



AEROPAC Spring 2016 Newsletter

Photo by Phoenix 4, courtesy of Curt Von Delius

President's Pad Jim Green

Greetings, fellow AEROPAC members!

We will be starting this year's launches with a shiny new wireless launch system. Thanks to Gene Engelgau for researching, purchasing, and testing this new system.

The equipment cleaning party went well thanks to the crew of volunteers who cleaned last year's crud off our rails, rods and other equipment. Thanks also to Lynn Cominsky for letting us use her property for the job.

There are reports of dry playa so MUDROCK might not be so muddy

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after all.

The FAA has re-evaluated the hazards around our launch area and is reducing our daily waiver altitude. High flights will have to be done during the Saturday morning window. I'll send out more information when the waiver has been processed.



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Dr. Lynn Cominsky Recognized with Science and Academic Awards

AEROPAC's own Dr. Lynn Cominsky has been recognized and lauded recently for her achievements and efforts from within both the scientific and academic communities. Most of us know and appreciate Lynn through her work with the S4 program. S4 = Small Satellites for Secondary Students: <http://s4.sonoma.edu/>.

However, Lynn's activities and accomplishments go well beyond this scope and within the last several months her contributions have been recognized.

LIGO Project:

Lynn was recognized for her role as part of the team of scientists working to observe a key part of Einstein's Theory of Relativity – the "Laser Interferometer Gravitational-wave Observatory" (LIGO) project. This team "observed ripples in the fabric of space / time called gravitational waves, arriving at the earth from a cataclysmic event in the distant universe. This confirms a major prediction of Albert Einstein's 1915 general theory of relativity and opens an unprecedented new window onto the cosmos." California Assembly member Bill Dodd presented Lynn with a certificate honoring her role in LIGO's educational program.

For more on the LIGO project and Lynn's role see:

<http://www.sonoma.edu/newscenter/2016/02/gravitational-waves-detected-100-years-after-einsteins-prediction.html>

and

<http://www.sonoma.edu/newscenter/2016/03/cominsky-honored-by-state-for-work-on-gravitational-waves-discovery.html>

Award from American Astronomical Society (From the Sonoma State University Newsletter)

"The American Astronomical Society has selected Lynn Cominsky for its Education Prize for her long-standing leadership of the Sonoma State University Education and Public Outreach (E/PO) [group](#), which has had a broad and significant impact both within its local community and nationally. It means a lot to Cominsky partially because she's been a member of the organization for most of her professional life."

"It's a reflection of the work I've done my whole career as an educator in terms of using astronomy to get people more involved in taking more science courses," says Cominsky.



Dr. Lynn Cominsky Recognized with Science and Academic Awards

For the full article see: <http://www.sonoma.edu/newscenter/2016/01/physics-and-astronomy-professor-lynn-cominsky-receives-two-awards.html>

Sally Ride Excellence in Education Award Society (From the Sonoma State University Newsletter)

“She is also the recipient of the second-ever American Astronautical Society's Sally Ride Excellence in Education Award, recognizing the delivery of space education or the use of space in STEM (science, technology, engineering and math) education. This award was largely for her work with SSU's CubeSat program, in which a student team launched a tiny satellite into orbit around Earth in 2013, and the S4 program (Small Satellites for Secondary Students), which teaches educators to build experimental payloads to fly on tethered weather balloons or rockets, enabling students to participate in the thrill of experimental design and implementation.

Although the S4 program has ended, the rocketry work will continue through Cominsky's new NASA grant that will develop a rocket-based curriculum beginning in five California community colleges this year and expanding to 10 next year. “I really want people to get hands-on with the hardware,” says Cominsky. “People love launching things.””

The Wang Family Excellence Award (From the Wang Family Excellence Award “Procedures” page)

“The purpose of the Wang Family Excellence Award is to recognize and celebrate those California State University (CSU) faculty members who, through extraordinary commitment and dedication, have distinguished themselves by exemplary contributions and achievements in their academic disciplines, while having a discernable effect on students. The Chancellor’s Office shared these comments from previous CSU selection committees:

- A Wang nominee should be regarded as a “superstar” on the campus.
- Nominees should be making multi-faceted contributions to the learning community, such as involving students in their research, arranging and supervising student internships, involving students in community service, recruiting students, and publishing.

From the Sonoma State University Newsletter:

“Sonoma State University physics and astronomy professor Lynn Cominsky has received the \$20,000 Wang Family Excellence Award for her extraordinary commitment to student achievement and exemplary contributions in her fields.”



Dr. Lynn Cominsky Recognized with Science and Academic Awards

"Receiving the Wang award is the biggest thrill of my career," says Cominsky. "It is wonderful to know that my dedication to the CSU is so widely appreciated and that my efforts to improve STEM learning nation-wide are being recognized."

As a scientific co-investigator on three NASA high-energy astrophysics missions and founder and director of the [Education and Public Outreach](#) group, Cominsky develops exciting educational materials that inspire students to pursue STEM careers, to train teachers nationwide in the use of these materials, and to enhance science literacy for the general public. She has developed curriculum used by tens of thousands of students nationwide and has helped train master educators that have infused NASA science into the classrooms of more than 65,000 teachers.

Source: <http://www.sonoma.edu/newscenter/2016/01/cominsky-receives-20000-wang-family-excellence-award.html>

A video created by the California State University's Chancellor's office that features Cominsky can be seen here:

http://www.calstate.edu/faculty_staff/wang-awards/awardees/2016/2016-lynn-cominsky.shtml



Dr. Lynn Cominsky, Professor and Chair, Physics and Astronomy, Director, SSU Education and Public Outreach at SSU



Project ARQUE

J. DuBose with W. Walby, K. Baumann

A couple of years ago I exhibited my lack of historical understanding concerning the origin of the much loved / hated “bolt on” ARLISS fins in the presence of William Walby. William, who goes a long way back in AEROPAC, straightened me out and in the process told me a pretty wild and very interesting story which goes to the very early historical roots of the classic ARLISS airframe. I decided that this tale would make a great newsletter article since it relates to the evolution of both ARLISS and AEROPAC. I have always been fascinated by history as it always helps explain how we got to where we are today.

What follows is the tale as related to me by William Walby and Karl Baumann. This IS, believe it or not, a true story.

In 1996 it seems there were a couple guys that started hanging around AEROPAC launches and asking a lot of questions. Eventually, they approached Pius Morizumi, who was then the AEROPAC Prefect and President. It turns out that these guys were from NASA Ames and had a project in mind in which they thought AEROPAC flyers might be interested.

One of the NASA guys was named “Bud” and like some other aspects of this story, who Bud actually was has gotten a little fuzzy. We were not successful in coming up with Bud’s last name but “Bud” and his son actually joined AEROPAC and were active for several years. As for his partner, no one seems to remember even his name. So as this story was bandied back and forth he was re-incarnated as “the other NASA dude”. And since this was prior to the ubiquitous digital camera / cell phone camera, few photos seem to exist.

A data mine of AEROPAC archives reveals no one named “Bud” so that was probably a nickname or maybe a “code name”?

Bud and his friend proposed a project that would involve flying rockets as fast as possible. The rockets would carry NASA avionics packages while NASA tracked things and recorded telemetry from the packages. The avionics and telemetry were early developmental tests of the long discussed, and still not perfected, Scramjet - a hypersonic, > mach 5 aircraft. [See https://en.wikipedia.org/wiki/Scramjet](https://en.wikipedia.org/wiki/Scramjet).

One really nice feature of the proposal was that NASA would pay for everything - the airframes, avionics, motors, reload kits, launch rail, etc. The AEROPAC participants would build, launch and recover the rockets and payloads.

So, fly rockets multiple times as fast as possible at taxpayer’s expense and under the umbrella of a federal government agency that would clear any obstacles – what is not to like?

Granted, “great pains,” according to Karl, were to be taken to protect the avionics packages, but we always do that anyway, right?



Project ARQUE

A number of people expressed interest and were chosen including Pius Morizumi, Karl Baumann, Mike Penner, Chet Geyer, Ed Hackett, Sue McMurray, and William Walby.

The effort was christened "Project ARQUE." The launches would be held outside of AEROPAC launches, under a NASA waiver and outside of the TRA umbrella, for reasons that will be obvious as the tale unfolds.

Project Arque, Year 1

Karl Baumann designed the first iteration airframe which was christened "Pluto." This was a 4" minimum diameter, filament wound fiberglass rocket. Karl, then owner of Mojave Desert High Power, ordered 6 kits of parts from a company called Dynacom (now defunct) and built 5 of them (and still has one un-built Pluto). Karl also gave these rockets what he called a "handsome" paint job. The fin cans were orange, the air frame was white and the payload section and nose cone were orange.

AltAcc altimeters from now defunct Black Sky were installed to control what would be a single event deployment of the avionics package and airframe. Walston trackers were also installed and would be managed by the Walston guru, Sue McMurray. The parachutes were from a company called Spectrachutes, which seems to still be in business.

Motors were selected for their "thrusty" characteristics including the Aerotech M2400T, Kosdon M2400F (Fast), which featured a G10 fiber glass removal case and Kosdon N4000F snap ring motor.



Project ARQUE team members:

Chet Geyer, William Walby, Sue McMurray, Pius Morizumi, Mike Penner, Karl Baumann and "Other NASA Dude."

Pluto Airframe fin can and AT 98/10240 hardware

It is likely that the mysterious "Bud" took this photo. Photo courtesy of Karl Baumann



Project ARQUE

Aerotech M1939W motors were also selected.

A November 1996 launch date was set. On the appointed day NASA showed up with several 16 wheel semis full of gear –large ~60ft antennas which were set up on the edges of the playa along with portable radars and mobile offices.

As the fun unfolded, the rockets were launched and soared to between 20 and 32k' and were recovered up to 7 miles away. The Kosdon 4000 motors pushed the Pluto to 32K and seriously ablated the fins and nose cones. Speeds close to mach 2 were achieved by most flights. Five or six flights were made that year.

Project Arque, Year 2

The next year, 1997, NASA had a new, larger avionics package and an onboard patch antenna that would not fit in the 4" Pluto airframe. A second generation airframe was needed and the Optimal 150 kit from Black Sky was selected. This was a 6" "canvas phenolic" airframe with a 98mm motor mount and featured "bolt on" fins. Height and weight were similar to today's ARLISS airframes and they were quickly dubbed "Lard Ass." The phenolic canvas airframes were extremely tough, easy to machine and drill, and included a fibreglassed phenolic reinforcement tube inside the airframe to help secure the fins.

Editor's note: I don't really think of modern ~700 mph ARLISS rockets as "LARD ASS"es. But compared to ARQUE v1 Plutos with Kosdon Fast motors, I can see how the nickname came to be.

What was REALLY interesting was that the flight profile changed dramatically from the first year. Instead of a vertical launch, this year's launches would be made off a Black Sky rail modified to tilt to a 45 or so degree angle. The rockets were hung underneath, something like you see when Black Brants are being launched from Wallops.

Clearly, with the larger, heavier Optimal 150 airframes and off vertical launch the velocities and altitudes were not going to match those of the Pluto rockets. Typically, the rockets flew to 5 to 6 k' and achieved (lost to history) velocities. NASA installed two ~60ft antennae along the sides of the playa and the flights were made between these points kind of like a football field goal.

At apogee, pyro charges broke the rocket apart. The nose cone and upper body kept going down the playa while the fin can section deployed a drogue, turned around? and landed aft end into the playa. At some point, the main chutes deployed and recovered the NASA avionics package and the rest of the rocket.

Two teams had been created among the AEROPAC flyers and were pre-positioned on the playa for speedy recovery. One team was to retrieve the fin cans and attempt to return them to flight-worthy status ASAP,



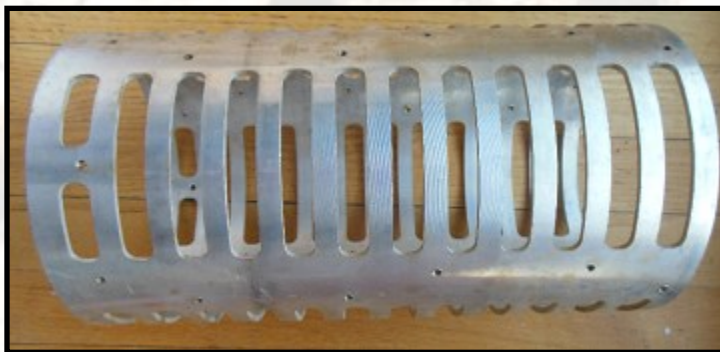
Project ARQUE

i.e., change the sure-to- be mangled fins, repair zippers, swap airframe parts, replace shredded parachutes and make any other changes required. The other team would retrieve the upper part of the rocket along with the payloads. As in the first year, utmost attention was given to recovering the payloads safely.

