



AEROPAC Fall 2020 Newsletter

Photo by Phoenix 4, courtesy of Curt Von Delius

President's Pad

Greetings fellow AEROPAC members. Another year, another set of obstacles.

We did manage to pull off all of our scheduled launches despite the Covid-19 pandemic and wild-fires. A big thank you for the cooperation that made this all happen.

We purchased a hand washing station and made masks and hand sanitizer available at RSO and registration.

Nevada has lifted its restrictions to allow 250 people or 50 % capacity so maybe we will have a somewhat normal launch season next year.

We are working on a 5 year launch calendar and a 5 year BLM permit.

What's Inside

Page 2 - NASA Student Launch

Page 7 - James Marino's Final Flight

Page 12 - ARLISS M S4 PocketQube

Page 15 - 2020 AEROPAC Flight Counts

Page 16 - ARLISS 2020 - NOT REALLY

Page 20 - S4 PocketQube 54mm

Page 23 - Falcon 9 ARLISS Lite Airframe

Page 25 - COVID Madness: 3D Printed Rockets

Page 27 - How Not to Spend the Summer Solstice

Mudroc would not be Mudroc without someone getting stuck in the mud and we did have one person looking for a rocket get stuck. Thankfully there were a few people with the right equipment to pull him out.



NASA Student Launch

Leilani Zagross NAR Jr L1



NASA's SL 2020: From Proposal to Pandemic

January 2020 launch at Mojave Desert Advanced Rocket Society (MDARS). This would be our last launch before the project was halted in March due to COVID-19.



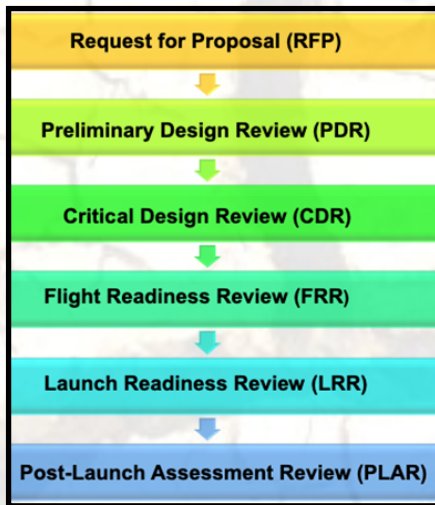
Each year, NASA's Student Launch program challenges pre-college and college rocketry teams throughout the U.S. to carry out an authentic NASA engineering design cycle (shown below) that spans 8 months. The overarching goal for Student Launch is to develop a payload, deliverable on a launch vehicle, which supports NASA's mission and the Space Launch System. The 2019-2020 challenge required university teams to create a payload that recovered a sample of simulated lunar ice, and pre-college teams could create a payload to carry out a scientific experiment of their choosing. Teams must satisfy nearly 100 NASA-derived requirements as well as satisfying team-derived requirements including personnel hazard analysis, failure modes and effects analysis, and environmental hazard analysis.



Team Athena, my high school team from Los Angeles, successfully completed the truncated 2019-2020 challenge. Student Launch is not for the faint of heart. My “on the job” experience began in late August of 2019 as I began writing the first of many drafts of the Request for Proposals and it ended 7 months and some 250 work-hours later. During this time I also received my NAR Jr Level 1 Certification.

NASA Engineering Design Cycle

Our team’s prior rocketry experience was limited to TARC, and we were fortunate that Becky Green graciously offered to be our Mentor. Becky provided crucial guidance regarding design, materials, dual-deploy, and safety.



We challenged ourselves to design a scientific payload that was relevant to the “Artemis Generation.” We designed, built, and tested the ability of a low cost, low energy, wearable-size cosmic ray detector to withstand high acceleration flights. We envisioned that these sensors could not only measure cosmic ray exposure for space travelers, but also be set up in arrays on Mars to provide information about origins of cosmic rays.

The Launch Vehicle

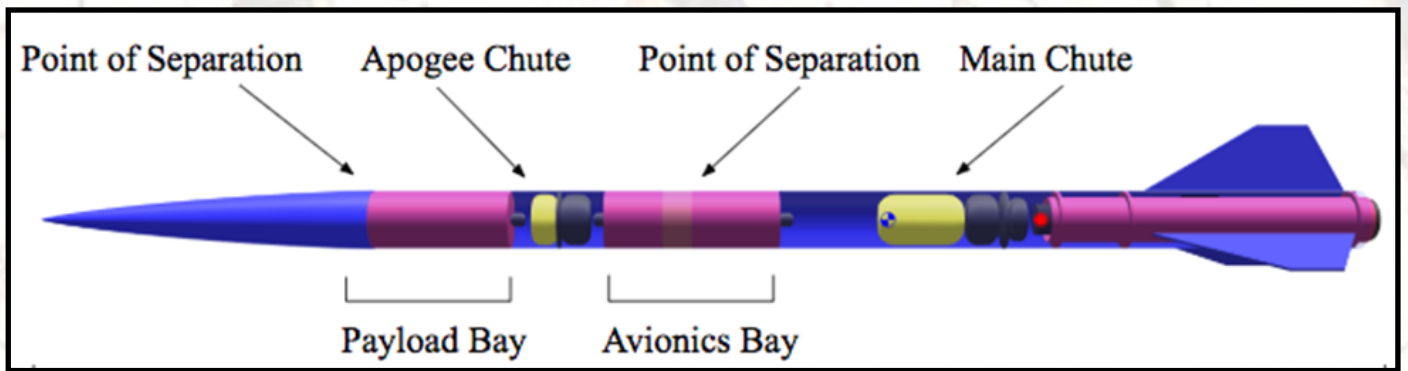
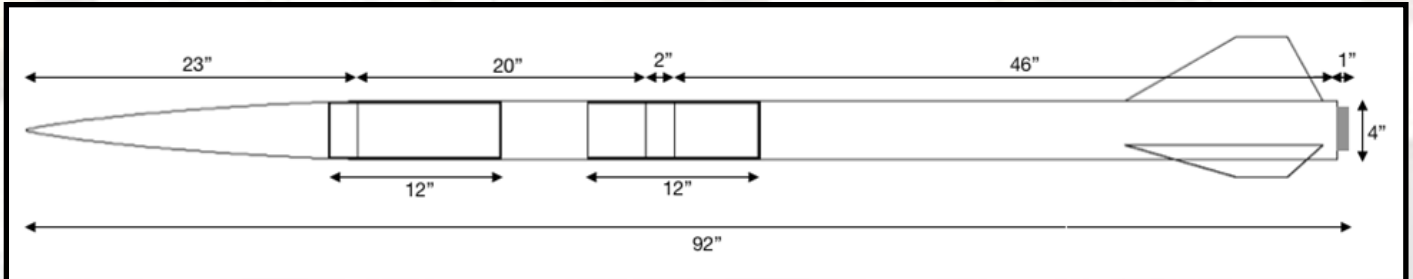
Some of the key constraints outlined by NASA that affected our design are shown here. The acceleration requirement was our own since we wanted to test the effect of high acceleration on the payload.

Our launch vehicle was a 4” Madcow DX3 XL that we modified to 12” payload. The dimensions and positions of rocket sections are shown in the drawings below. The total length of the rocket was 92”.

Key NASA Student Launch Requirements	
Altitude	3,500-6,000 feet
Stability	Minimum: 2.0 calibers
Velocity	Minimum: 52 fps at rail exit
Mach number	Less than 1
Thrust-to-weight	Minimum: 5:1
Descent duration	Maximum: 90 seconds
Acceleration (our requirement)	Minimum: 10 g’s
Kinetic Energy for Each Section at Landing	Maximum: 75 foot-pounds
Wind Drift	Maximum: 2,500 feet from launch pad



We utilized Open Rocket to simulate flight behavior at five different wind speeds. Before the rocket and payload were built, initial simulations showed a maximum altitude of 5,200 feet. Simulations run prior to



Team Athena with mentor Becky Green

our demonstration launch of the 20.2 pound rocket on an AT K828FJ ranged from 5595 to 5484 feet depending on wind. The altitude of our actual launch was 5,586 feet, which exactly matched our 5 mph simulation. We felt pretty good about that!

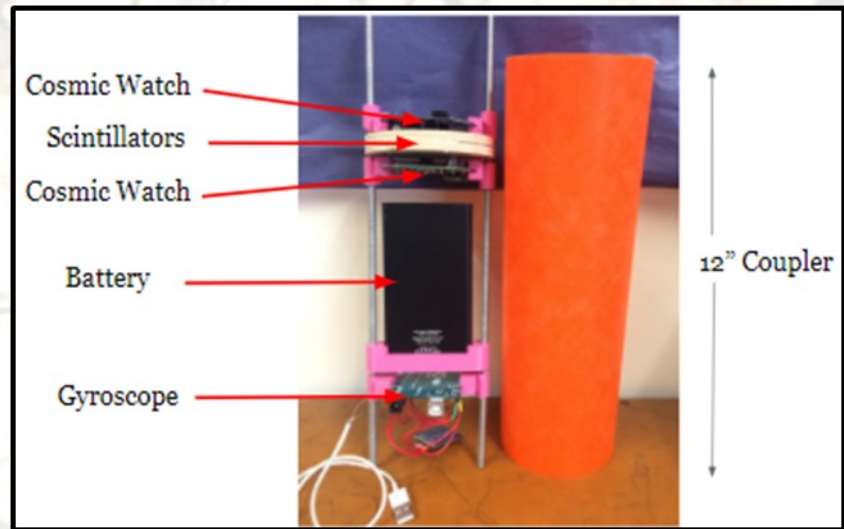
The Payload

The mission of Project Mew-on was to test the robustness of a low cost, low energy, low mass, wearable-size, muon detector ("Cosmic Watch") during high acceleration flights.

