HIGH POWER ROCKETRY

MAGAZINE OF THE TRIPOLI ROCKETRY ASSOCIATION

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SEPTEMBER 2022

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TRIPOLI Report

JOURNAL OF THE TRIPOLI ROCKETRY ASSOCIATION

Volume 33 Number 3

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Address submissions to:

Ken Good
Tripoli Report Editor
2927 Cross Creek Court
Gibsonia, PA 15044
kjgood25@aol.com

Tripoli Rocketry Association Officers

President Bob Brown
Vice President Gary Dickinson
Secretary Steve Shannon
Treasurer Dave Rose
Directors:
Pat Artis
Neal Baker
Gerald Meux, Jr.
Gary Rosenfield
Christopher Short

Business Office

Tripoli Rocketry Association, Inc.
P.O. Box 87
Bellevue NE 68005
Telephone, voice: (402) 884-9530
Telephone, fax: (402) 884-9531
E-mail: info@tripoli.org

TRA Website
http://www.tripoli.org

HIGH POWER ROCKETRY

MAGAZINE OF THE TRIPOLI ROCKETRY ASSOCIATION

TRIPOLI Report

JOURNAL OF THE TRIPOLI ROCKETRY ASSOCIATION
Volume 33 Number 2 - June 2022

Cover photo: *Day 2 take-off at LDRS-40, Lucerne Dry Lake.*

Inside photo: *Successful recovery on Day 3 of LDRS-40.*

Both photos by Jim Wilkerson/Tahoma Photography.

LDRS-40 RETURN TO LUCERNE

LDRS-40 was held this year at an historic high power venue, Lucerne Dry Lake, near Victorville, CA. Some old(er) high power veterans will recall early activity at Lucerne, one of the first reliable locations for those who were at the forefront of serious rocketry experimentation. For those who are curious about those early days at Lucerne, extensive information is captured in Mark Canepa's excellent ***Large and Dangerous Rocket Ships***. If you haven't read this book yet, you really should (see advertisement in this issue).

Ironically, it would be many years until an LDRS was held at Lucerne, the first one being LDRS-20, July 19-22, 2001. LDRS would come back to the dry lake two more times before this year, with LDRS-29 in 2010, and LDRS-35 in 2016. For all of these events Rocketry Organization of California (ROC TRA Prefecture #48) has been the host organization, and they invariably conduct a great event.

Veterans of Lucerne are aware of the weather/wind patterns, which significantly impact rocket activity. As a desert environment, it is important to stay hydrated and be otherwise prepared for heat and bright sun. Also, flyers should plan to get going as early as possible, since high winds - often with dust devils - reliably kick in during the early afternoon and generally shut down the range. This year, the weather was hotter than what is normally seen in June. Nonetheless, some excellent flying was experienced this year.

Presented in the pages that follow are: a gallery of rocket activity for each of the four days of the event, a launch summary report, LDRS-40 impressions offered by Francis G. Graham TRA #00001, and a summary of TRATech, the second year that this technical conference has been offered at LDRS.

All photos, except where otherwise noted, have been contributed by ***Jim Wilkerson, Tahoma Photography.***

LDRS-40 Gallery

Day 1 flying commenced at 6 AM and continued until 2 PM, when high winds ended flight operations.


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Day 2 flying began at 6 AM, continuing until just before 2 PM, when winds ended flight operations. Calmer wind conditions later permitted night flying, and 20 such flights took place.