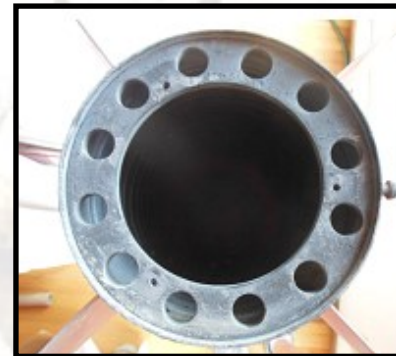
One flyer, assigned to recover the fin cans, made the observation that it was “pretty weird” to see an Optima 150 screaming down the playa right overhead. “They looked like a big bullet coming right at you.”

No effort was made to paint these rockets. Life expectancy was reckoned to be “nasty, short and brutish”, to use a Hobbesian phrase.

Clearly, these airframes were going to take a lot of punishment and in order to help keep the fleet flying NASA created an aluminum insert which would replace the Black Sky setup for attaching the fins. Milled from a solid 6” aluminum billet it was then installed inside the fin can like a coupler. Holes were drilled and tapped to secure the fins. This setup made the fin cans extremely strong and perfect for the application given the rough treatment these airframes were to endure. The idea was that the fins would suffer greatly, and creating a viable field replaceable fin systems was essential. Replacing bent, deformed fins for



An ARQUE project inspired ARLISS fin can “cage”



Business end of Jim Green’s ARLISS rocket. ARQUE Project inspired

this stage of the project became the rule rather than the exception. NASA also created a really cool looking motor retention system. It seems that a few of these may have survived to this day. Modern day ARLISS flyers may recognize the business end of Jim Green’s ARLISS (above).

And so began the practice of replacing on the playa, deformed “bolt on” fins, repairing zippers, swapping out airframe parts and shredded parachutes. The fine tradition of cobbling together a flyable 6” diameter, ~42lb, 100” long, “bolt on” finned rocket with precious payloads was inaugurated. And the tradition continues every September during ARLISS.



Project ARQUE

At this point, it should be noted, that the “modern day” requirement of changing fins (or sometimes trying to straighten out bent ones), repairing zippers, swapping out airframe parts and replacing shredded parachutes occurs most likely due to wind shear at altitude. A perfect example is day 1 and 2 of ARLISS 2015. There was perfect conditions on the playa but a nasty 55 mph wind shear at 7k' or so. After a couple of ugly flights, operations were halted.



Not untypical ARLISS aftermath – note bent fins, core sample (shredded chute), zipper (not visible), playa paint removal. However, all payloads were successfully deployed.

Another “perk” of the program was that the lucky folks in this program drove back to Fernley for the night and stayed in one of the few motels. All on the taxpayer, of course. Then it was back to the playa the next morning. Fernley was then a quiet rural desert burg, long before Top Gun and Amazon.

Fernley is still a favorite overnight spot for ARLISS student teams, especially the Japanese students.

Project Arque, Year 3

The following year, number 3 for Project Arque, NASA decided that significantly more speed was required. Plans soon morphed into something REALLY interesting. NASA ordered a couple of 7” Viper 5 sounding rockets. These rockets were mach 4 capable and included a “1.1 self destruct” system. The rockets were shipped to Aerotech where the propellant grains were cast into the carbon fiber motor case and then shipped back to NASA Dryden, Edwards AFB in southern California.

The flight plan was to helicopter the Vipers to a peak at the southern end of the Sheldon Wildlife Refuge. Sheldon WLP is over the mountains if you keep going instead of turning off at 12 Mile entrance. This peak, most likely Mahogany Mountain, is visible from where we launch today if you look up the dry lake arm in



Project ARQUE

the direction of Soldier Meadows . The Vipers would be launched basically horizontally, flying at mach 4 toward Razorback Mountain. The self destruct device would kick in and destroy the rocket after the avionics and telemetry performed their jobs.

This was going to be quite a show!! The paperwork was submitted and things seemed to be on track.



Proposed flight path of Viper 5 - ~ 40miles

Then suddenly and sadly, as the excitement built, fate intervened. The “ARQUE” project was transferred from NASA Ames to Dryden Flight Research Center in southern California. No one seemed to know exactly why this occurred but Project ARQUE, at least the Black Rock / AEROPAC version, died.

According to Karl, one of the Vipers did fly at White Sands, New Mexico but the other one is lost to history, at least ours. Karl thinks it is probably still somewhere at Dryden. The Viper series of sounding rockets were known mostly as the booster for the “boosted dart” program. <http://www.astronautix.com/lvs/viper.htm>

Shortly thereafter, Tom Rouse and Bob Twiggs brainstormed the ARLISS concept. Discussions regarding possible airframes landed on the Optimal 150. It was the perfect rocket to fly a payload of 3 cansats and would require minimal reconfiguration to become the workhorse of the ARLISS program.

The ARLISS airframe has evolved over time but the “bolt on” fins which are attached with screws through the airframe and into an aluminum cage inside the fin can, remain a feature of most airframes flying today. Tom Rouse had the fins, fin can “cage” and a shorter cage version acting as an Av Bay coupler manufactured for several years. The cages, instead of being machined from a solid billet of aluminum, were made from aluminum agricultural pipe.

As a reward for participating in the Arque project, team members were given the Pluto rockets. In fact, William Walby did his Level 3 Certification with a Pluto flying on an M850 hybrid.

So next time you are pounding on or replacing a mangled ARLISS fin, you will understand and hopefully appreciate, the historical significance of this time honored tradition.



AEROPAC's New Wireless Launch Control System

GENE ENGELGAU

So the much-vaunted (or not!) AEROPAC launch system has been around for as long as I have been coming out, which is 2008. That not really that long ago, compared to many AEROPAC members. But what is more interesting is that I don't recall talking to anyone who knows what came before this system. It may even pre-date Richard Hagen (at least some parts probably do). I'm going to guess it was 15 years old anyway, maybe older. So with the passing of the revered Richard Hagen, and knowing that Richard and his company were the driving force behind keeping this running it seemed like a good idea to possibly get a new launch system!

I began to gather input at the 2015 XPRS launch to see if folks had any ideas. Mike Riss, who is one of the ROC regulars at our XPRS launch, said their club had recently purchased a system from Wilson F/X and so far they really like it. So that seemed like a good place to start.

Mike sent me the specs of their new system, and introduced me to the guys behind Wilson and I was off. F/X is run by Pastor Brad Wilson, and Dan Fox. So yes, Brad Wilson goes by the handle Rocketrev, and he is a church pastor, and flies rockets! They were both amazing and helpful getting through the whole process. They also accommodated some customizations that I asked for later in the process. They have been making this system for some time and have around 20 or so clubs using it. What is even cooler is it can be set up to be completely wireless so no more cables to lay out and have to fiddle with to get them going.

Our new system is very close to the ROC system in capabilities, but not as many total pads. Here are some specs for the new system:

- Eight banks of pads, and each bank had 8 has outputs (64 total)
- Completely wireless
- Range up to 1 mile, so we can use it on the way-away pads
- All wireless data is encrypted so there is no chance that a similar system can launch our rockets.
- Bank selections are designed so only one can be active at a time. No chance to arm one bank, but inadvertently arm another bank as well.
- The pad boxes have local continuity check, a very LOUD alert and a light to indicate when each is armed, with a bright light.
- Each pad box also has a button that when pressed will read out the battery voltage as a series of beeps.

The new launch controller is even more amazing:



AEROPAC's New Wireless Launch Control System

GENE ENGELGAU

- Once a bank is armed, and a pad selected, a pad status LED indicates continuity at the pad (green), or no continuity (red). No more guessing!
- We can directly read the local battery voltage at the controller, and the remote voltage of the bank selected! No more guessing if the batteries are low. And no more trips out to the pads to check the voltage.
- And it's all integrated into a NEMA watertight pelican case.

Finally, the system is low power. The standby current of this system is very low so we should be able to get through an entire launch on a single charge (at least for the bank boxes).

Photos:



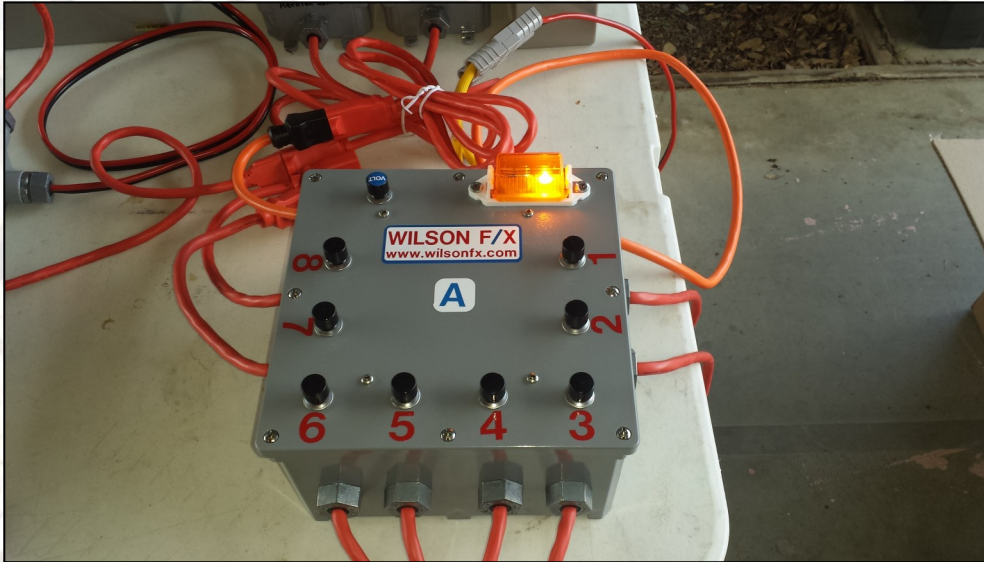
The new Launch Controller. It's about 15" W x 12" D. Compact, easy to use, and waterproof with the lid closed.

Watch Gene setup the Launch Controller and 1 bank of pads in < 2 minutes:

https://www.dropbox.com/s/4yud42thsdf1405/20160416_103734.mp4?dl=0

AEROPAC's New Wireless Launch Control System

GENE ENGELGAU



One of the five pad boxes. This box controlled eight pads. We have three of these for the Low power, and both rows of high power pads. We also have two quad boxes (each controls four pads) for the away cell, and the way-away cell.



A wireless transmitter node. These are 900Mhz transmitters and have a higher power output. Wilson F/X tested configuration to over 1 mile distance at Black Rock.



Gene tried the system out at the April Snow Ranch launch. It worked great! Here is the away-pad setup. We launched the whole day using the new equipment.



ARLISS Data Logger Project (Part 2)

Bob Feretich

Originally published in Sport Rocketry magazine November / December 2015

In the first part of this article (Dec. 2013), I described the need to measure the forces to which rocket payloads are subjected. It also described the measurements made by the AL-016 Data Logger and how the recorded data can help identify events occurring during a flight. This article discusses the more advanced data analysis that is performed to measure rocket flight effects on payloads. (The flight data referenced in this article is from the September 2014 ARLISS Event (www.ARLISS.org). It can be found at www.rafresearch.com/arlissdatalogger/flightdata/ARLISS2014/index.xml .

Our initial analysis indicated that student payloads are being subjected to acceleration shocks that are larger than we expected, but surprisingly, the huge acceleration spikes (up to 176 g) did not correlate strongly with payload damage data. This was believed to be because the duration of these shocks, and therefore the energy contained within them, is small. That drove the development of more advanced post-processing analysis of the data collected by the AL-016 Rocket Data Loggers.

The Spacecraft Payload Environment

After the cold war, the DNEPR project was formed to convert the Russian/Ukrainian multiple-warhead R-36M ICBM into a vehicle to lift commercial payloads into orbit. That vehicle is now being used for many of the student CubeSat launches. The DNEPR Space Launch Systems User's Guide specifies the "spacecraft environment" (including vibration and shock loads) that should be expected by payloads launched into space. It specifies the vibration and shock loads in terms of frequency bands.