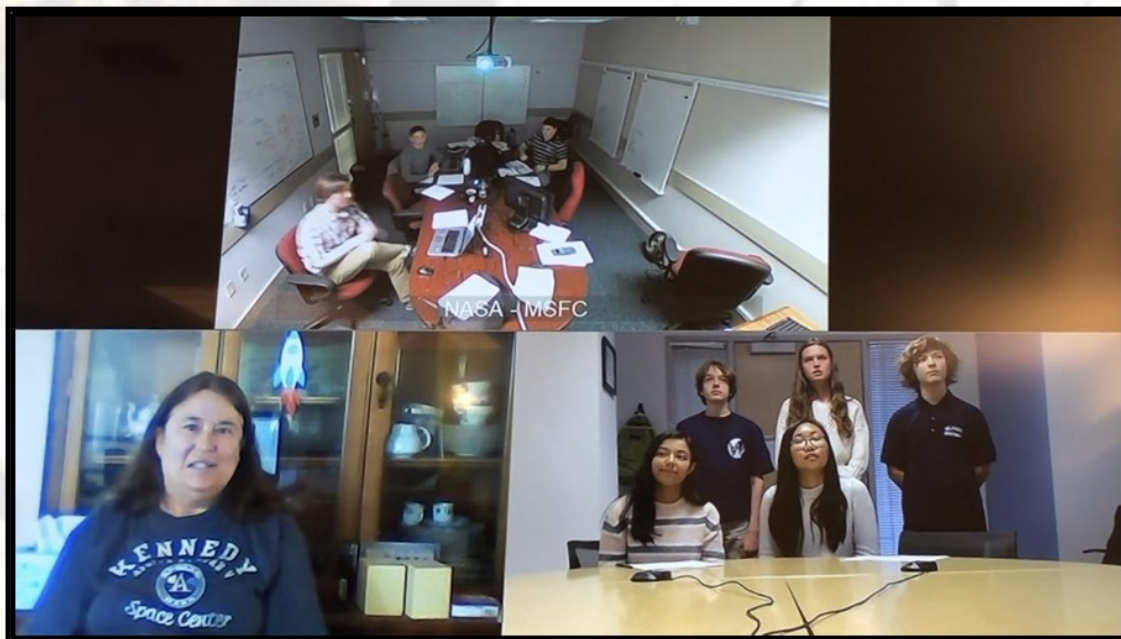


Multiple baseline ground tests were performed including recording cosmic ray counts at Mt Wilson at an altitude of 5,700 feet, a lab-built centrifuge, and experimentally determining the effect of angle of incidence.

The circuit boards for the cosmic ray detectors were obtained from Cosmic Watch and required soldering of surface mount components. A pair of detectors was used for coincidence measurements, which ensure to reliability. To maximize surface area for detection, custom scintillators were fabricated to precisely fit the internal diameter of the coupler (payload bay). A gyroscope measured the angle of the launch vehicle throughout the flight.



NASA Videoconferences



Student Launch requires teams to present their progress to NASA, answer questions, and receive feedback at three key points: PDR, CDR, and FRR. Top: Marshall Space Flight Center. Left: Mentor Becky Green. Right: Members of Team Athena presenting.



Results

Our demonstration flight yielded over 48,000 data points. We detected several instances where there were gaps in the data from what we suspect were loose connections, but post-launch testing indicated no damage to detectors from a high acceleration launch of approximately 13 g's. We had hoped to be able to pinpoint the exact number of cosmic ray counts during the approximately 100 second long flight and were devising methods to do so before our next flight.

COVID-19 cut Student Launch short by a month, which meant teams did not get to travel to Huntsville to fly. While we would have liked to have had one more flight to further test our payload, we still have more than enough data to analyze from our pre-COVID-19 demonstration flight.

NASA held a virtual awards ceremony in July and our team was recognized with the 2020 NASA Student Launch Judges' Choice Award, the top award for secondary school teams. The inscription on the award

says, "For the best combination of payload innovation, vehicle design and construction, and public engagement."

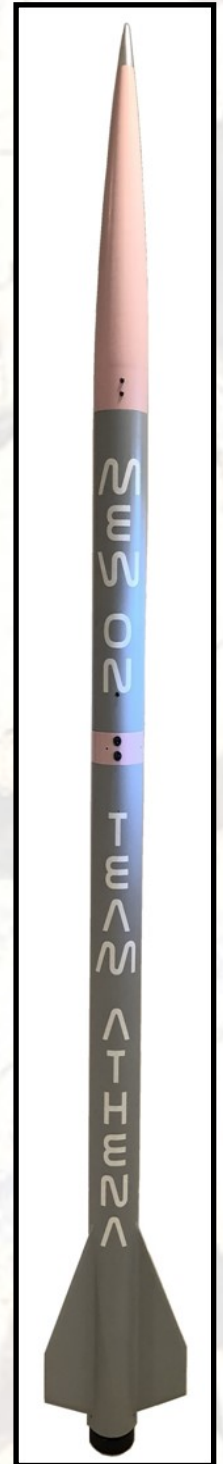
NASA's Student Launch is truly an educational experience like no other. I wish all of high school was like this. I would like to give special thanks to the NASA panel of judges; my teammates; our Mentor, Becky Green; our Adult Educators Kathy Griffis, Joe Wise, Bob Baker; the Wildwood Institute of Stem Research and Development (WISRD); and our team parents.



My NAR Jr Level 1 Certification rocket flown on an AT H135W. (Certified by Becky Green)



Graphics by Clay Wilson, CW Graphics, Reno NV





James Marino's Final Flight

Dave Raimondi

During his life, I had the privilege of being James Marino's friend. This was a gift that enriched my life, the lives of my family, and my extended Rocketeer family. I have felt the loss of James every day since his passing on March 7th, 2020. In keeping with his wishes and those of his beautiful wife, Laura and daughter, Rose, I was asked to help James fly one more time.

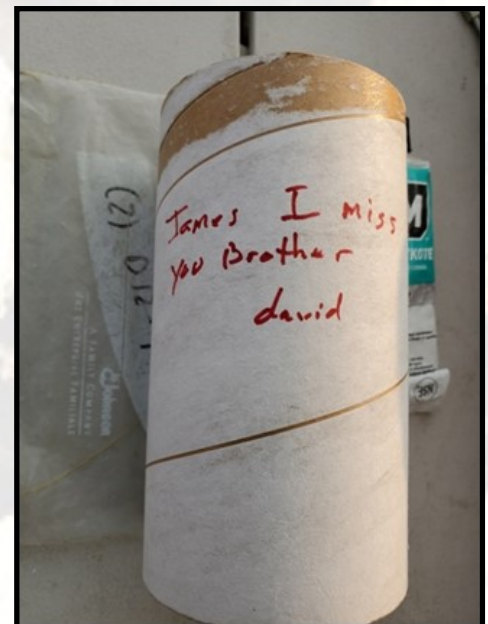
I was pretty nervous about the Final Flight. This was the first time I was preparing James' Competitor 5, and I only had the one 98mm M2500 AF, so it just had to be perfect. To quote Gene Kranz, "Failure Is Not An Option". The Competitor – 5 rocket was built by James and adapted by myself for his final flight.

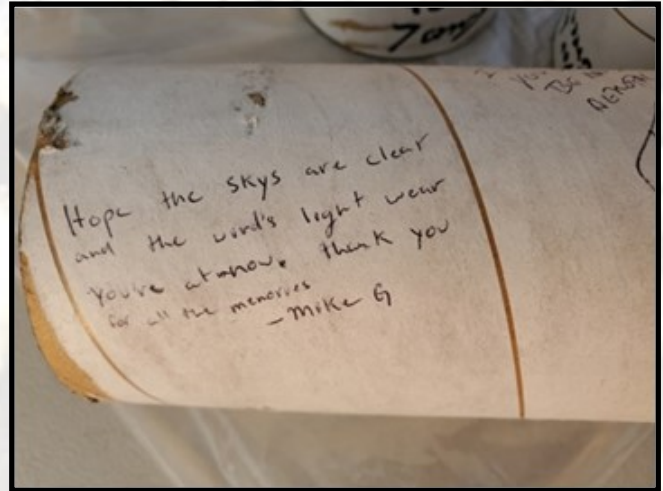
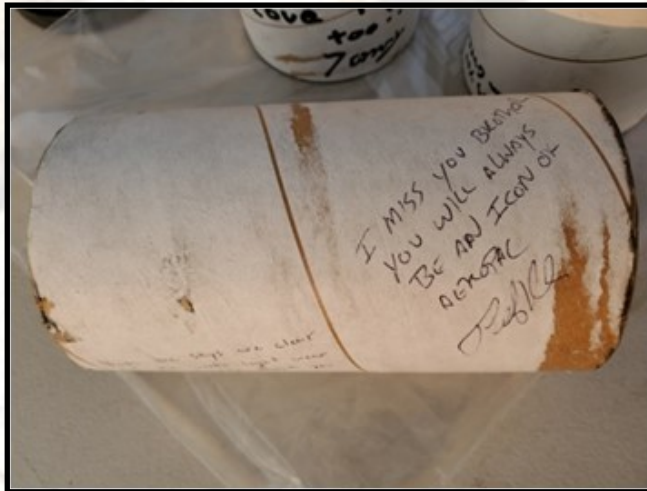
I modified the top of the rocket to cut down the size of the deployment charge to get the nose cone off. I decide the best way to do the deployment was to do it ARLISS style, with a coupler closed off at one end with the deployment charges below the coupler. The coupler was tethered to the top of the electronics bay with 15 feet of Kevlar cord, and the nose cone would come down on its own parachute.



On Saturday September 19th, I awoke to better visibility conditions in Black Rock than we had experienced during most of the week of ARLISS. It was a positive sign for James's flight. I knew there would be some modifications needed for the motor liner, so I consulted with Tony Alcocer and Jim Green to correct the ¼ inch gap at the aft closure. Jim Green to the rescue.....after measurement, he was able to cut the liner down to size and everything fit perfectly.

The motor being used for the flight was a 98 mm M2500 Aluma Flame, which was made by the James Propulsion Systems (JPS for short). As I was getting ready to put the motor together, Tony Alcocer stopped by and decided to write a message on one of the grains. We then had others add their love and respectful messages to the other grains.





Messages on other grains:

Tony Alcocer: James you are going to love this motor too!

Jim Green: Gonna miss you brother

Astran: James Love and Miss you!

Kevin McGrath: Fly'em high James

With the rocket ready to fly by about 1:00pm, I had time on my hands for getting nervous awaiting the arrival of everyone coming to see James fly again. The Marino Family (including James's brother Mike), Raimondi Family and Dave & Carrie Vetterman all arrived at the launch site around 3:00pm. Socially distant hugs with masks ensued. It was a bit like old times, everyone talking and catching up.

I got everyone refocused on the flight and I attached the keychain video cameras – one forward/one aft, and was ready. I did not want to screw this up.....but I was ready!