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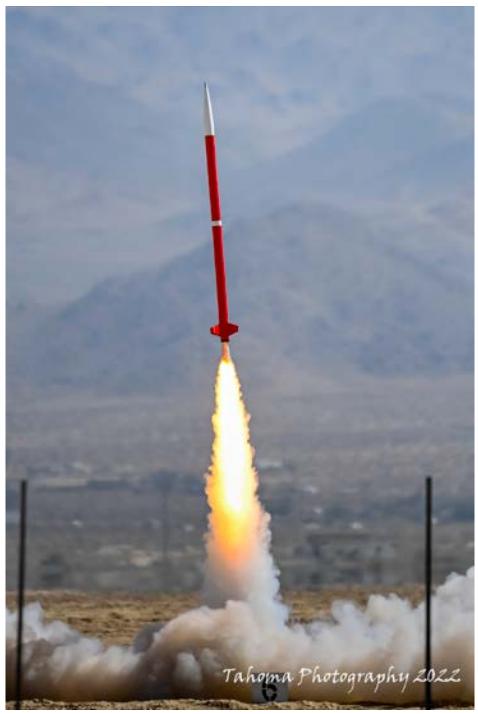
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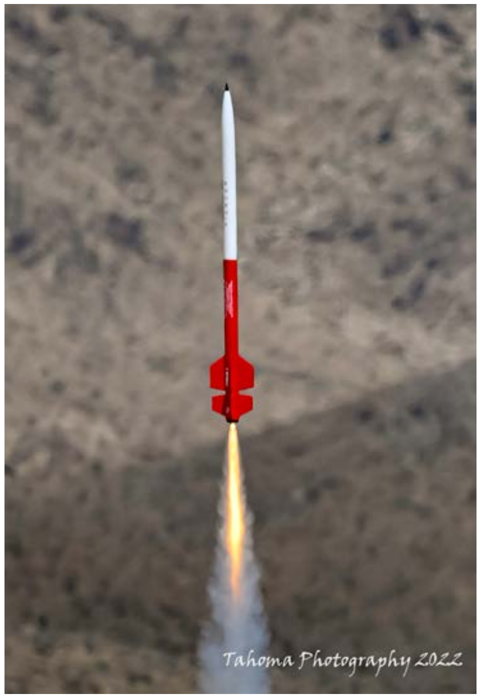
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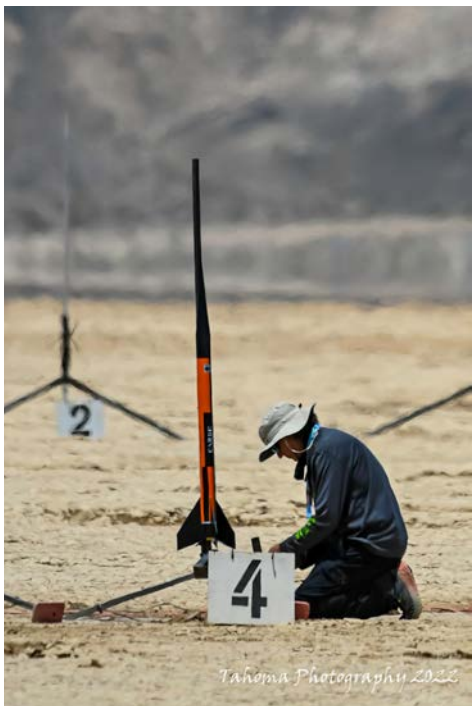
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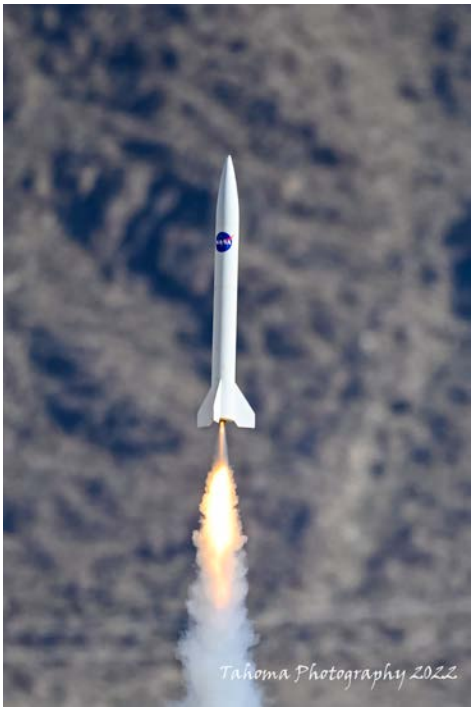
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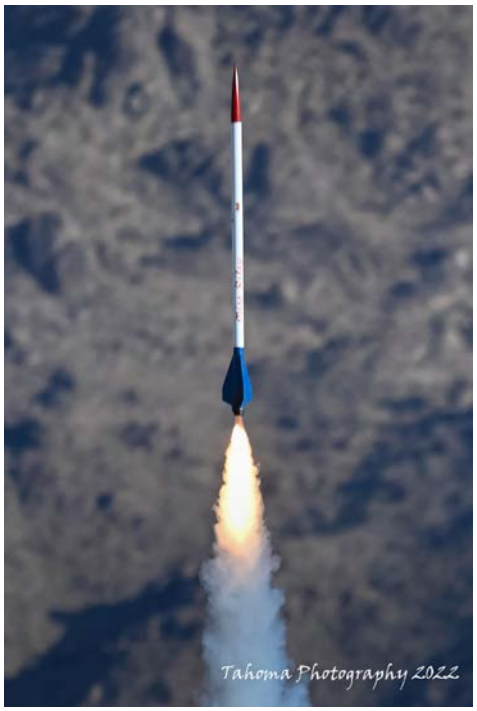
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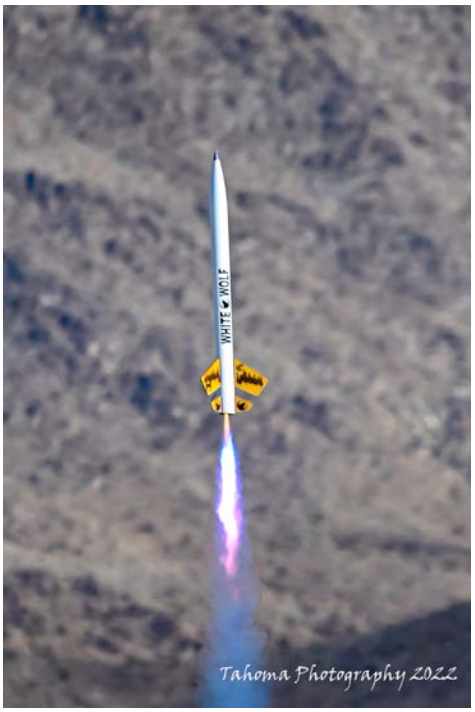
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Day 4 flying began at 6 AM, however the winds arrived very early; flight operations ended at 9:30 AM.