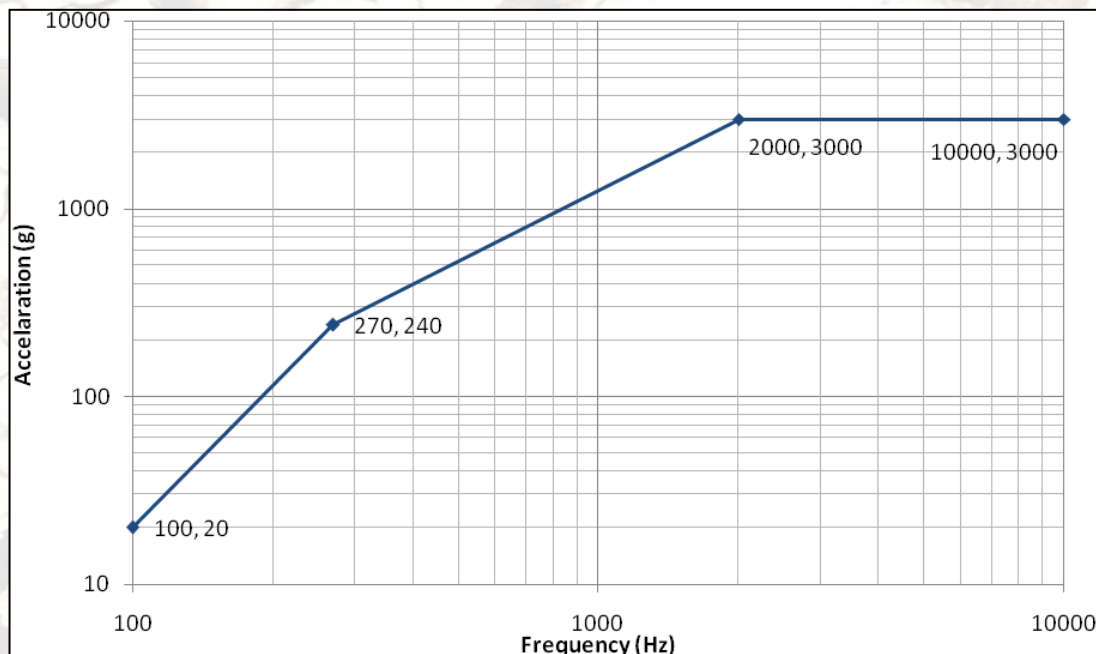


Figure 8. SpaceX Falcon 9 payload shock specification.

The SpaceX Falcon 9 Launch Vehicle User's Guide provides this chart as its payload shock specification



ARLISS Data Logger Project (Part 2)

Since the ARLISS program is a surrogate for exerting the hostile stresses of space flight upon student payloads, it's logical to strive to make our ARLISS launch vehicles match these existing commercial standards as closely as possible. To determine how our ARLISS rockets compare, we needed to analyze the accelerometer measurements in terms of frequency bands.

Acceleration Spectral Density (ASD)

The measured accelerations can be mapped from the time domain into the frequency domain by means of Fourier Transformation. ASD analysis performs a Fast Fourier Transformation (FFT) on two windows of flight accelerometer data, the launch window and a second user selectable time window. The windows can be from 48 milliseconds to 12 seconds wide. The longer duration time windows are used to analyze motor burn and coast periods. The shorter windows can be used to zoom in on specific fast occurring events. Figure 8 shows the recorded acceleration of a typical M1419W motor in an ARLISS rocket. Figure 9 shows what those forces look like in the frequency domain.

Note that "Mag" in the legends of the charts refers to magnitude, the length of the vector addition of X, Y, and Z. In a chart, if the magnitude line overlays any of the X, Y, or Z lines, visual priority is given to the X, Y, or Z line.

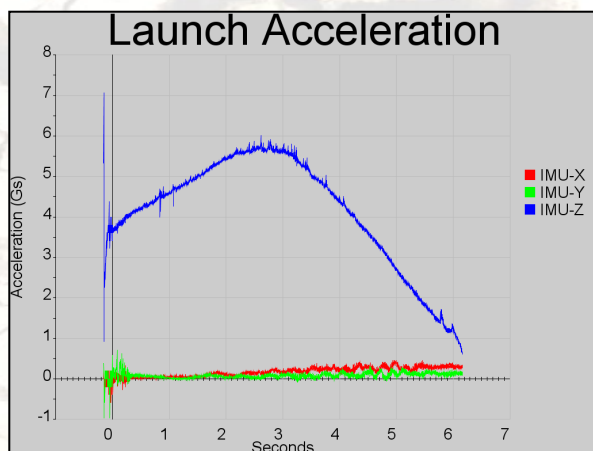


Figure 9

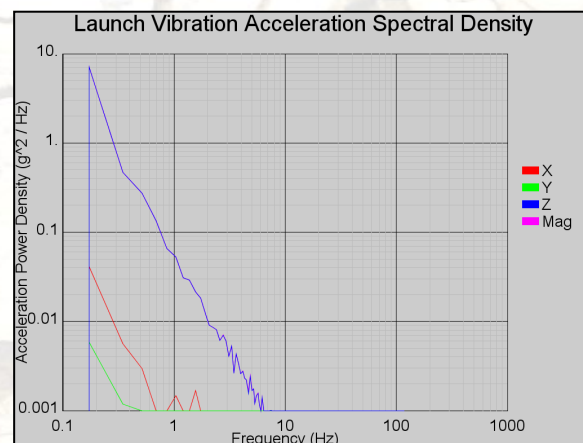


Figure 10

ARLISS Data Logger Project (Part 2)

The root mean square acceleration (Grms) is the square root of the area under the ASD curve in the frequency domain. The area under this ASD chart is 13.2g (the square root of the 173.1g² value displayed on the web page near the chart). ARLISS motor burn acceleration exceeds the DNEPR standard acceleration the 30-50 Hz band by 32%.

There is a sustained energy release during the entire 6.1 second analysis window. This makes the launch window a good candidate for this type of analysis. The coast window is also a good candidate for ASD analysis, but forces exerted by ARLISS rockets during this window were very small and uninteresting.

Unfortunately, the energy released during deployment window is not sustained, but rather released in very short bursts. The theory behind Fourier Transformations is based upon waveforms that extend to infinity in both positive and negative time dimensions. For the FFT based analysis to be accurate, the analysis period needs to be contained (or nearly contained) within the energy release. The energy bursts of the deployment window are too short to gather a sufficient number of data samples. Accelerometer sampling rates need to significantly improve before Fourier Transformation based analysis should be used to analyze deployment and pyro-shock events.

ASD is primarily used for vibration analysis, not short interval shocks. Several resources are available to help understand vibration and vibration measurements. I recommend [Harris' Shock and Vibration Handbook](#), by Cyril Harris.

Shock Response Spectrum (SRS)

The preferred method of measuring shocks (short duration impulse or vibration events) is to use a Shock Response Spectrum (SRS). The calculation of a SRS requires that the recorded accelerations be “played back” into an array of single degree-of-freedom (SDOF) systems.

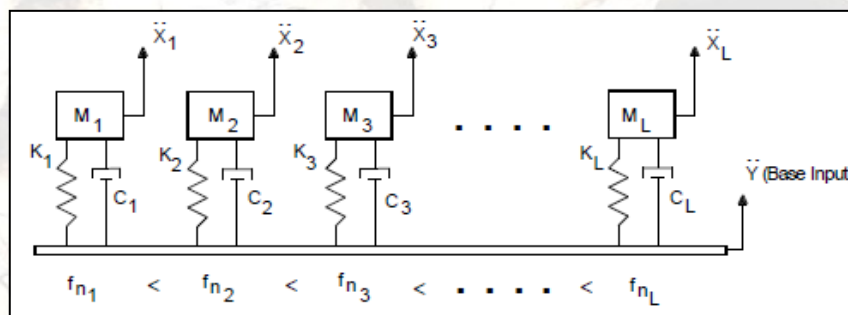


Figure 12. SRS array of SDOF systems, each with a unique Natural Frequency



ARLISS Data Logger Project (Part 2)

All of the SDOFs in the array have the same 5% damping factor, but widely distributed natural frequencies. (To produce results that can be read well on a logarithmic plot, we modeled six SDOFs per octave throughout the frequency range to be analyzed.) During the “play back” of the sample data, the peak response of each SDOF is captured and plotted.

The below SRS chart is from a CO₂ deployed payload that measured only 28.4g of peak acceleration. This was one of the softest deployments of the ARLISS launch event.

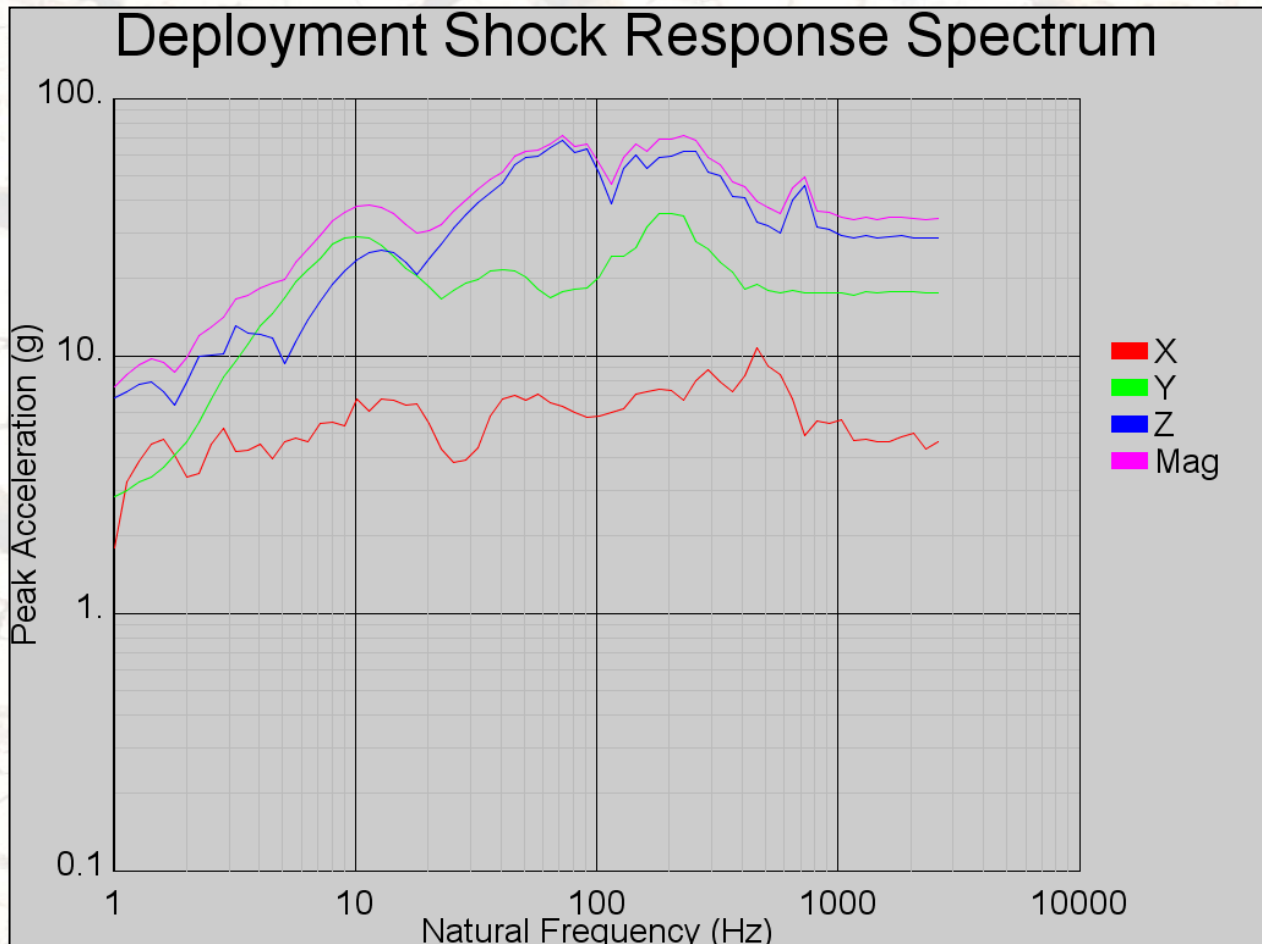


Figure 13. Deployment window events of a 28.4g flight (no payload damage)



ARLISS Data Logger Project (Part 2)

This SRS chart is easily compared to the Spacecraft Payload Environment specifications. At frequencies less than 100 Hz, acceleration shock should be limited to 20-25g. Even this CO2 deployment, one of the softest recorded deployments, exceeded the lower than 100Hz band shock limit by 300%. The magnitude of the deployment shock of this flight reached 70g at 70Hz. SRS is called a maxi-max analysis. It computes the “worst case” scenario as it assumes that worst case acceleration on each axis occurred at the same instant in time. But, even the Z-axis only SRS reaches near 70g.

Let’s compare the above flight to a flight of that same rocket made later in the week during light winds. Since the payload’s objective was to land then drive its way back to a designated GPS point, we decided to deploy the payload upwind. That way the wind would blow the payload’s parachute toward the GPS target rather than away. To achieve this we angled the launch rail about 3 degrees into the wind.