We all took some photos with the rocket and then with most of James' family in tow, we went out to the away cell. After a few more pictures and personal goodbyes, we headed back to the flight line. On the way back to the LCO table, I was starting to lose it. I thought if I kept the talking to a minimum, I could get through the flight.

With the Range closed, I got on the microphone and quickly talked about the rocket, motor and about how high I thought the rocket would go. (My guess was 12000 to 14000 feet.) I said, "God's Speed James" and started the countdown.



Jim Green fixing the liner that was too long



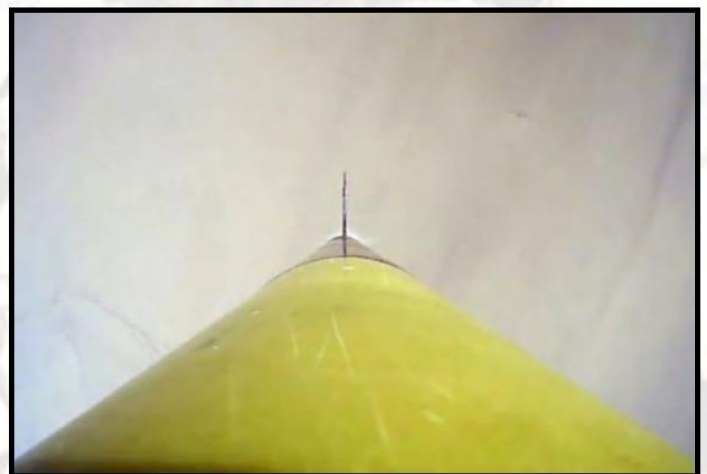
When I pushed the button, the motor lit immediately and the rocket leaped off the pad. Around 2000 feet the rocket had a small disturbance as the rocket broke through Mach 1 at 2423 feet. From the video you

can really see the ground fall away quickly.

The rockets maximum altitude was from the GWiz LCx electronics was 13,497 feet. The MC2 altimeter was a little more conservative with the max altitude at 12,315 feet.



Frame Grab from video camera looking down at launch



Nearing apogee, you can still see the flight line 12,000+ below about 1/2 way to the upper right corner



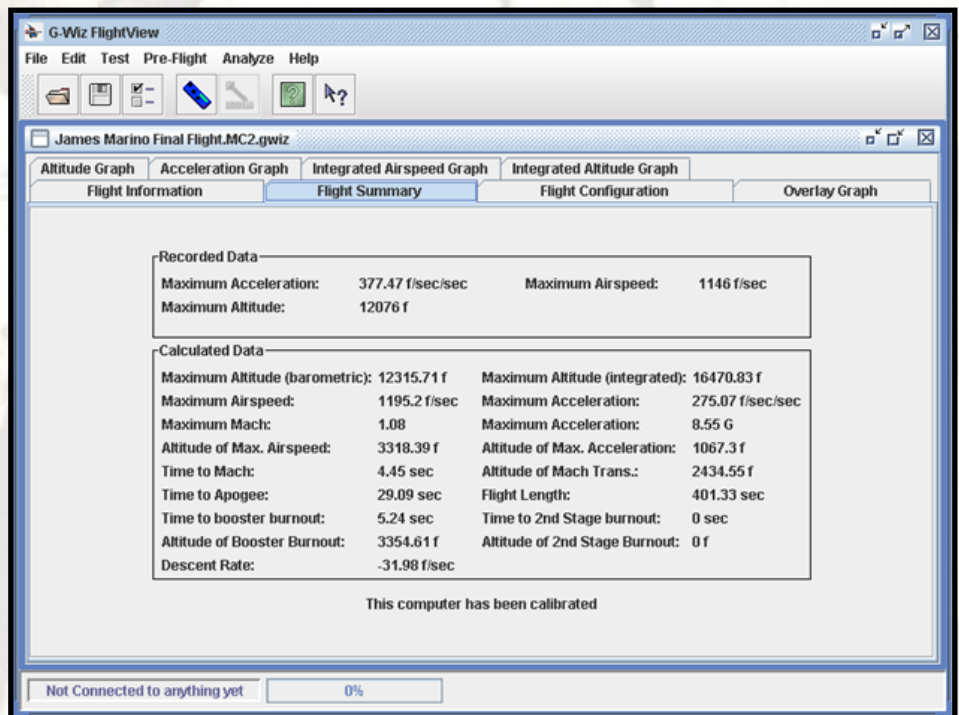
The rocket had a big smoke charge that was timed to go off about 3 seconds after the after apogee.

The rocket landed about 1/3 of a mile off the East Flight Line, and the nose cone was about 500 feet from the rest of the rocket. The flight was a 100% success, and was enjoyed by all.

James Marino was a great Rocketeer. James enjoyed going to the LUNAR Rocket Club launches at Snow Ranch, Tripoli Central California near Helm, and Aeropac launches at Black Rock Desert, NV. James was my mentor in High Power, but more importantly, he was my friend.



RiP James.



All photos and graphics courtesy of David Raimondi



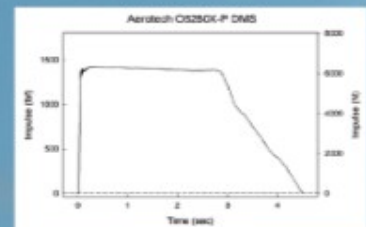
AEROTECH[®]
 CONSUMER AEROSPACE

*The Leader in
 High Performance
 Rocketry*

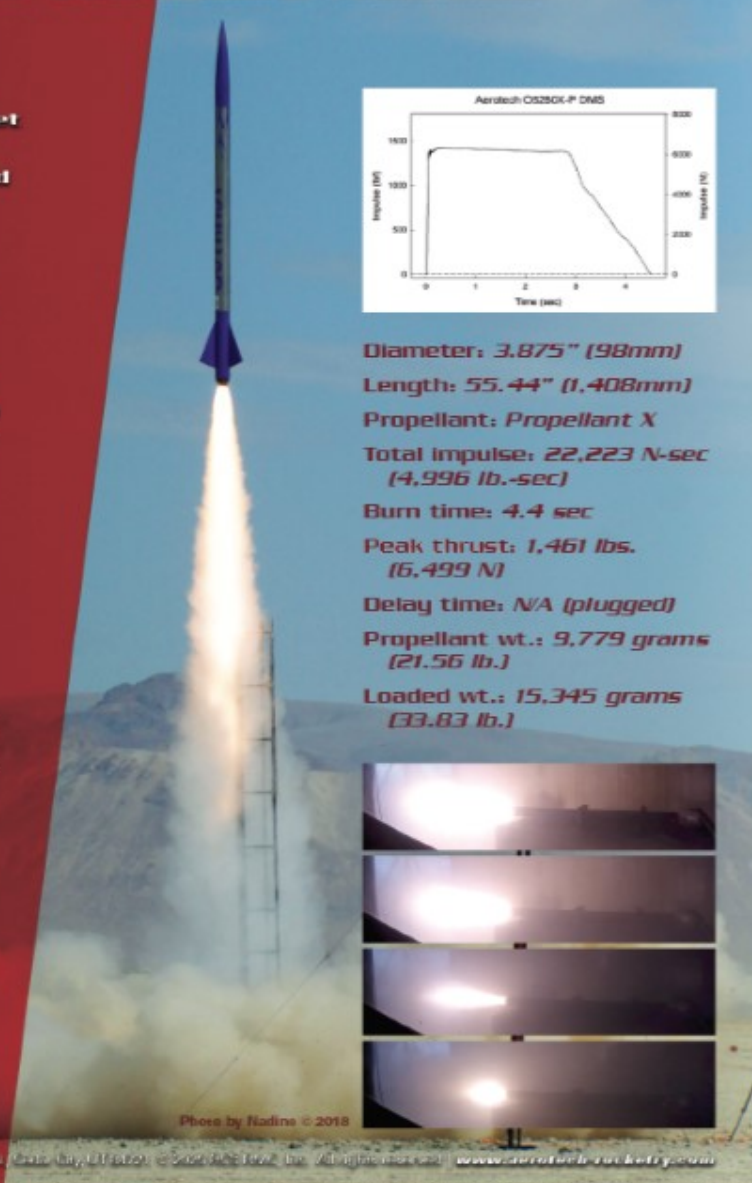
**Introducing The New
 05280X-PS 98mm High-Power
 DMS™ Single-Use Rocket Motor
 (No. 15528P)**

The Tripoli Certified 05280X-PS 98mm DMS Disposable Motor System™ Single-Use Rocket Motor produces the highest certified total impulse of any 98mm rocket motor ever sold to the high-power sport rocketry market.

- Features AeroTech's High-Isp Propellant X™ producing exceptionally high total impulse accompanied by a bright white flame and brilliant exhaust plume with moderate smoke.
- Delivers 22,223 N-sec of total impulse in 4.4 seconds making it ideal for extreme high-altitude attempts including two-stage flights to the edge of outer space / Von Kármán line!
- Designed with a filament-wound fiberglass casing, glass-reinforced composite phenolic nozzle and a machined aluminum bulkhead with built-in 1/8-16 thread for a matching eye bolt.
- Configured with a removable, threaded fiberglass DMS thrust ring designed to fit standard motor retainers.
- This is a "plugged" motor design producing only tracking smoke and requiring an electronically-activated recovery system.
- Sold in kit form and ships with FirstFire™ initiator, all necessary adhesives and instructions.
- May be purchased by L3 certified consumers 18 years of age or older and carries a suggested retail price of \$1,999.99.



Diameter: 3.875" (98mm)
Length: 55.44" (1,408mm)
Propellant: Propellant X
Total impulse: 22,223 N-sec (4,996 lb.-sec)
Burn time: 4.4 sec
Peak thrust: 1,461 lbs. (6,499 N)
Delay time: N/A (plugged)
Propellant wt.: 9,779 grams (21.56 lb.)
Loaded wt.: 15,345 grams (33.83 lb.)