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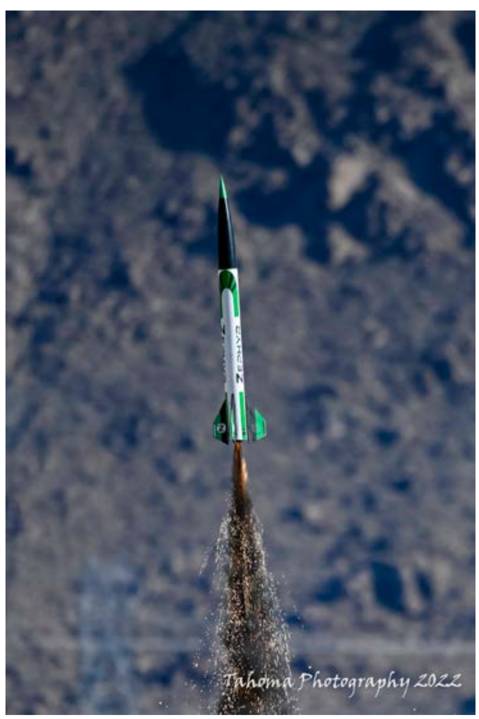
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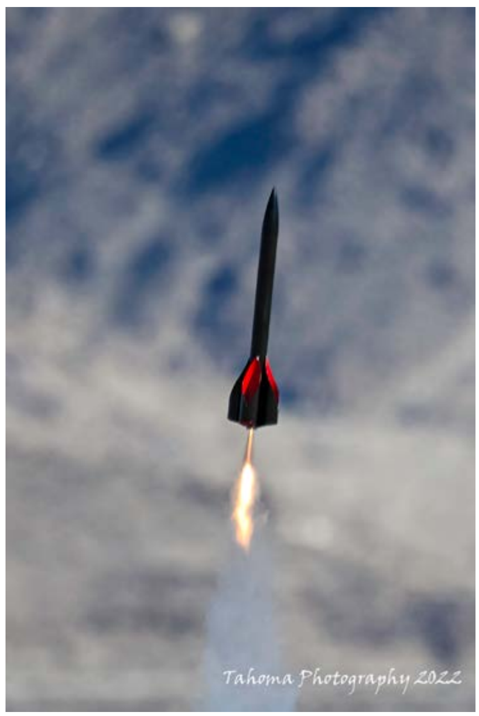
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LDRS-40 LAUNCH REPORT

The ROC LDRS-40 Launch Leadership Team

What a great LDRS 40! The weather was warm and the winds came for a visit each day.

Flying began Thursday at 6 AM and we flew until 2 PM; 1 Night flight was launched.

Friday we flew from 6 AM until the wind picked up just before 2 PM. The winds later slowed down enough for 20 night flights.

Saturday we flew from 6 AM until the wind picked up at Noon.

Sunday we flew from 6 AM - until the wind picked up again about 9:30 AM.

There were 250 pre-registered flyers, with many more joining to fly for a single day, and several hundred spectators.

Thank you to all the Vendors that came out and supported LDRS 40:

- Aerotech
- Animal Motor Works
- Chris' Supplies
- Discount Rocketry
- Dynasaor Rocketry
- LOC Precision
- Rocketman Parachutes
- SBR
- Tahoma Photography
- Wildman Rocketry.