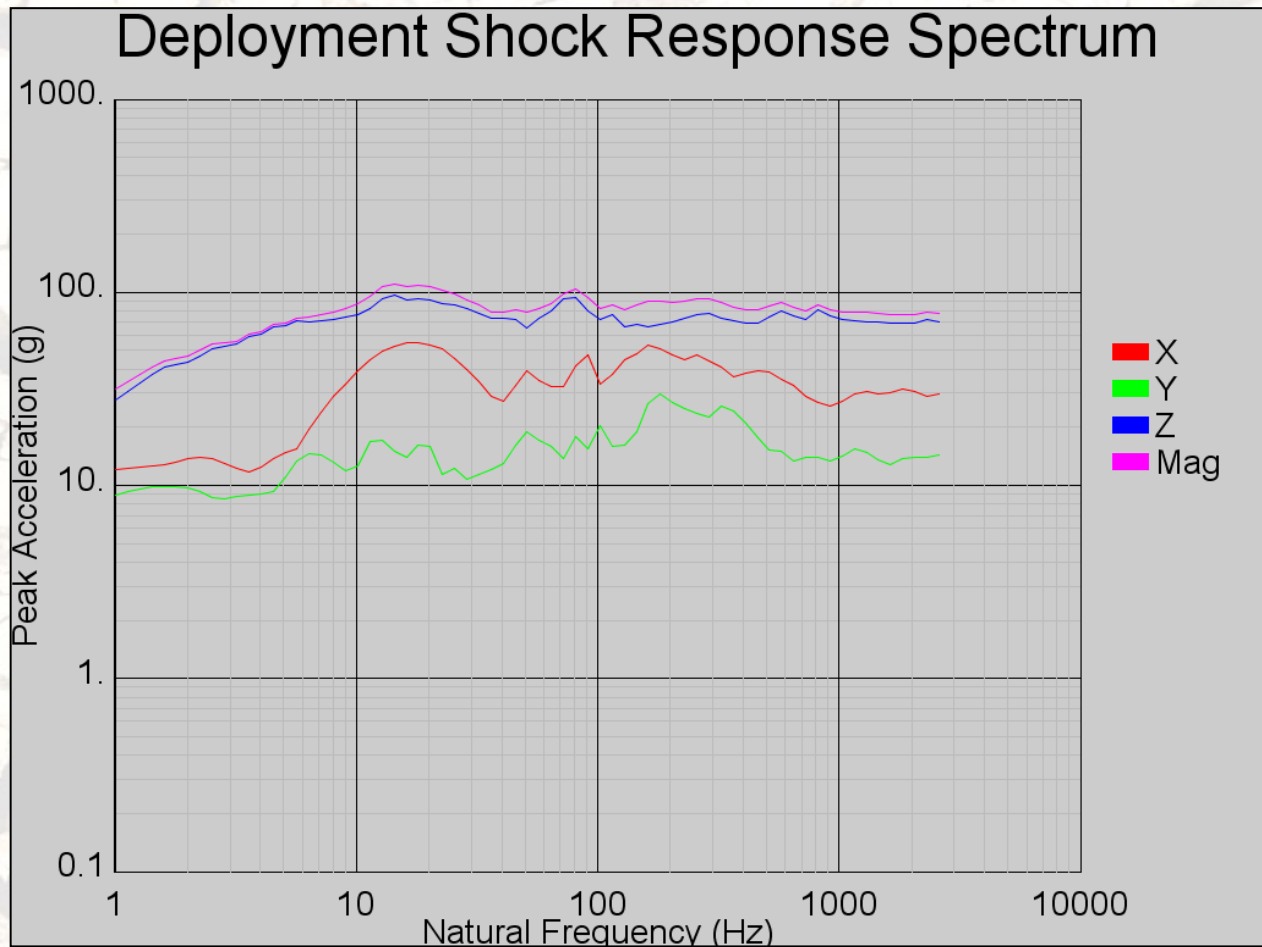


Figure 14. SRS chart of the “Into the wind” flight.



ARLISS Data Logger Project (Part 2)

The angled launch combined with the natural weather-cocking of the over-stable rocket resulted in a deployment that occurred several hundred yards upwind. The wind blew the payload back toward the target point as planned, but deployment shock broke parachute shroud lines resulting in a hard landing. The damaging shock was not caused by the deployment pyro event, but rather the inflation shock of the parachutes.

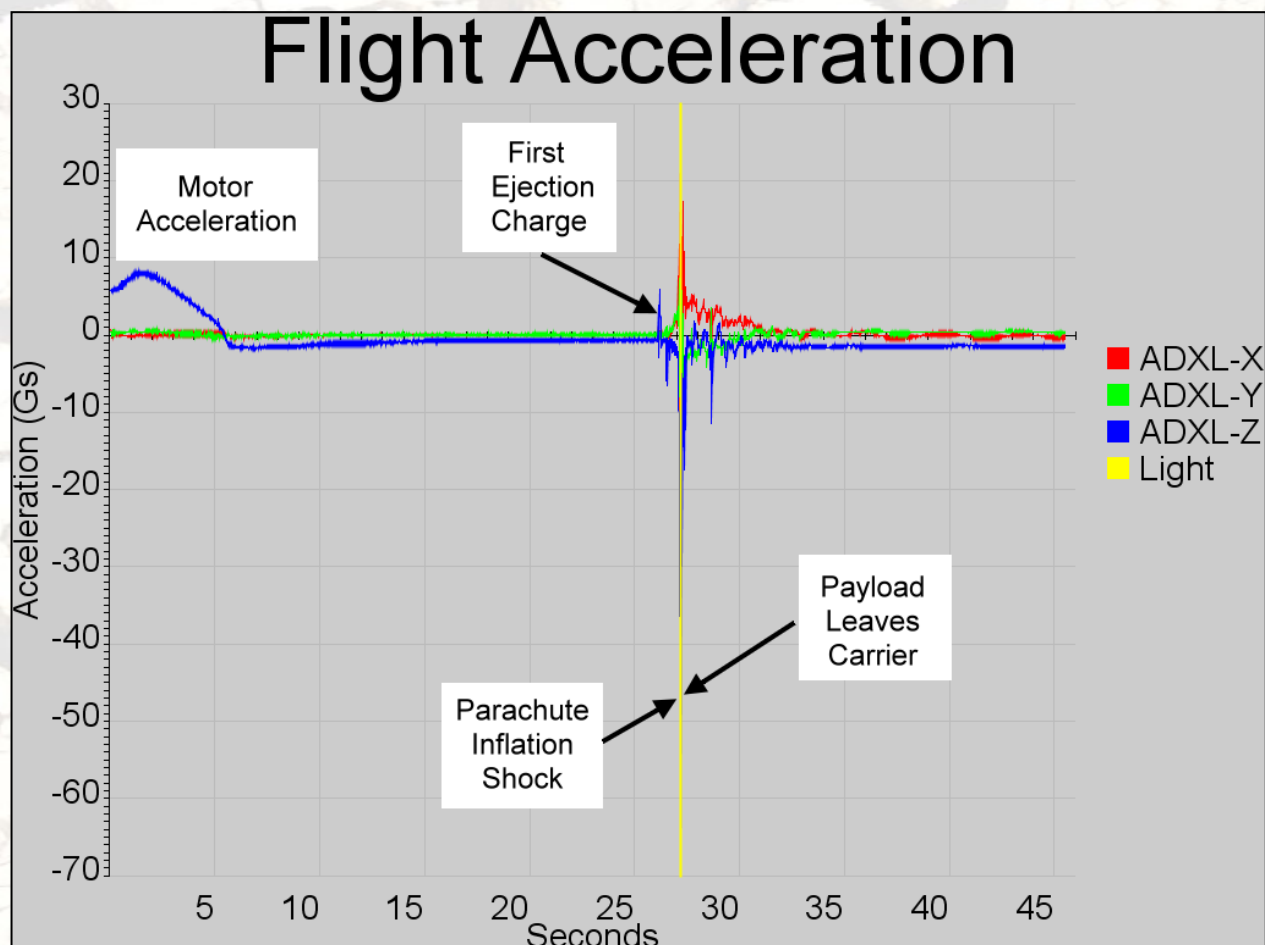


Figure 15. Time domain measured acceleration of the “Into the wind” flight.

The “first ejection charge” separated the rocket and deployed the main parachute at apogee. However, apogee just means that the vertical velocity has zeroed, because of the angled launch and weather-cocking, the rocket still had a substantial horizontal velocity. The rocket’s main parachute inflated suddenly causing a -65g shock. This shock was strong enough to prematurely



ARLISS Data Logger Project (Part 2)

deploy the payload. (The “Light sensor” detected payload deployment at the instant of main parachute inflation). If the payload was ejected with roughly the same horizontal velocity as the rocket, then it also would have experienced the same parachute inflation shock as the rocket. It is not surprising that some of its parachute shroud lines broke.

Examining the SRS (Figure 14) of this flight more closely, we can see that not only that the peak acceleration values exceeded 100g, but that also the frequency of the peak moved down to 11Hz. This exceeded the DNEPR standard by a factor of 1000%.

Again I recommend the above referenced Harris book for more information regarding the SRS and shock measurement, especially Chapter 26, Part II which deals with pyroshocks.

One important characteristic of pyroshock is the knee in the SRS curve. If the acceleration sensors are very close to the pyrotechnic charge, they will make a “near field” recording. Further away, they will make a “far field” recording. The characteristics of a “near field” recording are data series that generally increase left to right across and off the chart. A “far field” recording contains a knee where acceleration starts to reduce with higher frequencies. A pyro-charge produces energy across a very large frequency range. However, energy at the higher frequencies drops off very quickly with distance. If the SRS chart does not show this a knee, then the frequency response of the acceleration sensor is not adequate for measuring the recorded shock. Since all SRS charts from the ARLISS event showed a knee in the SRS plot occurring below 100 Hz (less than $1/10^{\text{th}}$ the sampling frequency of the AL-016’s accelerometer), the frequency response of the Logger’s accelerometer has proved more than capable of handling the shock events of high power rocketry.

Conclusions

Both the ARLISS motor burn (M1419W) and payload deployment create shocks in excess of the commercial payload standards. ARLISS motor burn acceleration exceeds the DNEPR guideline acceleration the 30-50 Hz band by 32%. However, modern commercial payload rockets use nozzle thrust vectoring rather than fins to stabilize the flight of a rocket. Since high power rockets use fins, it is important that our rockets reach an aerodynamically stable speed before they leave the launch rail. Reducing motor thrust could bring us into alignment with the DNEPR standard, but at the cost of longer launch rails and perhaps a smaller margin of safety.

Payload deployment, by far, is the worse of the two problems. Deployment shocks exceeded the DNEPR guidelines by 300% for softer deployments and 1000% for the rougher deployments. CO₂ deployments typically resulted in lower peak shocks than black powder deployments, but the magnitudes



ARLISS Data Logger Project (Part 2)

of pyro shock in general did not seem to be strongly correlated to reported payload damage. All of the reported payload damage involved damage to the payload mechanical structure. Pyro-shock, because of its high-frequency content rarely mechanically damages payload structures. Pyro-shock is known to cause intermittent (contact bounce) and permanent (solder ball fracture) failures in electrical components. I believe that some of the strong pyro-shocks may have caused payloads to malfunction, but because of the unknown cause of the malfunction and because some payloads were overly fragile, the payload teams did not want to cast blame on the rocket's deployment system.

Damage Reports: (# of flights)

- 12 Payload disposition reported "No damage".
- 32 Unknown. (No payload disposition filed.)
- 1 Damage believed to be caused by payload being dragged across ground by parachute.
- 1 Damage believed to be caused by payload deploying while the rocket has significant horizontal velocity.
- 1 Payload got tangled with rocket's parachute. Both came down hard. Severe damage.
- 1 Payload's wire hub broke on landing. (No further info available)
- 1 The carrier deployed, but the payload got stuck in payload carrier. (Too tight of a fit.)
- 1 Rocket deployed neither parachutes nor payload. Rocket, payload, and Logger destroyed.

At launch, a section of the flight card was to be given to the payload team, filled out after they recovered their payload, and returned to an ARLISS coordinator. This failed to occur on over 60% of the flights. We know nothing about the payload damage that may have occurred during these flights.

Most importantly, the AL-016 Data Logger has provided a measurement capability that creates a basis for better understanding what is occurring during rocket flights. The data enables rocket builders to observe the stresses generated by their flights, formulate experiments, and ultimately to improve our ability to provide a more consistent and less stressful flight for payloads. Payload designers can see the stresses that their projects need to be designed to withstand. As new theories and analysis methods are developed, the published flight information provides a historical database for back-testing and data-mining.

More information on the AL-016 Rocket Data Logger is available at <http://www.rafresearch.com/rocketdatalogger/> .



AEROPAC 2016 Equipment Cleaning Party

On April 16, Lynn Cominsky and Garret Jernigan again hosted the annual AEROPAC equipment cleaning party. In addition to cleaning and inspecting the equipment, this year we eliminated a lot of gear made obsolete by the new Wilson FX wireless launch system. As part of that effort, the old LCO table was gutted by getting rid of what we won't need with the new system. It is now considerably lighter and easier to maneuver in and out of the trailer. We were able also to eliminate at least several hundred pounds of spooled wire and ancillary hardware. In addition to new launch system, it is rumored that a new PA system is in the works.