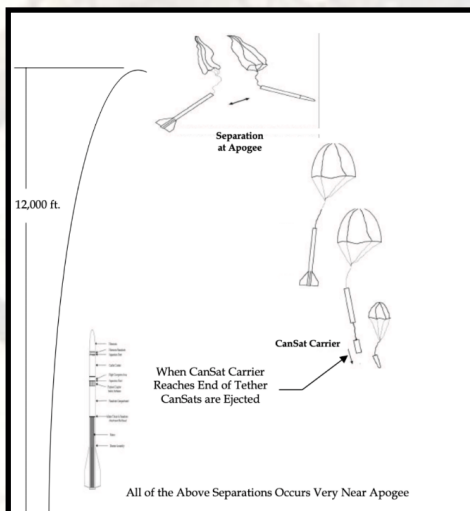
Photos by Nadine © 2018



ARLISS M S4 PocketQube

Ken Biba

ARLISS ^{1,2} - A Rocket Launch for International Student Satellites - is a 20 year old STEM program begun by Professor Bob Twiggs and the AeroPac ³ rocketry education organization. It began looking at a unique partnership ³ of highly experienced amateur rocketeers flying reliable, reusable sounding rockets, carrying sophisticated student robotic satellite payloads on a number of missions. ARLISS's first satellites were the size of soft drink cans, and became the first instance of what we know today as CanSats. Today, ARLISS remains a major STEM competition event in September of each year in the Black Rock Desert of northwestern Nevada, but CanSats have spread to many events throughout the world. Launchers at ARLISS put student satellites up to ~10,000' and deploy student satellites to perform a STEM mission in a hostile environment and challenge them to find their own autonomous way home. Two classes of high power launchers - the 75mm ARLISS K on 54mm K motors and the 150mm ARLISS M on 98mm M motors - fly these missions at major rocket launches. ARLISS has evolved over its 20-year history to support a wide range of missions and launchers. The most common ARLISS missions use larger CubeSat-sized satellites that typically are deployed to fly an autonomous mission to return to their launch site by crawling, flying or whatever method the mission designer chooses. Recent designs incorporate AI deep learning tools to improve mission accuracy all the while retaining basic mechanical robustness necessary for a successful mission.



In 2014, a new form of ARLISS satellite and mission was also invented by Professor Twiggs - PocketQubes - 5 cm cubic satellites, 1/8th the volume of a typical 10cm CubeSat that can fit in your pocket. These pico satellites, enabled by Moore's Law, have now reached LEO, but are of a size, cost and capability that allow them not only to do their own missions, but to totally replace the legacy soda can format and challenge the CubeSat-sized sats. The author's S4 project - Small Satellites for Secondary Students - has created an Arduino-based platform of software, 3D printed packaging, wireless telemetry and sensors to construct STEM missions in this new, smaller pico satellite size. A 5x5x5cm basic S4 Pocket- Qube quantum is called the 1P size, and a 5x5x10cm package is a 2P and so on ⁴.

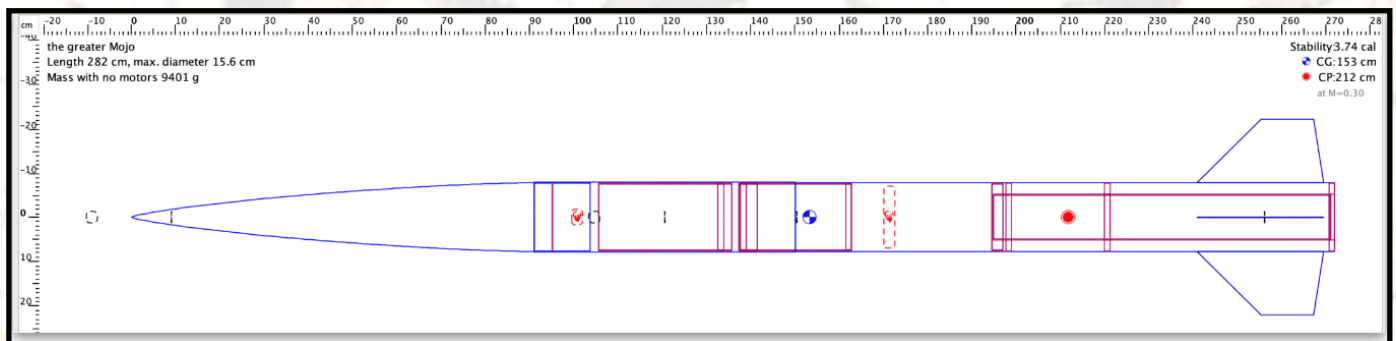
1 and 2 <https://www.dropbox.com/s/9cqc000bp0jwlfp/Sport%20Rocketry%20ARLISS%201.2014.pdf?dl=0>https://www.dropbox.com/s/0ghdfftp07d6di/ARLISS%20Podcast%20TRS_90B.mp3?dl=0

3 www.arliss.org<https://www.dropbox.com/s/4i4729zyfppuny6/PocketQubes%20are%20the%20New%20CanSats.pdf?dl=0>

4 <https://www.dropbox.com/s/4i4729zyfppuny6/PocketQubes%20are%20the%20New%20CanSats.pdf?dl=0>



For student STEM missions, a new family of small launchers, ARLISS Lite _s, allow flying missions with these new small payloads not just at major rocket launches using high power rocket motors, but also on 24mm E motors at local parks or 29mm or 38mm motors at larger venues. This widens the scope and accessibility of these STEM adventures to more students, in more places, at lower cost. But that does not mean that the classic ARLISS missions are obsolete - rather, more missions can be flown with greater sophistication in more places and at lower cost. S4 PocketQubes naturally fit the legacy 75mm deployment carriers for ARLISS K - tripling the capacity by allowing 3-4x the sats per flight as before, using the same carrier in the same air frame. ARLISS M is the workhorse launcher for ARLISS today. It is typically a six inch airframe launched on an M1419 to ~10,000'. Satellite deployment is just after apogee and the satellite finds its own independent way as the airframe is recovered separately. An ARLISS M has a 6"x11" payload bay for deployable missions but typically has a large nosecone that is usually empty ... space that could be used



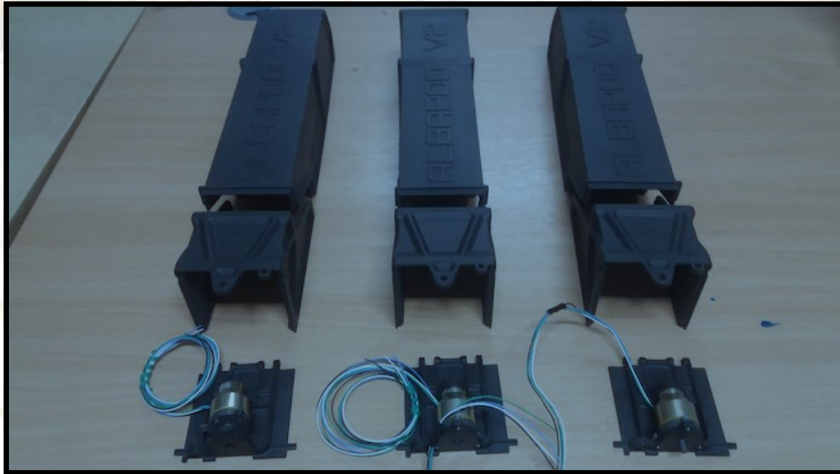
for payloads not independently deployed but recovered with the airframe.

A modular deployer, that fits both the existing payload carrier as well as the nosecone, could carry potentially many S4 PocketQubes - some to be deployed from the carrier and some to be recovered with the nosecone as captive payloads. 3D printing lets us be creative with the design. As we shall see, this enables an ARLISS to carry up to 28 S4 1P pico satellites, less if deployed and volume is needed for recovery gear, but still a huge increase in mission capacity. We can now think about not just an independent one-satellite mission, but experiments with swarms of pico satellites, in local radio communication, using a distributed portfolio of redundant sensors to execute a sophisticated mission. CubeSat and PocketQube deployers for orbit are typically rectangular tubes, loaded with a sequence of cube shaped pico-satellites, spring loaded with a door, that when opened - lets



5 <https://www.dropbox.com/s/j09eha9id0ugav9/ARLISS%20Lite.pdf?dl=0>

the spring push the satellites out from the deployer. That's a classic CubeSat deployer. And these have now been size reduced for PocketQubes - as illustrated here by Alba Orbital's 6 3D printed PocketQube deployers.



The S4 ARLISS M Deployer emulates that same behavior, but since we have more room, and the pyro deployment event itself gives the energy to push the picosatellites from the deployer, the design can be both simplified and expanded. And is well suited to implementation via 3D printing.

This is an expansion, since rather than one single string of satellites, we can fit parallel strings of satellites in a 6" airframe - in fact, four parallel strings in a six inch diameter airframe ena-

bling deployer volume of up to 28P of S4 pico satellites.

It is also simplified, since a mechanical door and spring are no longer necessary because we can use the energy from the deployment event to release the S4 pico satellites in the same way that current payloads are deployed. It is made up of three components, each 3D printable in a modest hobbyist printer. I chose to use a translucent PETG for this version.

- A base unit of 8P capacity. This can be used for the nosecone as well - adding 8P of captive carry capacity.
- A middle unit of 8P capacity that stacks on the base unit.
- A top unit of 4P capacity that stacks on either the base or middle unit.

From these three components we can construct payload deployers for as little of four S4 sats up to 20 or more. They can be any combination of 1P, 2P or 3P S4 sats. Illustrated to the right is a 20P capacity deployer (in captive carry configuration), that fits into a standard ARLISS M payload carrier as an insert. Capacity is reduced when in deployed carry mode - allowing room for each sats recovery method.



Since it fits into a standard fiberglass coupler, the base unit can also fit inside the nosecone coupler, adding another 8P of captive carry S4 payload capacity.

6 <https://www.tctmagazine.com/3d-printing-news/crp-technology-3d-print-pocketqube-satellite-deployer>



AEROPAC 2020 Flight Counts

MUDROCK

Motor Class	Flights
A	10
B	10
C	11
D	6
E	1
F	6
G	6
H	20
I	12
J	10
K	13
L	3
M	7

Total: 115
 Research flights: 8
 # of Flyers: 39
 Reported by: Mike Riss

AERONAUT

Motor Class	Flights
A	0
B	7
C	7
D	3
E	2
F	7
G	7
H	12
I	15
J	18
K	13
L	3
M	4

Total: 98
 Research flights: 8
 # of Flyers: 31
 Reported by: Mike Riss

ARLISS

Motor Class	Flights
A	1
B	6
C	16
D	5
E	5
F	8
G	16
H	9
I	3
J	3
K	4
L	5
M	3
N	1

Total: 85
 Research flights: 2
 # of Flyers: 21
 Reported by: B. Green

XPRS

Motor Class	Flights
A	2
B	2
C	4
D	9
E	6
F	19
G	15
H	23
I	27
J	21
K	16
L	5
M	7
N	4
O	1

Total: 161
 Research flights: 22
 # of Flyers: 37
 Reported by: B. Green



ARLISS 2020 - NOT REALLY

Becky Green

WOW....what a year we've all had!!!!!!!!!!!!!! I hope everyone is staying safe from COVID, all the crazy fires in CA and OR and got to enjoy what little bit of a rocket season we had. With the Pandemic canceling almost every event, vacation and schools throughout the year, AeroPac managed to pull off our 4 launches for the year. However, they were highly modified due to the State of Nevada rules for only allowing 50 people at out door events. The BLM had to follow the same rules so we were held to 50 people per launch. I didn't attend Aeronaut to allow room for another flyer to have a spot and many others who attended earlier launches I noticed did not attend ARLISS or XPRS. We even had to purchase a hand washing station to put outside the porta-potties, put hand sanitizer at the RSO and Registration tables and had masks for anyone who didn't bring one. I noticed for the most part everyone was either wearing their masks or would back away if someone wasn't observing the social distance rule of 6 ft.

