	290.97	
		N			
Papi 94	1.60%	N	27.07	318.03	
		N			
silicon (1 drop per 500 grams)		N			
lamp black	0.20%	y	3.38	321.42	
		Y			
AL 300 micron	7.00%	y	118.42	439.83	
		Y			
AP 200	74.00%	y	1251.83	1691.66	
	100.00%		R45 1282 "a"= .01800 "n"= .3796 Density .05674 start		
Percent of Solids:		81.2%			

Batch Mixing Worksheet — Prospect 90

Density of this formula: 0.05900 | Slop factor %: 0.00% | Make Extra by weight: | Batch Weight (Grams): 1691.66 | Scale Starting Weight:

Ingredient	% of Total	Solid Y/N	Ingredient Weight	Running Weight	X
R45M HTPB	14.20%	N	240.22	240.22	
Dio Adi	3.00%	N	50.75	290.97	
		N			
Papi 94	1.60%	N	27.07	318.03	
		N			
silicon (1 drop per 500 grams)		N			
lamp black	0.20%	y	3.38	321.42	
		Y			
AL 300 micron	7.00%	y	118.42	439.83	
		Y			
AP 200	55.50%	y	938.87	1378.70	
AP 90	18.50%	y	312.96	1691.66	
	100.00%		R45 1282 "a"= .01800 "n"= .3796 Density .05674 start		
Percent of Solids:		81.2%			

Batch Mixing Worksheet — Prospect 400

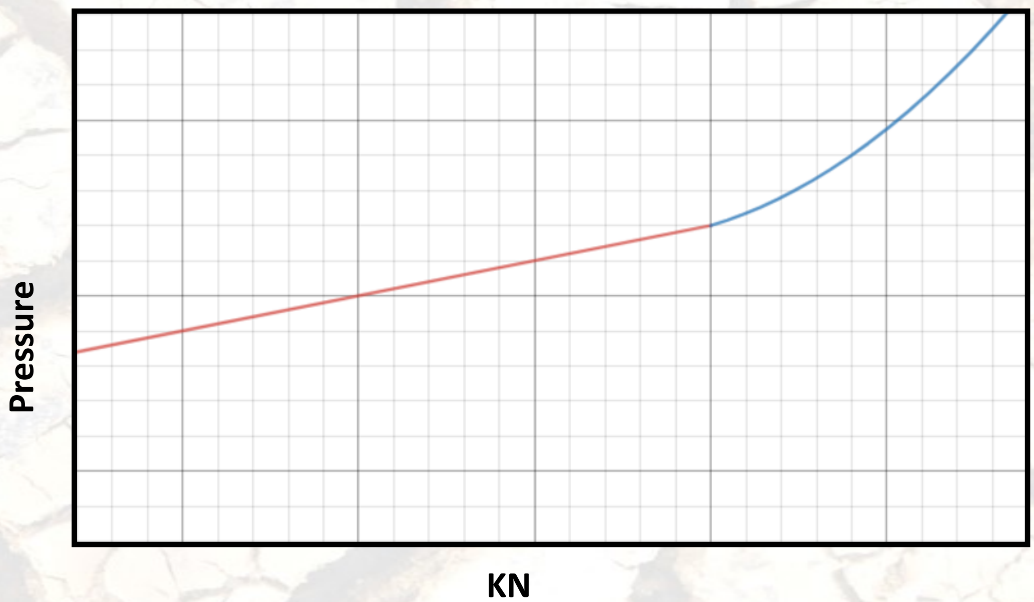
Density of this formula: 0.05900 | Slop factor %: 0.00% | Make Extra by weight: | Batch Weight (Grams): 1691.66 | Scale Starting Weight:

Ingredient	% of Total	Solid Y/N	Ingredient Weight	Running Weight	X
R45M HTPB	14.20%	N	240.22	240.22	
Dio Adi	3.00%	N	50.75	290.97	
		N			
Papi 94	1.60%	N	27.07	318.03	
		N			
silicon (1 drop per 500 grams)		N			
lamp black	0.20%	y	3.38	321.42	
		Y			
AL 300 micron	7.00%	y	118.42	439.83	
		Y			
AP 200	55.50%	y	938.87	1378.70	
AP 400	18.50%	y	312.96	1691.66	
	100.00%		R45 1282 "a"= .01800 "n"= .3796 Density .05674 start		
Percent of Solids:		81.2%			

Each formula was tested at three different KN values: low, mid, and high

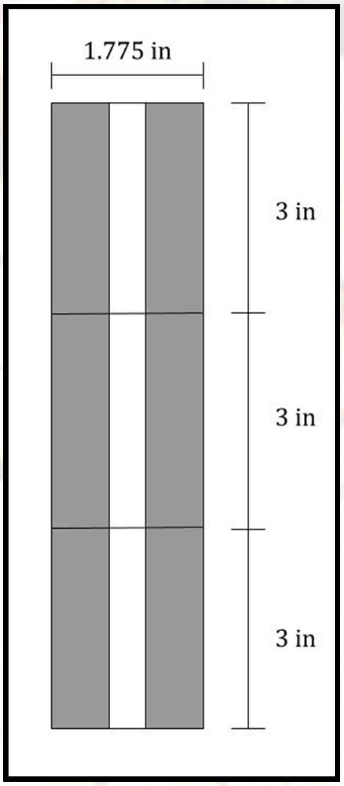
KN:

- **Kn is the ratio of the burn area of the propellant to the area of the nozzle throat**
- **This general graph shows the Kn values vs pressure. It can be used to understand how the propellant behaves**
- **For our purpose, we change the Kn by changing the nozzle throat diameter**



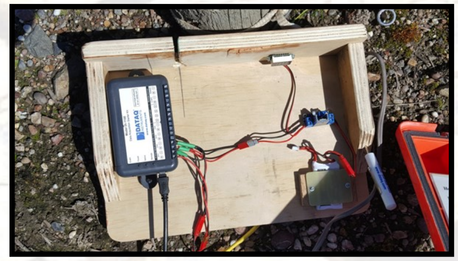
Grain Geometry:

- Nine total motors:
  - Qty 3 – 90 AP
  - Qty 3 – 200 AP
  - Qty 3 - 400 AP
- Each with different nozzle size(different Kn)
- Three Grains per Motor
- 3 inch Grains
- Concave Ends to Promote Flame Distribution
- 1.775 Inch Diameter
- 0.75 Inch Core

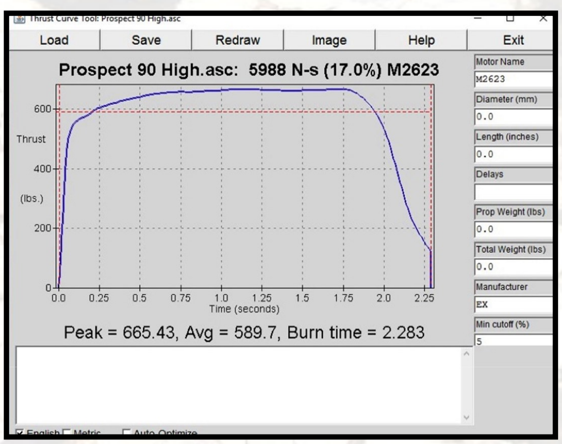


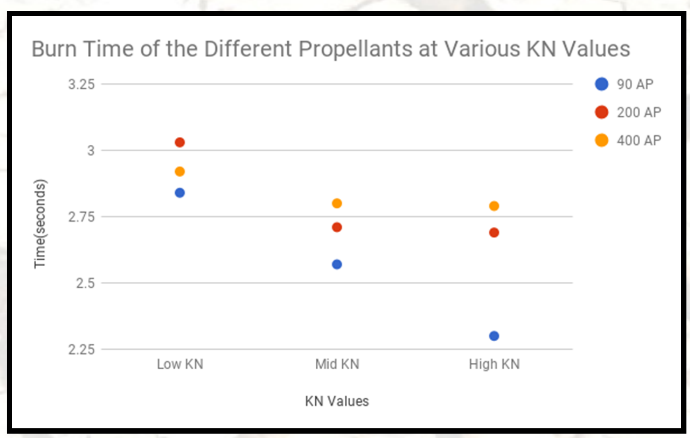
Experiment Design:

- Motor Stand and Stakes
- Data Collection Equipment:
- Pressure Transducer
- Dataq Instrument
- Copper tube filled with grease
- Battery with voltage regular
- Laptop:
- Dataq Program
- Thrust Curve

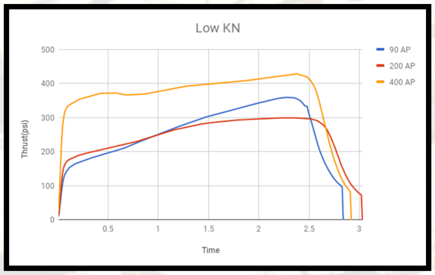


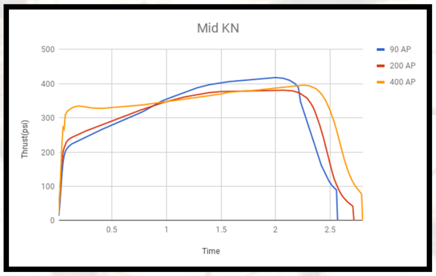
Motor Tests:

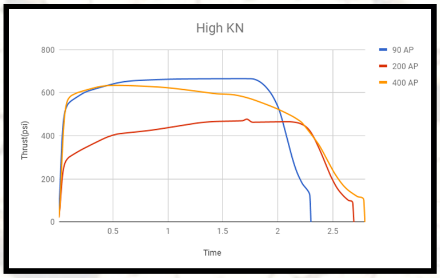




Thrust vs Time Graphs







Conclusion:

The data shows that as the particle size of the ammonia perchlorate decreases, the burn rate of the propellant increases.

The next step would be to find the best ratio of 90 AP to 200 AP to achieve the fastest burn time

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