Setting up the launch range will now be considerably faster and more nimble. In fact, Gene Engelgau demonstrated the ease of setting up wireless system for 1 of the 3 pads we will have in operation. It took a little over 2 minutes to get to launch status.

Unfortunately, the grunt work of setting up the rails and pads will continue.

Several folks worked on the more mundane task of giving the launch rails and rods their yearly acid bath, rinse and lube jobs.

We ended the day with pizza, Lynn's brownies and Sonoma County strawberries.

Attendees: Eric Kleinschmidt, Dick Jackson, Ken Adams, Sam Sampayan, James Sampayan, Tom Fetter, Bill Kellerman, Peter Clay, Evan Curtis, Juniper Slouber, Daryl Paris, Michael Paris, Alan Skinner, Gene Engelgau, Jonathan DuBose





AEROPAC 2016 Cleaning Party



Tom Fetter and Sam Sampayan



Alan Skinner



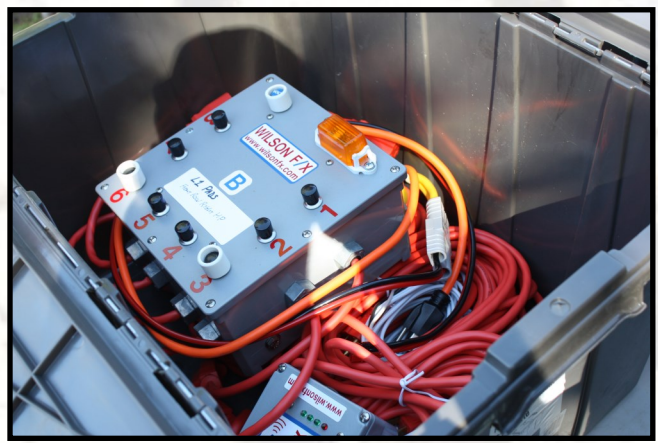
Michael and Darryl Paris with James Sampayan



Dick Jackson, Eric Kleinschmidt, Ken Adams



Stuff we won't need now



Part of the Wilson FX launch system



Fruity Chutes

Custom Parachutes

Aerospace Recovery Solutions

Chutes for low power - mid power - high power - uav





Fruity Chutes feature:

- Lightweight 1.1oz Mil-spec Ripstop
- Sizes from 12" up to 16'
- Low, Mid and Hi Power Designs
- Heavy duty bridle and swivel
- Your choice of colors and pattern
- All seams are double stitched
- Hi Power feature 550lb shroud lines
- Iris Ultra with a Cd of 2.2
- Choose the options you want

Fluorescent Colors

Lemon	Tangerine	Lime	Purple

Standard Colors

Coconut	Blackberry	Cherry	Blueberry

extreme rocketry

Reviewed Nov, 2008 Issue!

www.fruitychutes.com - fruitysales@fruitychutes.com

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"As a former member of the US Parachute Team, and as a FAA Licensed Senior Parachute Rigger, I am exceptionally picky about parachutes. The Fruity Chutes are not only made to manned parachute quality, but offer amazing efficiency - which is why they're the only parachutes in my rockets!"

February 9, 2015 - James Flenner, FAA licensed Senior Parachute Rigger, former member US Parachute Team, TRA L3



SUPPORT OUR COUNTRY
OVER 95% US MATERIALS
100% US LABOR



Tripoli's > 50k' Process for Black Rock

Jonathan DuBose

In order to fly a project to greater than 50,000 feet at Black Rock, the flyer must submit his project for analysis and approval by the Tripoli Class 3 Review Committee (C3RC). This process was put into place in order to insure that flights stay within the FAA waiver cylinder. The regular max altitude is 150,000 feet with a 10-mile radius from the center point of B. We also have a call-in waiver on Saturday at 9 to 11 for 200,000 with a 17-mile radius from the center point of B.

I had a number of questions about this process and after talking with a few people, mainly Curt Von Delius, in January I made my application to the TRA C3RC to fly my two rocket "Full Bore Linear Panic" greater than 50,000 feet this year.

In order to de-mystify this process I am presenting my application and the feedback from the TRA C3RC analyst, Dr. Ken Overton. Perhaps this will be of value to those flyers are interested in flying above 50k'.

Tripoli Rocketry Association Class 3 Project Submittal

(Applies to any single stage or multistage project with combined 40,960 ns or more propulsion)

Launch Event: AEROPAC MUDROCK or XPRS (dependent on weather / wind conditions)

Launch Site: Black Rock, Nevada Lat/Long: 40° 50.980'N 119° 7.449'W

Launch Date(s): MUDROCK June17 -19, 2016, XPRS Sept. 16-18, 2016

COMPLETED FORM MUST BE SUBMITTED TO [KENT.NEWMAN@COMCAST.NET](mailto:kent.newman@comcast.net) NO LATER THAN 90 DAYS BEFORE THE LAUNCH DATE

Flier Data:

Names, addresses and email (list primary contact first)	TRA No.	Cert Lvl
Jonathan DuBose	11505	3
XXXXXXXXXX		
Sacramento, CA 95835		

Rocket Geometry:

Rocket Name	Full Bore Linear Panic (Two Stage)	Length	168.25"	Diameter	3" 4"
Weight (dry/wet)	Sustainer: 7.81 lbs / 23.26 lbs Booster: 11.02 lbs / 39.19 lbs Total: 18.835 lbs / 62.45 lbs	Fin location (from tip of nose)	Sustainer = 44.5" Booster = 57.5"	Fin angle (if any)	N/A

Briefly describe project (using component detail - airframe, fins, nose, payload, etc.) regarding specific materials, method of construction, fin attachment method, etc. Gen-



Tripoli's > 50k' Process for Black Rock

erally the more complex the project, the more detail is required. Photos and/or drawings are expected. Use additional paper as required:

This project is a two stage scratch built minimum diameter project with a 4" booster staging to a minimum diameter 3" sustainer. An Aerotech N1000W will power the booster and an Aerotech M685W will power the sustainer. Rocksim simulations indicate that the sustainer will reach apogee in excess of 80k and reach mach 2.1. The project will be launched from AEROPAC's "Uber" launch pad which utilizes a 30' rail.

Both airframes are filament wound "G12 fiberglass rocket tubing... manufactured from premium fiberglass roving and epoxy" from Rocketry Warehouse. All couplers are made with the same material and process.

The booster airframe is fitted with a RouseTech aluminum fin can in a 3 fin configuration. These fins are anodized .090" thick aluminum and are attached to aluminum rings epoxied to the airframe with Proline System 4500 high temperature epoxy. Stainless steel button head screws attach the fins to the aluminum rings. The fins have a 16" root chord. The booster is fitted with qty 2 15/15 rail buttons.

The booster electronics will deploy a drogue parachute at apogee with a backup charge at apogee plus 5 seconds. The main parachute will be deployed at 1200' with a backup charge firing at 1100'. An on board 70cm Ham based tracking system allows both telemetry and tracking of the booster. Both the drogue and main parachute are deployed from the booster body tube. The drogue is connected with a 15' Kevlar tether and the main with a 20' Kevlar tether. A "Y" harness connects both tethers and is arranged to allow the drogue to deploy while the main chute remains seated. A cap secured by 4 2/56 nylons screws will retain the main chute in the airframe until the deployment charges are fired. Sealed redundant deployment charges of 1.5 grams of black powder will deploy the drogue chute and charges of 2 grams will deploy the main.

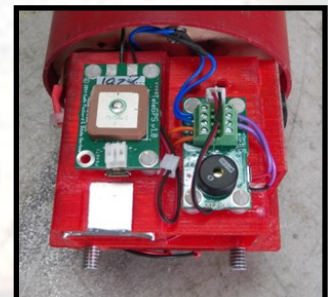
The booster motor is retained with a 1/2" Baltic birch and G10 fiberglass bulkhead secured to the airframe with 4 6/32 stainless steel screws. A 3/8" bolt threads through this retainer and into the threaded forward closure on the 98 / 15360 Aerotech motor.



**FBLP Booster with 3 fin
Rousetech fin can**



**FBLP Booster showing main &
drogue with "y" harness**



**FBLP Booster electronics – Altus
Metrum Easymini, TeleGPS**



Tripoli's > 50k' Process for Black Rock

The booster was flown as part of a full stack test flight at AEROPAC's XPRS in September, 2015. Early main deployment was observed resulting in the addition of a cap to retain the main parachute until designated deployment altitude.

The booster and sustainer are mated utilizing an inter stage coupler (ISC) made of T6061 aluminum and custom machined to accept the 75mm sustainer motor which extends below the sustainer airframe by 4.385". The ISC is secured to the airframe with qty 8 4/40 stainless steel screws. The Roussetech 75/7680 sustainer motor is fitted with a "min diameter/ slimline" rear closure allowing it to slide smoothly into and out of the ISC. The ISC "well", which accepts the motor from above, has been machined to extremely close tolerances that allow the sustainer 75mm motor to slide in and out smoothly while maintaining close tolerances eliminating "wobble".

The booster and sustainer will drag separate. This was successfully tested in the September, 2015 test flight.

Qty 3 of 2/56 nylon screws secure the ISC airframe section to the booster airframe preventing separation until parachute deployment charges are fired.

Provided the boost is acceptably vertical as determined by the sustainer electronics, the sustainer motor will be initiated at booster motor burnout plus 4 seconds. This delay may be lengthened if it is ascertained that very calm winds aloft are in effect the morning of the launch between 15k' and 22k, the altitude where staging will occur.

The 2015 test flight demonstrated a near perfect vertical boost from the AEROPAC Uber Rail.

Sustainer motor ignition will be accomplished utilizing a proven "headend" ignition system. This system consists of a small hole drilled through a standard Aerotech compatible forward closure. This opening is enlarged on the bottom end of the closure to .25". An MJG J-Tek electric match is fed through the opening and fed through a customized forward seal disk with an opening positioned above the offset core of the motor. The opening on the bottom of the forward closure is then potted with a high temperature ceramic mixture (Cermacast 575N) which hardens and is proven to prevent hot motor gases from burning through the forward closure. The electric match head is fitted with a pyrogen device that when ignited will initiate the sustainer motor. This system was successfully tested at XPRS, 2015.

The plastic nozzle cover will be retained on the motor nozzle acting as a burst disc.

The sustainer nose cone is a Von Karman 5:1 Filament wound fiberglass with a screw on aluminum tip. The nose cone is secured to the airframe with 2 2/56 nylon screws. A 70cm Big Red Bee GPS tracking system is contained within the nose and mounted on a custom assembly (see photo). Sealed charges of 1.0g with a



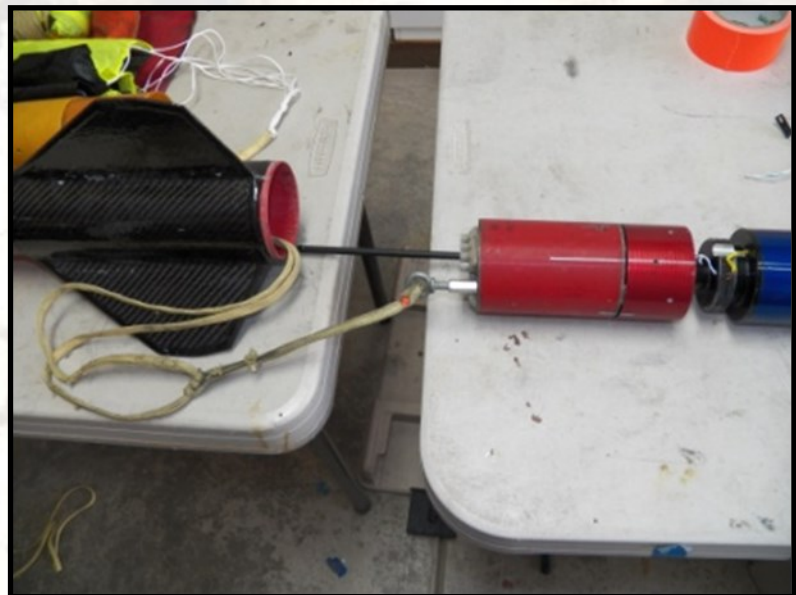
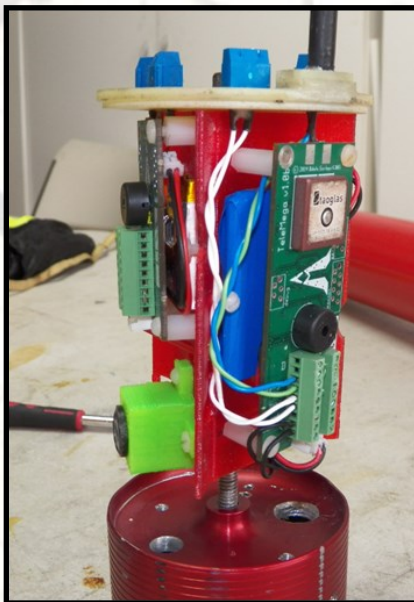
Tripoli's > 50k' Process for Black Rock

a backup of 1.5 grams will separate the nose cone at apogee plus 10 seconds with a backup at apogee plus 15 seconds respectively. This apogee delay is per the flight computer manufacturer based on a 100k' maximum on the barometric altimeter. This method has been successfully flown in 100k' plus flights.