I was in contact with UNISEC and US Universities throughout the year trying to see if we could manage to hold the ARLISS 2020 event. This would be the first time since ARLISS started in 1999 that we were in danger of not being able to hold the event. As time grew closer, foreign travel bans, quarantines, 50 person limit etc. it finally proved to us we were not going to be able to hold the ARLISS 2020 event as it normally would be. I still had the hope of 3 US teams being able to attend and fly their projects. However, as each team would hear from their universities that they would be unable to get in their lab to retrieve their ARLISS projects, they would inform me they would have to drop out. Each



Registration observing social distancing

time that would happen, I'd reach out to folks on the XPRS waiting list and invite them to come to the ARLISS launch. That worked out really well as I had the full limit of 50 when I left home for the launch. When a few of us arrived Saturday late afternoon on the playa, we caravanned out to the launch spot. OOPS....who's that at our launch site? Yep, a group of UROC folks accidentally set up their launch pads right on our exact coordinates. They said they liked the spot and didn't realize it was where we set up. No worries at all....we just set up in back of them, watched the rest of their launches and they were out of there by noon on Sunday. That was before John Hochheimer and Jim Green took another trip into Empire to pick up the equipment trailer and the Uber-Rail and bring it back for set up. The good news is we had 3 of the guys from Tennessee who built the Uber-Rail and they set it up while the others set up the rest of the launch site. Wow.....they put that together so fast.....they acted like they knew what they were doing....LOL!!!!!!!!!! Here's where it got strange for me. On Sunday, I kept looking at the clock from about 2 pm and expecting all the students to arrive....but there were none.



Oh yeah...pandemic...
...no students.....I can do whatever I want, like just relax. I didn't have to show the students how to set up ARLISS camp, no students to do rocket camp with, no students to feed and no running back and forth down the flight line assigning student projects to flyers every day. Wow....what am I going to do with all this extra time? I had to do something....so

momma Beck fed about a dozen hungry guys breakfast lunch and dinner the entire time. Even a few strays....LOL!!!!!! Ah....now that's more like it. It felt a little more like a normal ARLISS launch.

Monday morning arrived and OMG....where did all this smoke come from? Fires in CA, OR....it didn't matter.....it was on the playa and made it a bit difficult to fly. However, it was much clearer air than where most of us came from in CA and OR. There were blue skies above us and we could sometimes make out the outlines of the mountains so we were able to fly. No rockets were lost. We would either have trackers on them or most of the time pick them back up just before landing. I managed to fly 18 times during the launch which included staying Sunday after everyone left and did some FAR 101 launches. That is a record for me....I know they were all small motors (C-I), motor eject and easy to prep....but I just don't normally do that....especially during ARLISS/XPRS. The one I didn't get to fly was my M750 flight which sims to 28K. I didn't have time to make an AVBay sled to put the tracker on it before leaving for the launch.



Photo by Becky Green

Where are all the students?

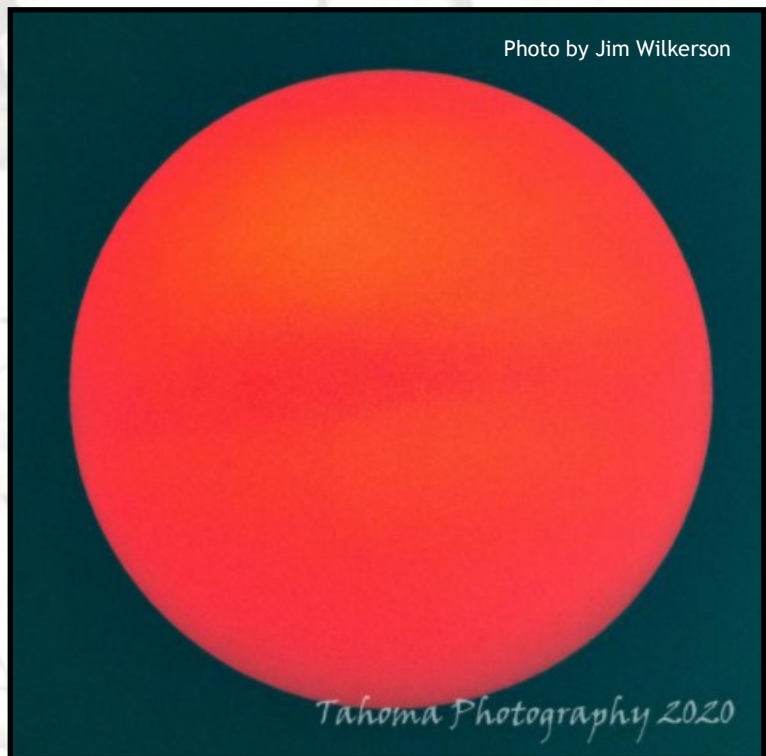


Photo by Jim Wilkerson

Tahoma Photography 2020

The sun Sunday evening before sunset



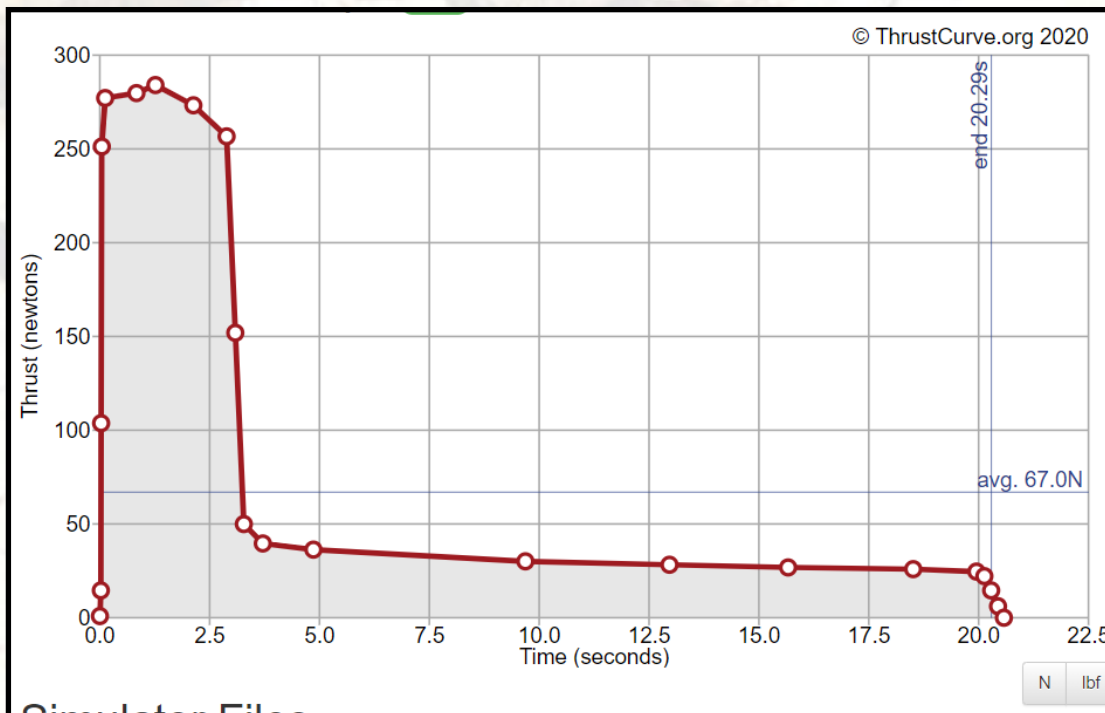
There were many of the 50 people for ARLISS who didn't show up at the launch. I'm wondering if it was because the word got out that there was smoke on the playa. Good thing there was no one on the waiting list who wanted to come but couldn't because of being full. The skies continued to get better every day.....but of course the best launching days were Friday-Sunday. Even the night skies got better just like when we arrived Saturday before the launch

We had a very smooth transition from the ARLISS launch into the XPRS launch. Everyone left in time on Thursday to make room for the XPRS folks. There were some XPRS folks who didn't come until Friday....but we stayed right at the 50-person limit the entire XPRS launch. I'll let someone else write a report on XPRS.

Thank you all for making this a great launch. Lots of folks helped with extra trips to Empire for trailer hauling, porta-potties hauled in and out, set up and tear down and all the help during the launches....you all know who you are. And a special thanks to our vendors who attended. Mike with BAR, Gene with Fruity Chutes, Gloria and Robert with AMW and Scott Binder with SBR.

We can't forget all the support of Karl and Gary with AeroTech/RCS who supplied many of us Demo motors that have just been certified. I kick myself for not noticing until I was packing up on Sunday that I brought 2 rockets that could have flown the K76 20 second burn motor. That is going to be a fun motor.

Aerotech K76WN-P Thrust Curve



Manufacturer: AeroTech

Designation: K76WN-P

Common Name: K76

Motor Type: SU

Delays: P

Diameter: 54mm

Length: 368mm

Total Weight: 1278g

Prop. Weight: 840g

Avg. Thrust: 66.8N

Initial Thrust: 265.8N

Max. Thrust: 299.7N

Total Impulse: 1349.8Ns

Burn Time: 20.2s

Propellant Info: White Lightning/Warp 9

Cert. Org: TRA

Snip from: <https://www.thrustcurve.org/motors/AeroTech/K76WN-P/>



Association of Experimental Rocketry of the Pacific

TRIPOLI Rocketry Association, Inc. Prefecture No. 23

Volume 26 Issue 2

Fall 2020

FRUITY CHUTES

PROFESSIONAL AEROSPACE RECOVERY SOLUTIONS



SINCE 2007

CODE

15%
OFF

Aeropac-15-FC-21

Expires: 12-31-2021

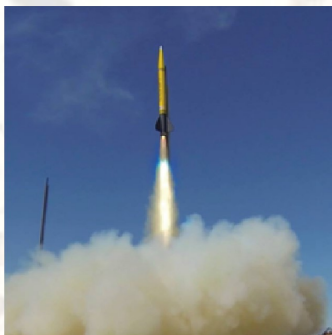
Eligible Products:

<https://bit.ly/370KWwa>



HIGH QUALITY PARACHUTES, SHOCK CORDS, CHUTE LINERS, RAIL BUTTONS, RIGGER JIGS, & MORE!