The sustainer 3 fin set is "tacked" to the airframe and "filleted" with Proline System 4500 high temperature epoxy. A two layer tip to tip lamination using 5.7 oz., 0.012" thick, 3K, 2x2 twill weave carbon fiber fabric insures that the fins will remain attached throughout the flight. This layup utilizes West System105 resin and 206slow hardener epoxy. The leading edges of the fins are painted with Proline 4500 epoxy.

Sustainer deployment utilizes the same "Y" harness setup as the booster. The 2015 test flight indicated the need for a cap / piston to secure the main chute until the designated altitude. This device has been added and ground tested.

The sustainer electronics are mounted on a 3D printed "tri-wing" mount which has a center shaft which is designed to accept a 1/4-20 rod which is threaded through this shaft. This assembly is mounted inside a fiberglass coupler. The threaded rod screws into an AEROPACK 75mm minimum diameter motor retainer which has been reinforced with an aluminum sleeve and also acts the motor thrust plate. The 3/8" threaded rod on the top of the Aerotech forward closure screws into the bottom of the retainer. Holes for qty 7 of 6-32 headless screws have been drilled and tapped through this piece and secure it to the airframe.



Left: Sustainer electronics with Altus Metrum EasyMega and Telemega. Right: Electronics bay buttoned up, ready to slide forward into airframe



Tripoli's > 50k' Process for Black Rock

Waiver: AEROPAC's regular max altitude is 150,000 feet with a 10 mile radius from the center point of the launch site. We also have a call-in waiver on Saturday typically between 9 to 11am for 200,000' with a 17 mile radius from the center point of the launch site.

Ideally, this flight will take place under the "call in" waiver which affords a greater recovery area.

Propulsion:

	Qty	Manufacturer (Ex.- Research – J. Smith Commercial – AT, etc.)	Propellant Type (solid, hybrid)	Burn Time	Designation	Propellant Weight	Total Impulse
Booster	1	Aerotech	Solid	13.4s	N1000W	7925g	14583ns
Sustainer	1	Aerotech	Solid	11.5s	M685W	4320g	7561ns
Total	2			24.9s		12245g	22144ns

Motor Description

Design (Bates, C-slot, etc.)	Booster – Bates Sustainer - Moon-burner	No of Grains	6 6	Core Diameter	XXXX
KN Range		Pressure Range		Propel. Length	
Volume Loading		Propellant Mass		Delivered ISP	
Multi-modal		% Solids		% Metals	
Initial Thrust (lbs)	472lbs	Thrust/Wt. Ratio	7.55 / 1		

Payload/Recovery:

Payload Description	No payload
Drogue (Manu/type/size)	Booster - Fruity Chutes cfc-18" Sustainer – Rocketman12" Mach II
Main (Manu/type/size)	Booster – Fruity Chutes IRIS Ultra 60" Sustainer – Fruity Chutes IRIS Ultra 48"
Deployment Method	Booster and sustainer are dual deploy. Each stage drogue and main parachute are deployed from the airframe utilizing a "Y" harness attached to 15' tethers for drogue with 20' tethers for main (Giant Leap .25 Kevlar). The "Y" harness of .25 Kevlar tether material sewn by J. DuBose. Deployment charges for booster and sustainer drogue deployments are sealed charges made from "surgical tubing". Redundant / backup charges for all deployments.



Tripoli's > 50k' Process for Black Rock

<p>Electronics (Brands & Models including tracking devices)</p>	<p>Booster – Altus Metrum Easy Mini, Perfectflite Stratologger CF Altus Metrum TeleGPS 70cm ham GPS system for telemetry / tracking.</p> <p>Sustainer – Altus Metrum Telemega for 2nd stage ignition, deployment charges, telemetry and tracking (70cm ham based GPS system), Altus Metrum Easy Mega for backup deployment charges. Big Red Bee 70cm GPS system for telemetry and tracking system.</p> <p>The Altus Metrum Telemega encompasses functionality that can be configured to prevent 2nd stage ignition should the boost be unacceptably non vertical. See further explanation in “Safety” below.</p> <p>Ground stations receiving telemetry from the GPS tracking systems: Kenwood TH-D72A with a 6 element Arrow antenna for the Big Red Bee.</p> <p>Android and PC (AltosUI) devices with Altus Metrum TeleBT Bluetooth / Teledongle systems with Arrow 6 element YAGI antennae for the Altus Metrum GPS units.</p>
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Launcher/Controller:

Description (Rail, tower, etc.- length; material; ground fixed or balloon, etc./ Wire controller, wireless, etc.):

The project will be launched from AEROPAC's 30ft "Uber" rail. The rail is 30 feet of 15/15 rail, secured to a tower constructed of powder-coated chromoly steel. The base can precisely pitch the tower 5 degrees in any direction, and a lift motor to raise and lower the tower. This launcher is extremely rigid and will provide more than ample guidance for a straight, and if needed, angled and directional boost.

A wireless electronic launch system available at AEROPAC launches will be utilized to initiate the booster.

Safety:

Safety codes/procedures followed:

The launch will be conducted following standard AEROPAC, TRIPOLI and NFPA 1127 Code for High Power Rocketry and Standard Rocketry Good Practices for a high power, complex launch. Additionally, a detailed checklist will be followed to assure that the prepa-



Tripoli's > 50k' Process for Black Rock

ration, arming and launch is safe and orderly

Three team members, all TRA Level 3 certified will be allowed at the launch pad during preparation and arming. The person arming the rocket will be project builder / owner.

Sustainer ignition will be governed by the ALTUS METRUM Telemega flight computer which will inhibit ignition if the flight is unacceptably non-vertical - >20 degrees off vertical.

The "Uber" rail will be precisely adjusted to compensate for winds aloft to assure the flight's touch-down occurs within the waiver, and this should be accounted for in the 6DOF dispersion analysis. The parameters of the "angle from vertical less than (degrees)" in the flight computer configuration will account for any tilt in the launch rail as TeleMega contains a 3-axis gyroscope and accelerometer which is used to measure the current angle. This angle is not the change in angle from the launch pad, but rather absolute relative to gravity; the 3-axis accelerometer is used to compute the angle of the rocket on the launch pad and initialize the system.

The flight will only be launched if the ground winds are calm, typically first thing in the morning at Black Rock, and the winds aloft are acceptable. Winds aloft data for Reno, NV, the closest tracking location, will be assessed early on the morning of the launch to determine if the conditions aloft are acceptable. The following location will be used to obtain this data: <http://www.weather.uwyo.edu/upperair/sounding.html>

More investigation is needed to determine what wind levels are acceptable.

Recognizing that a potentially unsafe condition exists with an ignition system installed in a motor, installing the propellant and completing motor assembly will occur as late in the process as possible. The final step prior to transporting the rocket to the launch pad will be completing the connection between the 2nd stage ignition terminal on the flight computer and the e-match potted in the sustainer motor. This will be the last step before loading the motor to the airframe.

The 3 different 70cm band HAM frequencies in use, 1 in the booster and 2 in the sustainer will be reserved using AEROPAC's signup list well prior to the launch. Additionally, announcements will be made with enough time prior to launch to insure all traffic transmitting on these frequencies are cleared.

Each launch team member will carry standard "family radio" devices that will be used to communicate between the launch team and launch control.



Tripoli's > 50k' Process for Black Rock

Prior to count down, assurances will be made to confirm the waiver is active, a NOTAM has been issued and that no rail traffic is visible.

The standard AEROPAC procedure for a complex, high power launch is that the LCO insures that all in attendance are standing, watching the launch and paying attention. "This is a HEADS UP flight" is announced.

Should a catastrophic event occur, the LCO will initiate the launch system siren. This will continue until it is deemed by the LCO, in communication with the launch team that all elements of the rocket are on the ground.

The launch team will continue to communicate with the LCO for the duration of the flight and communicate any issues discovered through the monitoring of data through the telemetry system for both the booster and sustainer.

Aerodynamic Data (please indicate if Submitter provided or Committee requested to provide):

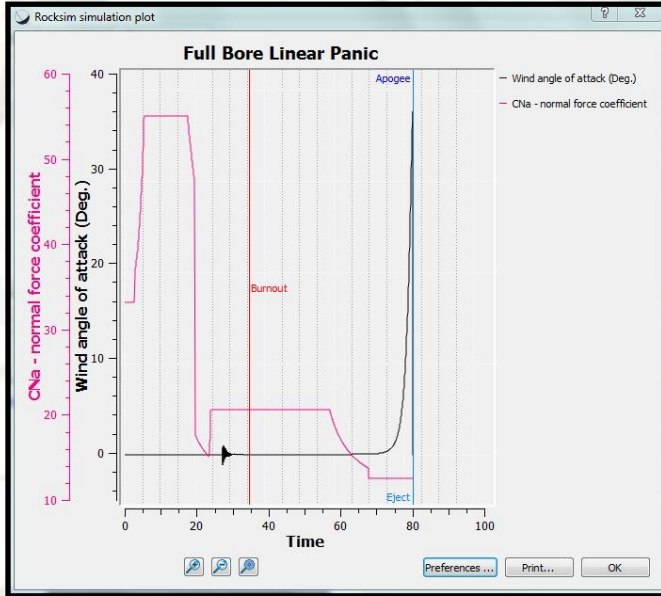
Ca vs Angle of Attack (AOA):	Attached		FAA Class 3 Committee	X
CNa vs AOA	Attached	X	FAA Class 3 Committee	
CP vs AOA	Attached	X	FAA Class 3 Committee	
Mass vs Time until Burnout (BU):	Attached	X	FAA Class 3 Committee	
Cg Location vs Time until BU:	Attached	X	FAA Class 3 Committee	
6 DOF Dispersion Analysis	Attached		FAA Class 3 Committee	X

Supporting Data (to be provided to Committee):

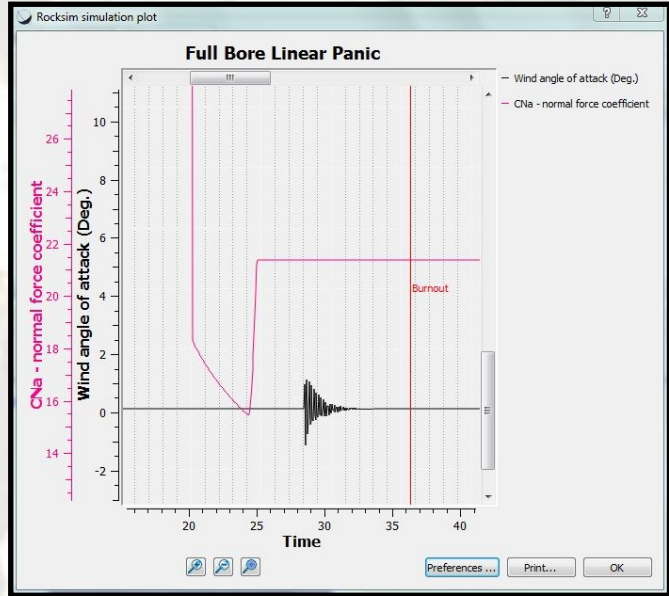
RAS Aero project file (.alx1)			RockSim File (.rkt)	X
Rasp engine file (.eng)	X		RockSim Pro File (.rkt)	



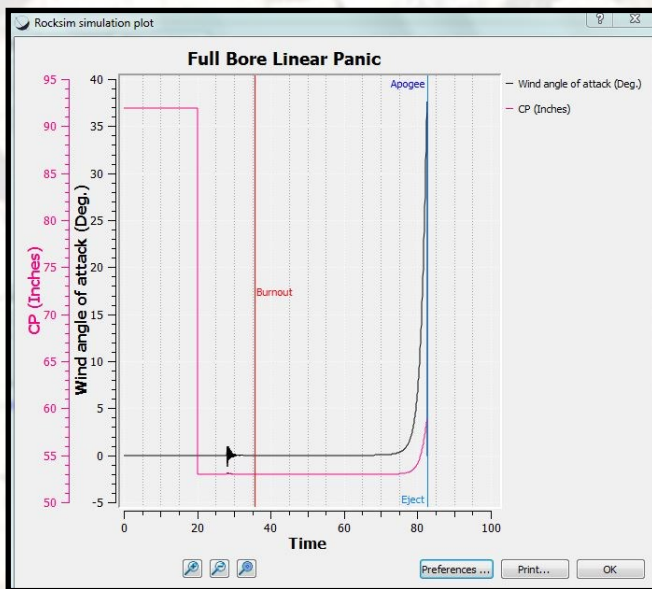
Tripoli's > 50k' Process for Black Rock



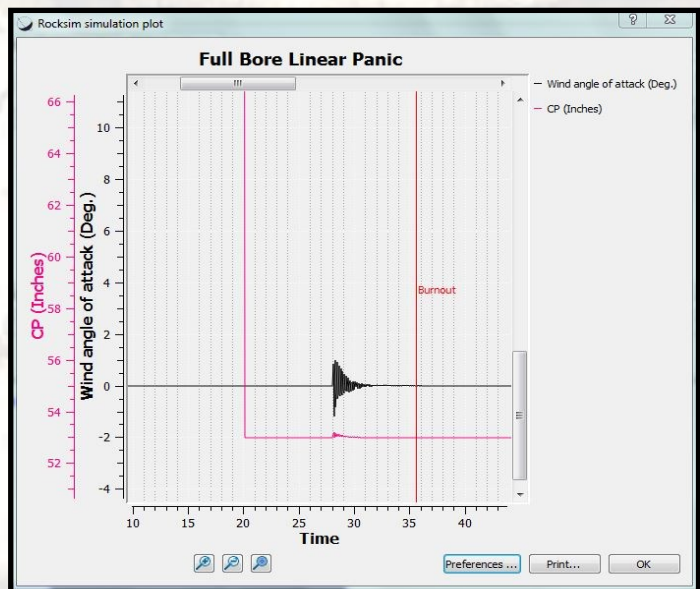
CNa vs AOA Macro



CNa vs AOA Micro



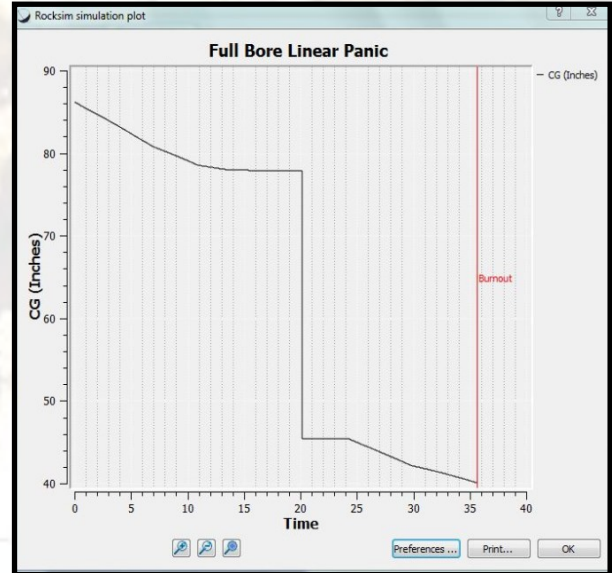
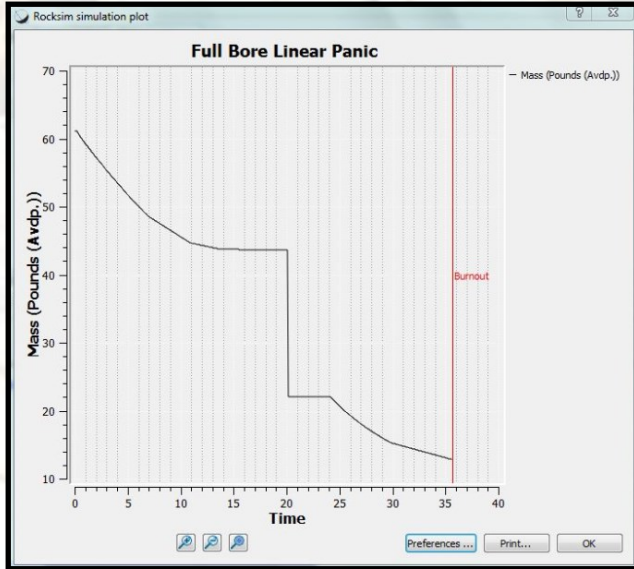
CP vs AOA Macro



CP vs AOA Micro

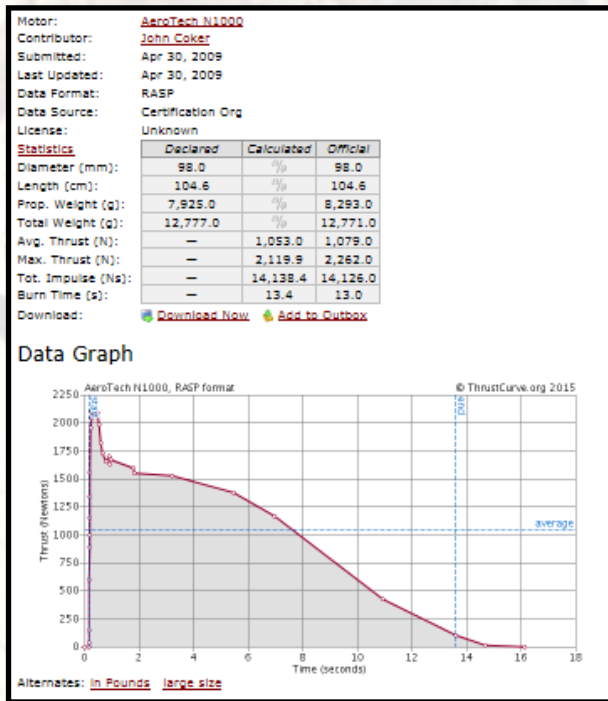


Tripoli's > 50k' Process for Black Rock

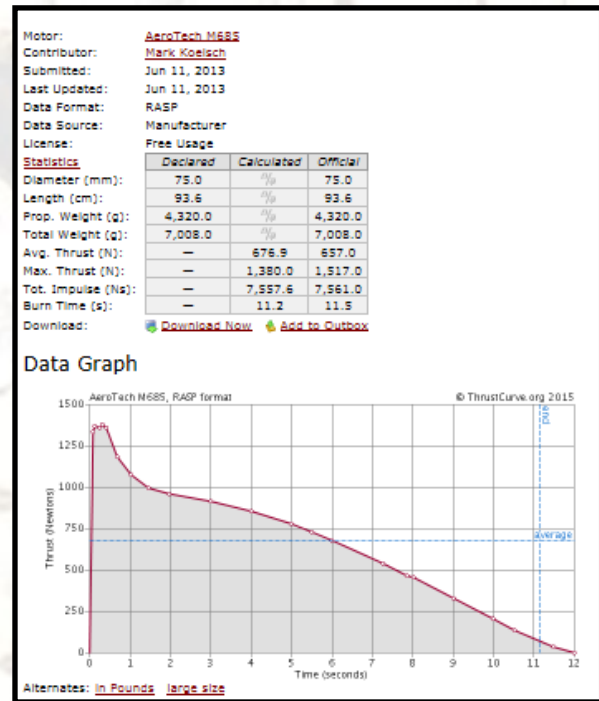


Mass vs Time until Burnout (BU):

Cg Location vs Time until BU:



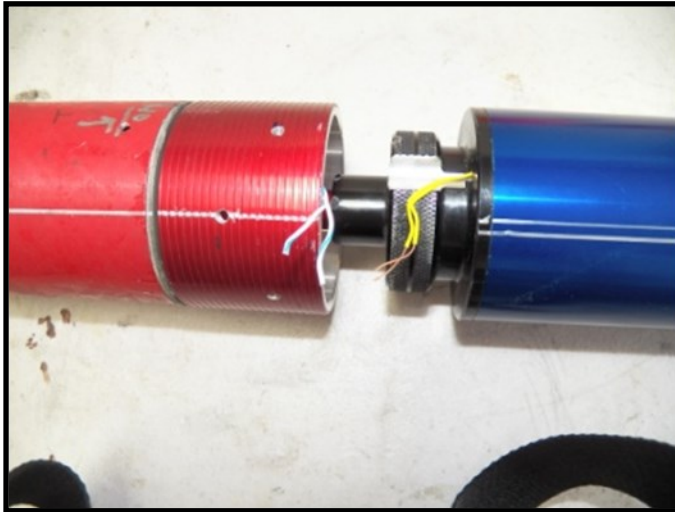
Aerotech N1000W Thrust Curve



Aerotech M685W Thrust Curve



Tripoli's > 50k' Process for Black Rock



FBLP Sustainer showing final connection for head end ignition



FBLP Sustainer showing fin can, nose cone

The following is the feedback and approval notice from the TRA C3RC analyst Dr. Ken Overton:

Jonathan-

The TRA C3RC has completed the review of your submission for Full Bore Linear Panic, attached. I'm expecting a spectacular flight and look forward to hearing how it goes.

After the flight, please drop me a note with the results so we can compare actual performance with the simulations. This is an important element in the Committee's effort to continually improve our process.

Good luck with your flight!

-Ken

Dr. Kenneth J. Overton, C3RC Analyst, TRA 11924 L3 TAP C3RC



Tripoli's > 50k' Process for Black Rock

Class 3 Review Committee

February 1, 2016

To: **Jonathan DuBose**, Flyer, jmdubose2000@yahoo.com,

XXXXXXXXXXXX

Sacramento, CA 95835

re: C3RC Review: 50K' Flight of Full Bore Linear Panic

Jonathan:

Thank you for submitting your proposed flight of your project to be flown during either the AERO-PAC Mudrock or XPRS events at Black Rock , June 17-19 and September 16-18, this year, respectively. As you know, the purpose of the TRA Class 3 Review Committee is to support the Tripoli membership in meeting Class 3 COA requirements of the FAA/AST. In addition, the Tripoli Board of Directors has asked that the C3RC review all flights expected to exceed 50,000' in altitude AGL. Based on your testing, the simulations, and our collective experience, your flight is clearly expected to exceed 50K'. The Committee appreciates your diligence in submitting your project, and we hope this review proves valuable to you and the launch authorities. At the request of the Chairman, I have handled the review of your submission.

Process

I have followed the standard Class 3 review process used by the C3RC in preparing this review. In short, this begins by reviewing your Submission and discussing various aspects of the project with you. I appreciate your responsiveness to questions. Next, we developed the RASAero II model from the supplied RockSim model and verified that the models agree with each other and the Submission. These models are used to develop as comprehensive a set of flight simulations as possible. Note that RASAero II does not have the same modeling capabilities as RockSim Pro. In this case, the RASAero II model does not incorporate the RouseTech fin can nor the detail of the sustainer fin tips.

Flight Simulation

For the flight simulation, I used the Black Rock Site B/B+ launch site data, PM winds aloft data from NOAA, and a vertical launch tower. The RASAero II simulation results are as follows:

Predicted Altitude: 120,655'

Maximum Velocity: 2,796 ft/sec (Mach 2.50)

Maximum Acceleration: 421 ft/sec² (13.1G)



Tripoli's > 50k' Process for Black Rock

Note that due to the inability to model the RouseTech fin can in RASAero II, I believe the drag is understated in the simulations. As such, I expect the altitude, velocity, and acceleration will be less than predicted. I think we should probably expect the project to achieve around 100K'.

Of particular interest is the stability margin during the ascent of the rocket, as shown in Figure 1. From the data

we clearly expect a stable ascent.