ROCKETRY



DRONES



PLANES



&

MORE

LOS GATOS, CALIFORNIA

(855) 462-4883

FRUITYCHUTES.COM



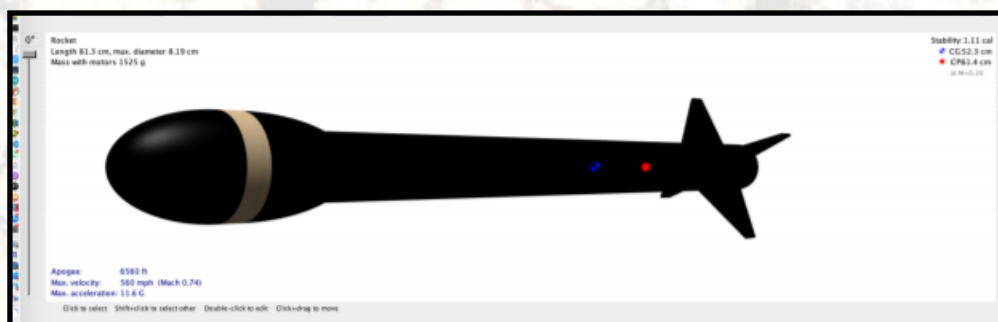
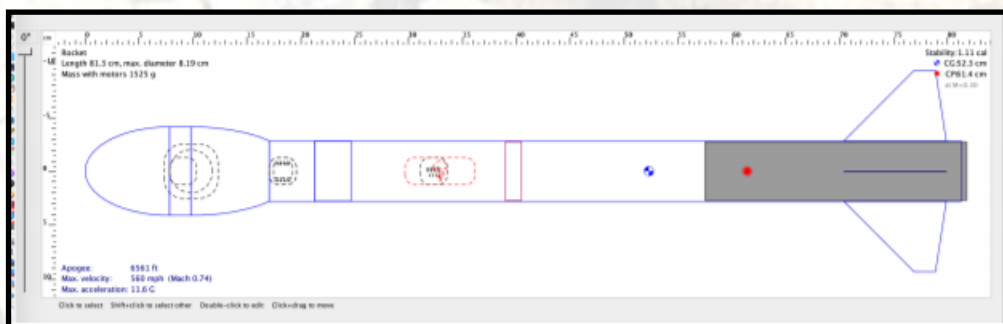
ARLISS Lite: An S4 PocketQube 54mm Airframe

Ken Biba

In this paper we document a new design for an ARLISS Lite airframe - based on a single piece of 54mm fiberglass airframe tubing - that is a minimum diameter airframe, largely 3D printed, that has outstanding aerodynamic performance. It can fly with a G80 motor to ~1800' AGL while the classic ARLISS K motor reaches similar altitude for ARLISS Classic of over ~7500'. We took advantage of 3D printing to create an aerodynamically optimized payload-carrying nosecone with an embedded avionics sled for deployment. Modular, it has a base capacity of a single 1p S4 satellite, a 3p carrier - with clear potential to be further extended. While the current nosecone is designed for captive S4 carry, the placement of the avionics allows for an as yet untested upgrade to deploy the S4 payloads much the same way the ARLISS Classic does ... though on a MUCH smaller airframe and with MUCH smaller motors. The airframe consists of a single 54mm fiberglass body tube with the following 3D printed components:

- A modular payload nosecone with embedded avionics mount for an Altus Metrum mini
- A recovery anchor for the recovery system
- A 4 fin fin can.
- Rail guide standoffs

I prefer using PETG for strength for an airframe this size. We added avionics, a recovery harness and a parachute of choice in this case a SlimLine aluminum motor retainer from Giant Leap Rocketry - about the same thickness as the fin can for minimum drag.



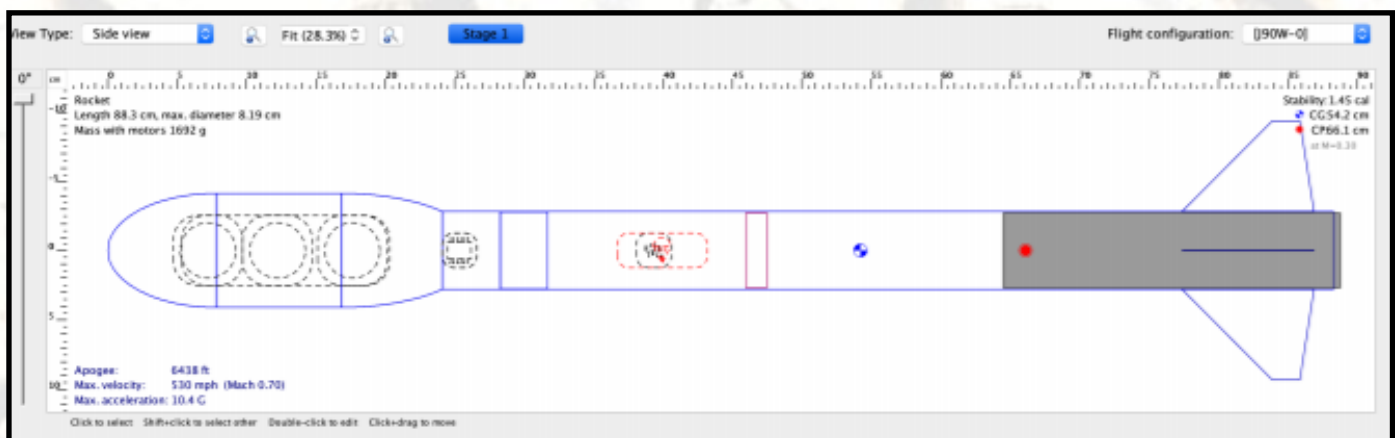
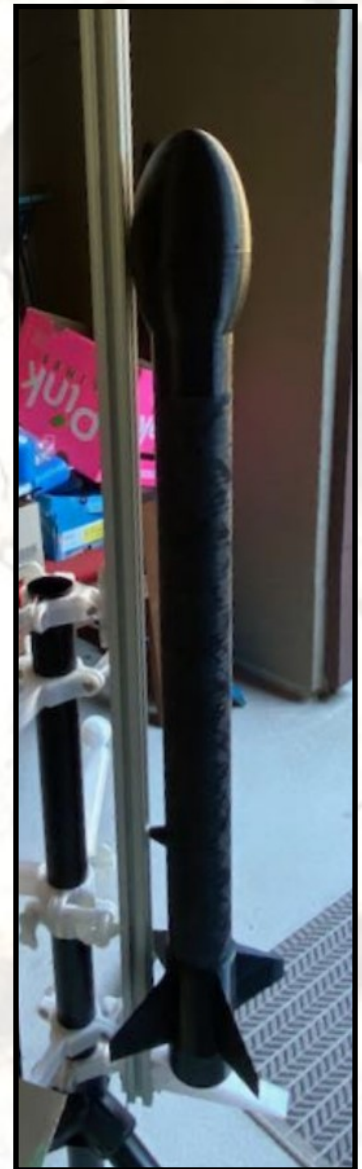


The COVID pandemic has placed a hold on test flights, but OpenRocket simulations suggest an outstanding range of performance on smaller HPR motors - bringing ARLISS to whole new range of fliers and locations.

Motor	Altitude (Ft AGL)	Max G Load
G80	1837	13
H180	2877	31
I211	4350	32
J90	6543	12
K550	7783	37
K185	9029	16

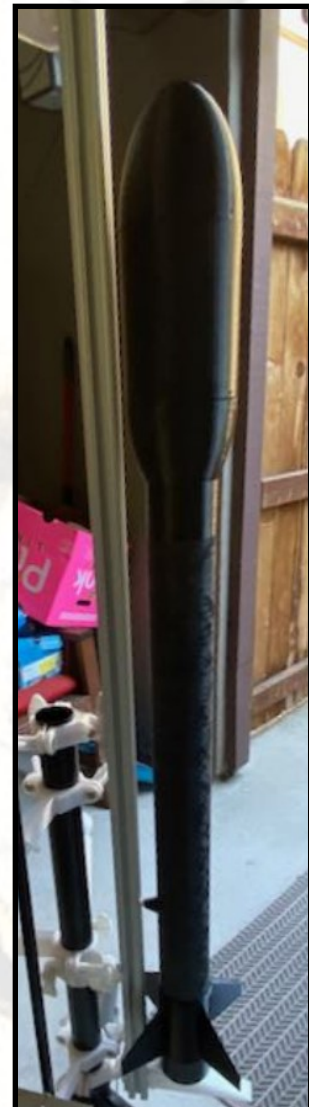
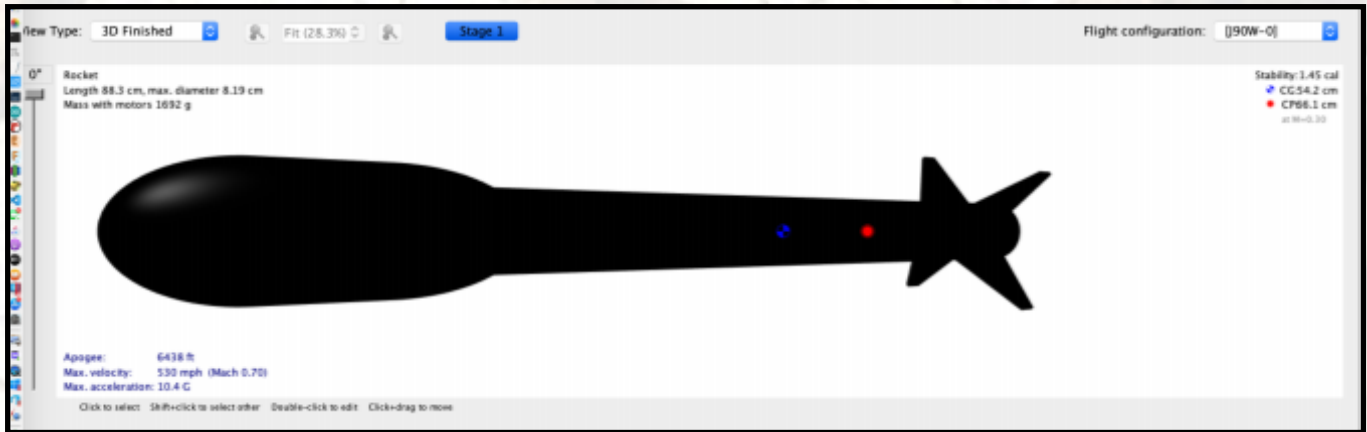
3D printing allows creating a modular family of airframes with different payload capacities - much as commercial orbital rockets support different size fairings for different payload capacities. An extended payload nosecone can carry up to 3p of S4 satellites. A 3p payload reduces apogee for small motors by 20% but might actually increase apogee with larger motors. This is a limitation of simulation that only experimentation solves.

The next steps are to test fly ... and think about how to implement active de-
ployment.





The .stl design files and Open Rocket model are on Thingiverse. ⁷



⁷ <https://www.thingiverse.com/thing:4551475>

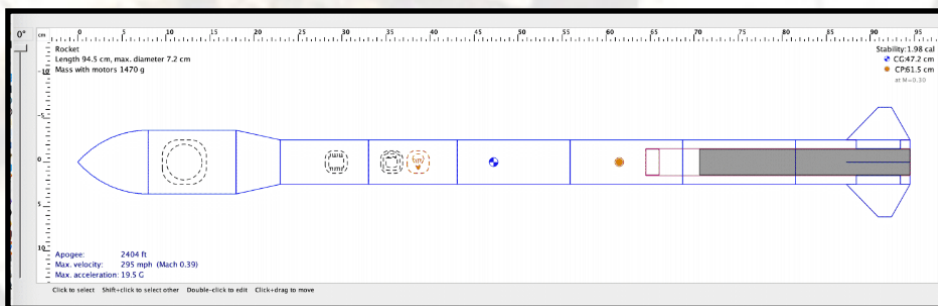


1/45th Scale Falcon 9 ARLISS Lite Airframe

Ken Biba

In this paper we document a new design for an ARLISS Lite airframe, based on a completely 3D-printed model of the SpaceX's Falcon 9. It's kinda heavy (all that plastic!) - but it's fun, can be displayed as a model with landing legs or for flying with a fin can - and can carry at least one S4 PocketQube. All the weight means it does not have the altitude reach of more optimized airframes but can still get to ~1000' AGL on a 29mm G76 up to ~2400' AGL on a H180. This uses the excellent Falcon 9 model by Ants in Africa as a foundation, modifying it to make it a flying model on hobby composite 29mm rocket motors from G thru H power to altitudes from 900' to 2500'. Being printed, its heavy - so it needs reasonably high impulse motors. And it's impressively big - just short of a meter long. It is intended that the model can be constructed for display, and using the clever modular structure of the original model, upgraded with components to make a flying version. It includes two types of payloads - a standard payload fairing and a Crew Dragon. With the standard payload fairing it has room for electronic payloads - in particular a 1p S4 PocketQube.

It can be flown with motors that use chemical delay but is probably best flown with compact avionics for low speed apogee parachute deployment. An embedded avionics mount for an Altus Metrum EasyMini is included.



The following basic modifications to the original model have been made:

- It replaces the model's second stage motor with a retention system for parachute recovery and an embedded avionics bay for deployment.
- The payload bay has also been modified so it can contain a real S4 satellite payload with sensors.
- A motor mount arranged to use a 29mm fiberglass motor tube has been integrated. The display F9 motor/landing leg section can be removed and replaced with the flying motor mount. The motor mount integrates a screw-on motor retainer and a fin can.

7 <https://www.thingiverse.com/thing:2914233>





- A 3D printed fin can has been integrated into the motor mount. I printed it in translucent PETG for strength and subtleness.
- Integrated stand off 1010 rail buttons have been integrated into the airframe for rail launch. I am printing in PETG for robustness though I suspect ABS or strengthened PLA should work as well. In addition to a printer and filament, the design needs the following rocketry specific items:

- An 8" section of 29mm fiberglass motor tube - I used Madcow Rocketry components.
- A recovery harness - I like kevlar tubing.
- A parachute.
- + Avionics - I like an Altus Metrum EasyMini but other small inexpensive avionics can be used.



In this first version, the S4 payload is a captive carry ... the payload stays with the rocket.

A possible upgrade is to deploy the ARLISS Lite S4 satellite from the payload bay after apogee. It looks like it's possible

with replacing the nosecone bayonet mount with shear pins, and putting a small deployment charge beneath the payload triggered by an avionics event just after apogee. It can be optionally configured for flight or display and for carrying S4. In the pics, the gray sections are the ones replaced in the flying version. The original model cleverly made the rocket in sections, with bayonet mounts between sections, so a single model can be configured for flight AND display. Next steps are to test fly ... and think about how to implement active deployment. The complete downloadable documents are on-line ⁸.

Motor	Altitude (Ft AGL)	Max G Load
G76	953	10
H128	1509	10
H180	2402	19



⁸ <https://www.thingiverse.com/thing:4550817>



COVID Madness: A Classic 3D Printed Rocket Collection

Ken Biba

The intersection of COVID quarantine madness, 3D printing and rocketry insanity has resulted in a new collection of (partially) flying classic 3D printed rockets. For reasons best left obscure, these are all to about the same scale - roughly 1/153. I thought I would share the insanity that a 3D printer gives when combined with house arrest. This is a partial collection of the rockets I've built on my patio.

All are to about same scale (~1/153) though Luna is a bit bigger scale so not quite right on relative size but closish. Luna, Saturn V, Falcon 9, SLS, Mercury-Atlas and N1 are all intended to fly as noted by the * below. For the flying models, I have updated to include 3D printed motor mounts, motor retainers, 1010 or micro rail guides (and standoffs in the case of N1 and Falcon 9) and recovery gear. All the models are resized to same scale. All models are using either 1010 or micro rail guides. The N1 appears able to fly without ugly fins. Sorta. From left and including link to Thingiverse for .stl and Open Rocket simulations:





Luna (design courtesy Jamie Clay)*	https://www.thingiverse.com/thing:3653943
Ariane 5	https://www.thingiverse.com/thing:4592500
Saturn V* 24mm	https://www.thingiverse.com/thing:3192548
India's GSLV - soon to launch astronauts	https://www.thingiverse.com/thing:4592507
Falcon 9* 18mm	https://www.thingiverse.com/thing:4572032
Soyuz	https://www.thingiverse.com/thing:1236930
Starship + Superheavy	https://www.thingiverse.com/thing:3894250
Vulcan	https://www.thingiverse.com/thing:2944453
New Glenn	https://www.thingiverse.com/thing:4592518
Electron	https://www.thingiverse.com/thing:2742387
Space Launch System* 24mm	https://www.thingiverse.com/thing:3240714
Mercury-Atlas* 13mm	https://www.thingiverse.com/thing:3203045
N1* 29mm	https://www.thingiverse.com/thing:4572029
Mercury-Redstone	https://www.thingiverse.com/thing:3115661

ARLISS Extreme printer would not print that small — a “toothpick”

Many of these are already man-rated real rockets: Saturn V, Falcon 9, Soyuz, Mercury-Atlas, and Mercury Redstone. GSLV may join the group in < 1 year and likely sooner than Vulcan. Starship is going to be VERY big. It will be interesting if it flies before New Glenn. Or even Vulcan.

Want to learn more about the real rockets these models represent? Here are some sites where you can learn about the past, present and future of space vehicles. WARNING: Do not open these sites unless you are prepared to be addicted!

Scott Manley: <https://www.youtube.com/channel/UCxzC4EnglsMrPmbm6Nxvb-A>

SpaceX: <https://www.spacex.com/>

Everyday Astronaut: https://www.youtube.com/results?search_query=everyday+astronaut

Boca Chica Live Stream: https://www.youtube.com/results?search_query=boca+chica+live+stream

NASA Spaceflight: <https://www.youtube.com/c/NASASpaceflightVideos>

United Launch Alliance: <https://www.youtube.com/user/UnitedLaunchAlliance>



How Not to Spend the Summer Solstice Weekend

A MudRock 2020 Launch Report by Wilson Alness TRA #13848, L3 / AeroPac #918, Portland OR

After a very reassuring weekend in Brothers OR last October, all signs pointed to a highly successful 2020 launch season on the horizon. This was of course to ultimately be thwarted and censored by the government, with TRA even going so far as to place a blanket ban on all rocket launches. Needless to say, it made all of those countless weekends in the shop feel like they were lacking an objective. After seeing 2 x OregonRocketry launches get cancelled with no recourse and little foresight, it was time to come up with a Plan C...normally MudRoc either conflicts with NXRS, or is too close date-wise. The day the launch announcement was made, I decided a Black Rock trip (having not been since BALLS 2018) was just what I needed to ease some of my frustrations surrounding the current situation and get out of Dodge for a long weekend. Game on.

Of course, no Black Rock trip is ever complete without at least some traveling at odd hours and a minor vehicle hiccup...this was no different. Once I picked up my rental van on Wednesday afternoon, the epic “cramming 5 days of work into 3 short days” conclusion was upon us, finally getting me away from my home office around 6:00 PM. No problem, as I still had plenty of packing to do both at the house AND over at the shop...finally got on the highway around 11:30 PM. It was a long, quiet trip down I-5 and then over the Willamette Pass. I left Springfield with 3/4 tank and nothing in the gas can, no problem at all – until I realized that every gas station on Hwy 58 would be closed at that time of night. Pulling onto Hwy 97 with nothing but fumes, she finally quit just 1.7 miles short of Chemult and the next 24-hour travel center. Dumbfounded over how close I had made it, I coasted into a snowplow turnaround and made some phone calls. Naturally, roadside assistance was no help given the early-morning hour and remote location. So I threw on a jacket, grabbed my gas can, and got walking through the brisk conditions. With 5 gallons of fuel in tow, a fellow driver at the Pilot center was kind enough to drive me back up the highway to my disabled vehicle – he was headed north on 97 en-route to Idaho, I believe. After filling the remainder of my tank and driving a bit farther, I pulled into Collier Memorial State Park and finally got some rest. Perhaps I thought that was it...