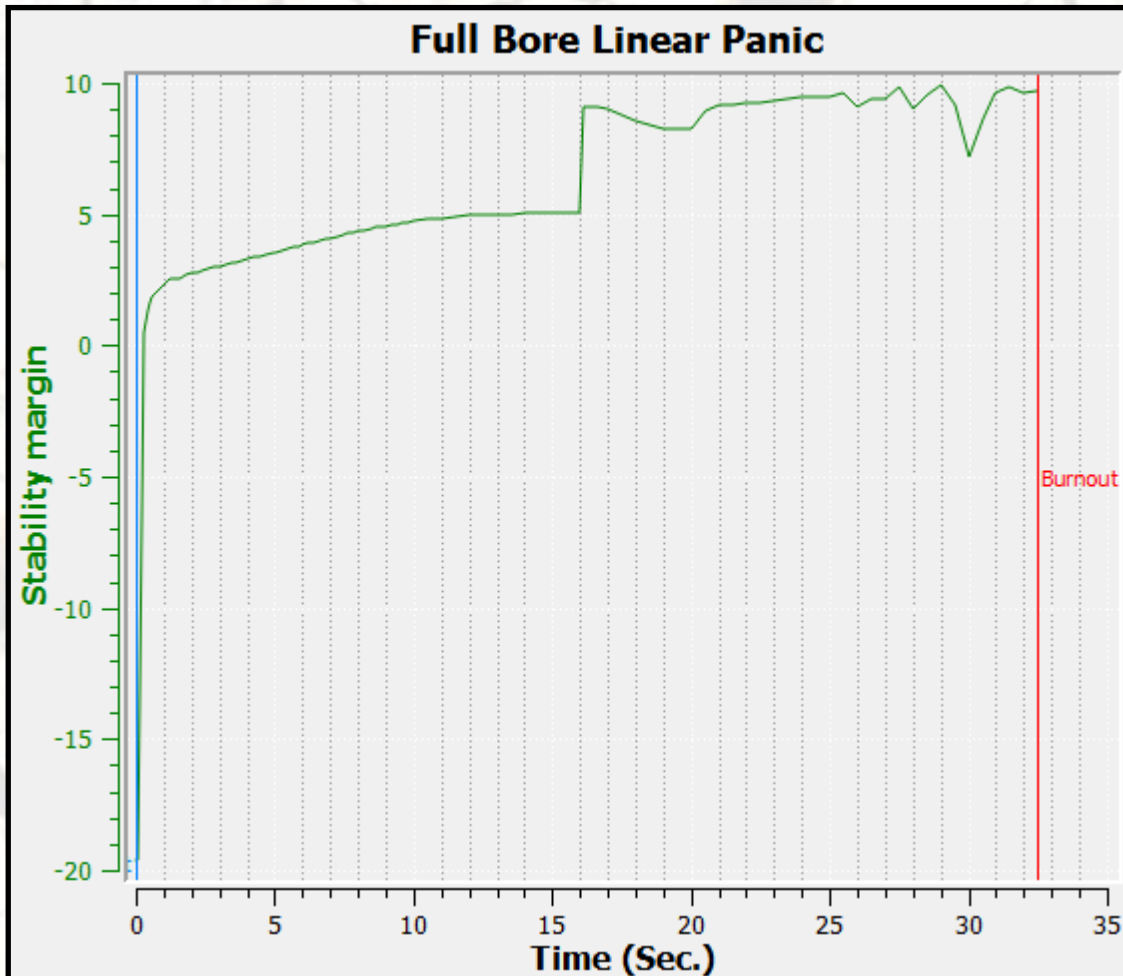


Figure 1: Stability Margin (calibers) vs. Time to Burn-out

Landing Dispersion

As part of the C3RC analysis, we perform multiple 3-sigma 6 DoF analyses under different recovery and wind scenarios. For your reference, Figure 2 shows the landing dispersion plot for a ballistic recovery of the sustainer under typical Black Rock

PM wind conditions. Figure 3 contains the dispersion for the booster under the same conditions. The Black Rock B+ launch site was used. As expected, the booster dispersion is considerably less than the sustainer dispersion.

It is important to note that the dispersion simulations demonstrated substantial impact of launch tower angle. You will need to verify that the launch tower is as close to vertical as possible when you launch.



Tripoli's > 50k' Process for Black Rock

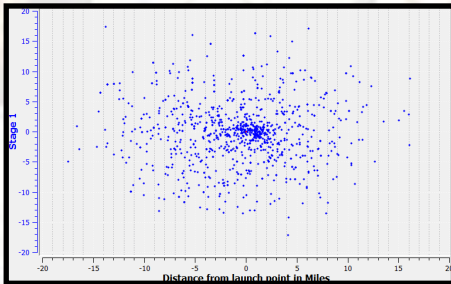
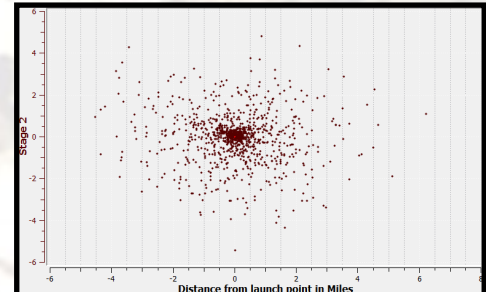


Figure 2(L): Sustainer Landing Dispersion Plot— Ballistic Recovery, PM Winds

Figure 3(R): Booster Landing Dispersion Plot - Ballistic Recovery, PM Winds



Fins

Given the expected maximum velocity of your rocket, I looked into the predicted performance of the fins. I modeled the fins, airframe, and attachment mechanism in the Aero Rocket FinSim program. Of concern are the divergence and flutter velocities of the fins. The booster employs a RouseTech fin can with 0.090" thick aluminum fins. I am familiar with this fin can having used it for a project flown during BALLS 19. The maximum velocity of the booster is predicted to be 1,140 ft/sec. The FinSim code predicts Divergence and Flutter velocities of 826 and 1124 ft/sec, respectively. Considering the previous observation regarding overestimation of the performance due to underestimation of the drag, I expect that, while the project will be close to the flutter velocity, the fins will be fine.

The Sustainer is expected to reach 2,796 ft/sec. The FinSim analysis of the surface-mounted CF fins predicts Divergence and Flutter velocities of 3,620 and 4,924 ft/sec, respectively. Thus there is no concern for the performance of the Sustainer fins.

The point of this discussion is simply to highlight how close to the edge you'll be with the Booster fin can. The Sustainer should perform well.

Summary

The simulation results lead to an expectation of a very high performance flight below the waiver altitude. The landing dispersion results suggest providing an additional margin of safety with respect to pad-to-flight line separation. You should also pay particular attention to the vertically of the launch tower.

I would also like to note that I am impressed with the methodical test program you've undertaken to get to this point. Your testing gives me additional confidence that your flight will be successful.

Please don't hesitate to contact me with questions or comments.

Good luck with your flight. Dr. Kenneth J. Overton, C3RC Analyst



“Hello, my name is Kate!”

You may have heard that introduction over the PA system just before some flights at Aeronaut or XPRS. It has become a signature of the TelemetryPro tracking system. Kate is a synthesized voice that reports GPS downlink information in real time during a flight. This adds a whole new dimension to watching a flight! Kate reports what is happening during all phases of a flight by announcing altitude, velocity, distance and bearing. Kate also reports staging events, drogue deployment, main parachute deployment and touch down. This allows everyone to know exactly what is happening even when the rocket is well beyond visual range.

Kate was first flown at XPRS in 2008. In those days, Kate was a laptop running custom software. Kate was never originally intended to be a product for sale. It was simply a hobby project that combined a passion for rocketry and electronics. However, after receiving a lot of requests from people wanting one, it became obvious that Kate should become a real product. That meant getting rid of the laptop and designing a system that was very reliable and very easy to use. Kate is now one of the most sophisticated GPS tracking systems available for high power rockets. Far more than just a pretty voice!

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- Records all flight data and voice.
- USB interface for flight data download on both units.
- Easy to use software generates a detailed flight report.



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Visit the website to learn more and to listen to flights narrated by Kate.



Magnitude.io— A talk with Ted Tagami and Tony So

On April 3 and 17, veteran ARLISS flyers flew 14 flights for Manteca and Lodi Unified School District middle and high school students at Snow Ranch, LUNAR's high power field east of Stockton. ARLISS K rockets were used to loft payloads created by middle and high school students in conjunction with a program developed by Magnitude.io. Aerotech J415W motors sent the projects to well over 4k'.

The Manteca Unified middle school launch at Snow Ranch on April 3 reminded this flyer of a full blown ARLISS event. Quite impressive...almost 200 kids (although a little younger than typical ARLISS), lots of excitement, enthusiasm and a real sense of teamwork .



Opening ceremony for Manteca Unified

The Lodi Schools launch the following week was just as impressive, over 100 kids, 6 payload flights and had the added element of 11 Level 1 certification flights (10 successful), 4 regular and 7 Junior High Power.

The following are some highlights of an interview by the AEROPAC Newsletter Reporter (ANR) and the driving forces behind Magnitude.io – Ted Tagami and Tony So.

ANR: Over 300 kids and at least 50, adults both teachers and parents, attended these launches, which were held on Sunday. How many kids and schools were involved at some significant level in this program?

Magnitude.io: We have 1100 kids from 19 schools involved.



Magnitude.io — A talk with Ted Tagami and Tony So

ANR: Taking a step back, what originally inspired you to put this program together?

Magnitude.io: Public schools in California are adopting new standards called the Next Generation Science Standards. A key component of these standards is the integration of science and engineering practice. We felt that nothing integrated the physical sciences quite like working with a simulated satellite in the volume of a soda can.

ANR: Clearly, you have some very high goals for Magnitude. What exactly are your objectives with the program?



Photo by J. DuBose

Manteca middle school students helped track their flight and navigated to the landing site.



Students from Manteca's Christa McAuliffe Middle School flew their payload in Dick Jackson's rocket. They also carried it to the launch pad and retrieved it back to the flight line.

Magnitude.io: We would like our students to be critical thinkers and problem solvers. In addition to raising the competency and comprehension of science phenomenon in young people, our goal is to have some of our youngest students build and launch a satellite into Low Earth Orbit within 5 years.

ANR: I see that you are working with the UC Davis School of Education to develop your hands on STEM curriculum. How did the relationship with UC Davis take shape?

Magnitude.io: UC Davis was recommended to us by one of our clients who had developed curricula with them in the past. We are pleased that we have a scaffold on which to build lessons and experiences in collaboration with school districts in California.

ANR: Describe a typical payload / project from conception to post flight follow up.

Magnitude.io: Students learn about various phenomena with the sensors that come with a CanSat. Barometric Pressure, Temperature and Humidity, Acceleration, a Magnetometer and GPS are the basic sensors. There are breakouts for optional sensors such as CO₂, Ozone, etc.



Magnitude.io — A talk with Ted Tagami and Tony So

After the rocket events the real work begins analyzing the flight data. Students review different aspects of their flight profile through the various sensors that were used in the CanSat. Deep investigation of this information can yield promising information: from the recreation of the CanSat in 3D physical space at any point during the flight, to calculation of the final altitude based on the barometric pressure of the day, or add the recorded latitude and longitude to visualize the flight in 3 dimensions.

ANR: How do you go about generating interest for the program within a school district?

Magnitude.io: The interest is already there. We usually work through a District Office or via an introduction to a Science Chair. We are at the dawn of the new space race. The Billionaire's space race. Elon Musk. Richard Branson. Jeff Bezos. This time, instead of the cold war, we have private industry driving it. The teachers and students are excited about our program and how it delivers on the core practices the student must understand.

ANR: Are you targeting any particular school level? The kids at the Manteca launch were pretty young - a lot of 6th graders.

Magnitude.io: While we have students that begin as early as the 4th grade, or are at University, our primary program is focused on 6-12th grade.

ANR: In addition to launching projects in ARLISS K vehicles, I see where some students put their projects up on balloons. How is the decision "rocket vs balloon" made?

Magnitude.io: Unfortunately, the high power rockets are not a year round activity due to dry grass most of the year. There are not too many places where we can launch. The high altitude balloons offer a unique experience that serves schools year round.

ANR: What do you feel is your greatest achievement so far?

Magnitude.io: It took a leap of faith to start a business in the education space. There are so many challenges. The fact that we've stuck with the vision has been an achievement in its own right.

ANR: Do you have plans to try to keep kids interested in what they have learned when a program ends? Are there any "next steps"?

Araya Buffington successfully flew her Level 1 Jr High Power rocket



Photo by J. DuBose



Magnitude.io — A talk with Ted Tagami and Tony So

Magnitude.io: Absolutely. Each teacher, each school, each district, has their objectives for STEM programs and the new standards. The foundation of our program is the integration of science and engineering practice. There are so many directions the students can go in. As students study the various disciplines, there are activities waiting for them in computer programming, engineering, electronics, physics, earth science, chemistry, etc.

ANR: You have a pretty strong group of folks on your Advisory Board, including ARLISS founder Bob Twiggs. How did you get Twiggs involved?

Magnitude.io: We were fortunate to meet Professor Twiggs early on and realized we had the same philosophy on STEM education and hands-on experiences. We hope to extend his legacy to students before they enter university.

ANR: Anything exciting on the horizon?

Magnitude.io: We've got a few projects in the works for later this year. Let's just say, "they are out of this world."

ANR: I notice that the motto for Magnitude.io is "A posse ad esse." Translate that for us.

Magnitude.io: It is Latin, meaning "from being possible to being actual."

Check out the Magnitude.io website at: <https://magnitude.io/>





AEROPAC's Year End Party

AEROPAC held its annual Year End party at Frankie and Luigi's in Dublin, CA again this year. After visiting for a while we got down with some excellent cuisine. Then we had a special treat—Bill Colburn gave a presentation on the history of model rocketry and expounded on his early efforts as part of the Rocket Research Society. Bill, of course, went on to bigger things and played a significant role in the Apollo Moon Project.

After Bill's talk, a raffle with some really nice prizes was held. The big prizes were an AT M1419 donated by Eric Kleinschmidt, an AT K550 donated by Bay Area Rocketry and a number of rocket kits. John Coker donated a nice 4" rocket but it was removed from the raffle with a vague explanation of "historically significant."



Left: Bill Colburn in 1956 with his award winning "telemetered" rocket featuring an Acorn Tube Oscillator Radio. Right: Bill delivers presentation at Year End Party



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