Later that morning I awoke and headed to Klamath Falls for breakfast and final supplies at Fred Meyer/Home Depot. No mishaps this leg, and I think the USDA agent in Tulelake asked me more questions about the lighting truss on my roof rack than about produce. (“YOU must be going to Nevada!”) After the final fuel/water fill in Cedarville, I was #5 to arrive at the flightline at around 2:30 PM. Parked in between Peter Clay and Dave Raimondi, I set up camp, got my pads put together, and was set for the weekend.





First up Friday morning was my carbon Mongoose 54 – “You Know What, They’re Both Named Bernie” – on a K1100T. She got out of the tower in a hurry and flew to a “whopping” 12,022’, Mach 1.26. Was an easy up-and-back with normal recovery, landing about 3/4 mile due east of the range.

Also on Friday, I flew my old PML Miranda on an even older AMW K670GG – not just to burn the motor, but also to test out an ARTS2 and some other electronics. I named the rocket “Vintage Classics” given how few things onboard were current. The motor let out a huge chuff (I thought it had gone out) before coming up to pressure – it pushed the Quantum/phenolic airframe, uh...pretty hard until she finally gave up right at Max Q. It rained parts behind the porta-potties and well out of anyone’s way – I got everything back but nothing was really salvageable except for the motor and electronics which went unscathed. Paul Bogdanich gave me a nice, custom smoke closure when he sold the hardware to me...so it made for some pretty sky-writing (like an airplane doing loop-de-loops) after the airframe shredded. Given that all the electronics DID in fact work, I call that alone a successful test ride.

That night was a lovely evening around the Jim and Becky Green “signature” burn barrel – great company and great beverages were had.

On Saturday I flew my biggest motor of the weekend – a 75mm M2700 with 36” of my new high-solids propellant that had done really well in some earlier test burns and flights. Just before arming, a powdered donut was placed on the nosecone as a salute to the great Alex McLaughlin. I estimated this motor should give my stretched 4” Broken Arrow (named “Curing Cabin Fever”) quite a ride to just over 20K. Unfortunately, it never went quite that far – moments after the button was pushed, the forward closure had a thermal failure in MOST spectacular fashion.

The liner was ejected and began twirling around like a firework, the fin section tumbled back in by itself, but all of the chutes deployed normally so the rest of the rocket fared well. Dave Raimondi’s remark on LCO summed everything up pretty well – “yeah, that...that’s all bad.” You really have to see Jonathan’s photos to experience the full effect. Fortunately, the rocket itself isn’t even too worse for wear, and some of the guys who helped me develop that formula were able to narrow down the point of failure...indeed, it was something I had never experienced before.





Determined to redeem myself – next on the pad was a 54mm Madcow Tomach (aka “Jolly Caucus Race”) on a red L1150, my 1st time doing a colored propellant. Lowell Hart was kind enough to mention “now remember, the LCO takes no responsibility for fire coming out both ends!” just moments before doing the honors. Despite the conservative geometry and Kn range, it actually cranked pretty nicely and performed very close to what I had predicted. The Raven3 logged some terrific data – 13,398’ AGL, 1,439 fps, Mach 1.29, 37.8 G’s. Special thanks to Peter Clay for spotting its recovery, reefing the main chute, logging its GPS location, and even driving me out to it!

My official LCO shift was from 4:00 PM-6:00 PM, and by then the winds were howling so nothing really flew other than a G motor and a few motor/igniter static tests. Still, it was pretty cool to be at the helm of the illustrious Wilson F/X LCU-64X controller for my 1st time...felt a bit like driving a sports car!

Saturday evening brought another fun night around the burn barrel, and a couple of night rockets. Most flew on Jim’s “Unicorn Farts” sparky propellant – a clever combination of red, blue, and titanium sponge that’s quite impressive at night!

Given the winds, I pushed my last flight of the weekend ahead to early Sunday morning so as to be on the road at a reasonable hour. A funnier joke could not be told. In the tower was “Drinking TV Static” (carbon Mongoose 75, same carrier of my M3000 Super Tiger out in Brothers last October) on an M840 with Jonathan DuBose’s TeleGPS system in the nosecone. It took off at a gnarly angle despite calm winds, with no conclusive GPS data after the gentle 9-second burn. Max reported altitude (about 22K





thanks to the angle) and coordinates were all decently believable, so I headed out. Approaching sagebrush N/NE of the flightline, I braved a small creek and promptly got the van stuck. After not receiving any response on the FRS radio, I emailed a distress call out to a few people on the flightline and began hoofing the 2-or so miles back to camp. Jonathan finally called me as I was getting close and relayed my message to James Flenner and Alan Skinner, both avid play-trekkers armed with ATV/Polaris RZR's plus infinite knowledge on local terrain. James schlepped me back out to the mud as we contemplated an escape plan. Without tow points on the rear bumper, the only way to haul me out was forwards. This meant the procedure was 2 x fold – first get me out of the creek, and then back OVER the creek...gulp.

After much contemplation and scouting missions by James and Alan, a reasonable crossing point was spotted not far from the “crime scene.” I hooked up Alan’s high-power winch to a tow point, then he applied tension as I got in the driver’s seat and tapped on the gas pedal. (I was soaked in mud at this point...) It worked, and I was freed! For phase 2, I followed him over to a much narrower/more shallow spot and received my mission debrief on “whatever you do, just don’t STOP.” I floored it, flew across the creek, and that was the end of my ordeal. We topped off fuel in the RZR's and all headed back to camp around 1:00 PM, but of course I still had to load... I was the last to leave at about 2:45 PM, so that was that.

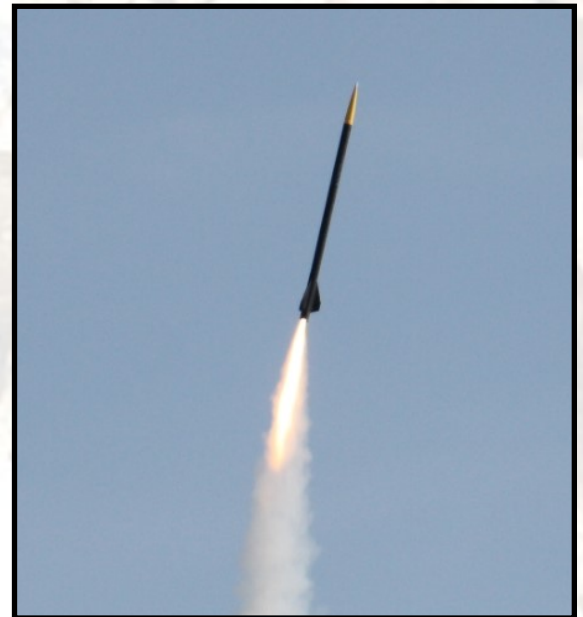
Video of recovery:

https://www.dropbox.com/s/2gxhi6kplulsgtf/20200621_124006.mp4?dl=0

https://www.dropbox.com/s/gvzb4blg286f10l/20200621_124334.mp4?dl=0

https://www.dropbox.com/s/nxo5hrhega3q1ih/20200621_124948.mp4?dl=0

Be sure to check out Jonathan’s visuals of this whole process, also! Special thanks to Pat Harden for recovering this rocket at Aeronaut the following month and coordinating its timely return to me – most appreciated.



“Drinking TV Static” heads for the Quin River sink





Topped off fuel in Alturas and had a lovely sit-down dinner in Klamath Falls before powering through the rest of the drive, stopping only occasionally for a short nap. Finally rolled into Portland during the wee hours, unloaded the van, and got home just in time to enjoy about 3 hours of actual sleep before going back to work Monday morning. My rental return later that afternoon was met with several sideways looks, but they quickly turned to laughs as soon as it was realized dust and mud were hardly of any concern.

Despite a few mishaps, the trip was far from a bust – I wish to thank you all again for being so accommodating and running such a great show. I can't tell you how enlightening it was to have a waiver open at 7:00 AM each morning, meaning no waiting around for BALLS staff to finally show up after their lengthy Bruno's breakfast while everyone else is left twiddling their thumbs during low winds. Special thanks to those in particular who went well-above and beyond:

- Jim "The Man" Green and Becky "The Charm" Green – both of whom this trip certainly would not have happened without. Thanks to all the countless coordination with the BLM/FAA, organization, and making phone calls at the crack o' dawn, I got to kick off my 2020 season with a Black Rock trip. Not to mention, it was really great having a guy just to sit down and talk motor stuff with. Over at the range head on Friday afternoon, Jim asked me "whaddya think, is this better than BALLS?" with a wink and a nod...though I'd say we both knew the answer.
- Peter "Easy-Up Wrecker" Clay and Dave "LCO/RSO Dude" Raimondi – for being fabulous camp neighbors (or putting up with me...not sure which). Peter handled LD duties with aplomb, headed up a seamless range setup/teardown, spotted one of my rockets, and we even got to trade some old stories from Brothers – back in the days of Acme Rocketry, Jane Fossen, and Dennis Winningstad. Dave filled in on LCO and RSO duties throughout much of the weekend, and I hope my constant calling you out for help there didn't take away from any of your own flights.
- James "Playa Trekker" Flenner – for heading up my mud rescue, schlepping me around in Fetch the Polaris RZR, offering a bit of guidance on where one of my missing rockets DIDN'T land, and providing some fabulous suggestions on what else to see/do around Black Rock besides flying rockets.
- Alan and Cindy "Dynamic Mud Duo" Skinner – they did the honors (?) of winching me out with their RZR-type rig, and joined James in the scouting mission of how to best maneuver me out. No matter how you look at it, the final results were quite spectacular!
- Jonathan "You're sending in all of this for the newsletter, right?" DuBose – for loaning me the goods I needed to get my M840 flight up on Sunday morning, helping with the rescue mission above, and calling my cell 1st thing Monday morning to make sure I arrived home safely.

Not to mention it was nice to put some other faces with names – William "Westy" Walby, Lowell "Wise Guy" Hart, Clay "The Other Wilson" Wilson, and several others. I look forward to seeing everyone again in 2021!



Largest rocketry inventory west of the Mississippi!



Order now for Christmas and for next years launches!

Get Your Orders in Now!

Visit our website: <https://bayarearocketry.com/>