Impulse Class	Number of Flights
1/2 A	3
A	16
B	26
C	45
D	38
E	20
F	56
G	67
H	119
I	95
J	77
K	49
L	19
M	22
Total	**652**

LDRS 40 Flight Summary Report

We had 652 flights over the course of LDRS XL! The table above breaks down flights by motor impulse class.

24 of the above flights were clusters with 2 or more motors. There were also additional flights that were 2 – 3 stages.

There were 45 Certification Attempts: 4 Jr. Level 1's; 23 Level 1's; 15 Level 2's and 3 Level 3. Congratulations to all those that were successful!!

Thank you to all who came and flew with us, helped LCO, FSR, RSO, Spotter, Pad Manage and Clean Up. We appreciate your willingness to volunteer!

A huge shout out to the ROC Board members, LDRS Committee members and the Tripoli Board Members that helped plan and organize LDRS 40 for the past 6 months.

Cari Schneider
ROC Membership Chair

SNIPPETS FROM LDRS-40

by Francis Graham, TRA# 00001

Part 1 - Rockets at Lucerne Dry Lake

It is Lucerne Dry Lake. Thousands of years ago, as the Great Pyramid was being built, native Americans fished and swam in this place. Since then, it has dried up. Now, with the most severe drought in human history caused by Global Warming, it is more parched than ever.

Nonetheless it was Jerry Irvine who determined this was a great place to test rockets, in his publication *California Rocketry*. Jerry is no longer with Tripoli, but Lucerne Dry Lake is a great place to test rockets, desolate and far away from habitations.

A vista of Lucerne Dry Lake. Photo by Francis Graham.

The event was called Large and Dangerous Rocket Ships 40, the main annual Tripoli launch. It is usually held in a more habitable place, because many of the rockets launched are from new/novice hobbyists. Tripoli has a certification level system, and a lot of LDRS attendees at any year fit into this category, for which Lucerne Dry Lake is oversized.

But there are some group projects that demand such space too. I saw a single stage J-impulse motor in a laminar minimum diameter rocket reach 14,770 feet altitude, verified by instruments carried aboard.

Above: Francis Graham (L) chats with TRA Director/ Treasurer Dave Rose (R). Photo by Gary Dickinson.

Below: Distant view of one of the many high-power rocket take-offs at LDRS-40. Photo by Francis Graham.

Above: Jim Peong and a small conical rocket.

Left upper: A long thin hobby high-power rocket, the "Andromeda"

Left lower: Ascent to 14,770 feet. Not dramatic - jets do double that - but not bad for a small rocket that would fit in carry-on IF the TSA permitted it.

Below: View from the Certification Table.

Photos by Francis Graham.

I was put to good use at the Certification Table. Since I am Tripoli Member #00001, Mark Clark, Bob Brown, Robin Meredith and others at the Certification Table introduced the new certs to me and I heartily congratulated them.

As one of the founders, one of the "archons" of this 58-year old organization, I tried to convey a sense of history to the new people entranced with the only machine yet devised to free humans from the bounds of planet Earth into Outer Space—the rocket.

Left: The launch ended this day at about 2 PM with the arrival of the customary Lucerne afternoon winds. Here, dust devils form on the parched lake bed. Photo by Francis Graham.

Below: A calm Lucerne sunset. Photo by Jim Wilkerson.

Part 2 - A Typical LDRS-40 Rocket Flight

As a follow-up supplement to **Part 1** of "Snippets from LDRS-40," presented here is a pictorial of a Tripoli rocket flight at LDRS-40, in this case one of Gary Rosenfield's rockets. This was also a special rocket flight for Gary - his successful Level 3 Certification attempt.

I'd first like to show the First Aid Tent (photo on the right) on the Lucerne Dry Lake Bed. This illustrates how Tripoli takes safety very seriously.

Photo by Francis Graham.

Photo by Francis Graham.

Photo by Pat Artis.

This is Gary with his large Level 3 rocket, in the photo on the left. Above, it is being erected on a launch pad more than 1,000 feet distant from spectators. Gary is assisted by Dane Boles and Karl Baumann

Photo by Dane Boles.

Once on the pad, the electronics for parachute deployment are armed. Memo: do not forget this step!

The roar is deafening. That's the thing about rockets. Car or ship breaks down? You can fix it. Even with an airplane, there are certain things a pilot can do in the air. But with a rocket, once that button is pushed, that's the way it is.

It was 4:59:52 PM in London (9:59 AM on the Lucerne Dry Lake in California) when this button was pushed.

Photo by Jim Wilkerson

Take-off photos by Scott Binder.

Above is another picture of the liftoff from Pad 6. The acceleration was 110 meters/sec. faster every second, maximum That's 11.3g's. Even the average was 6.14g's. All this information comes from the onboard instrumentation.

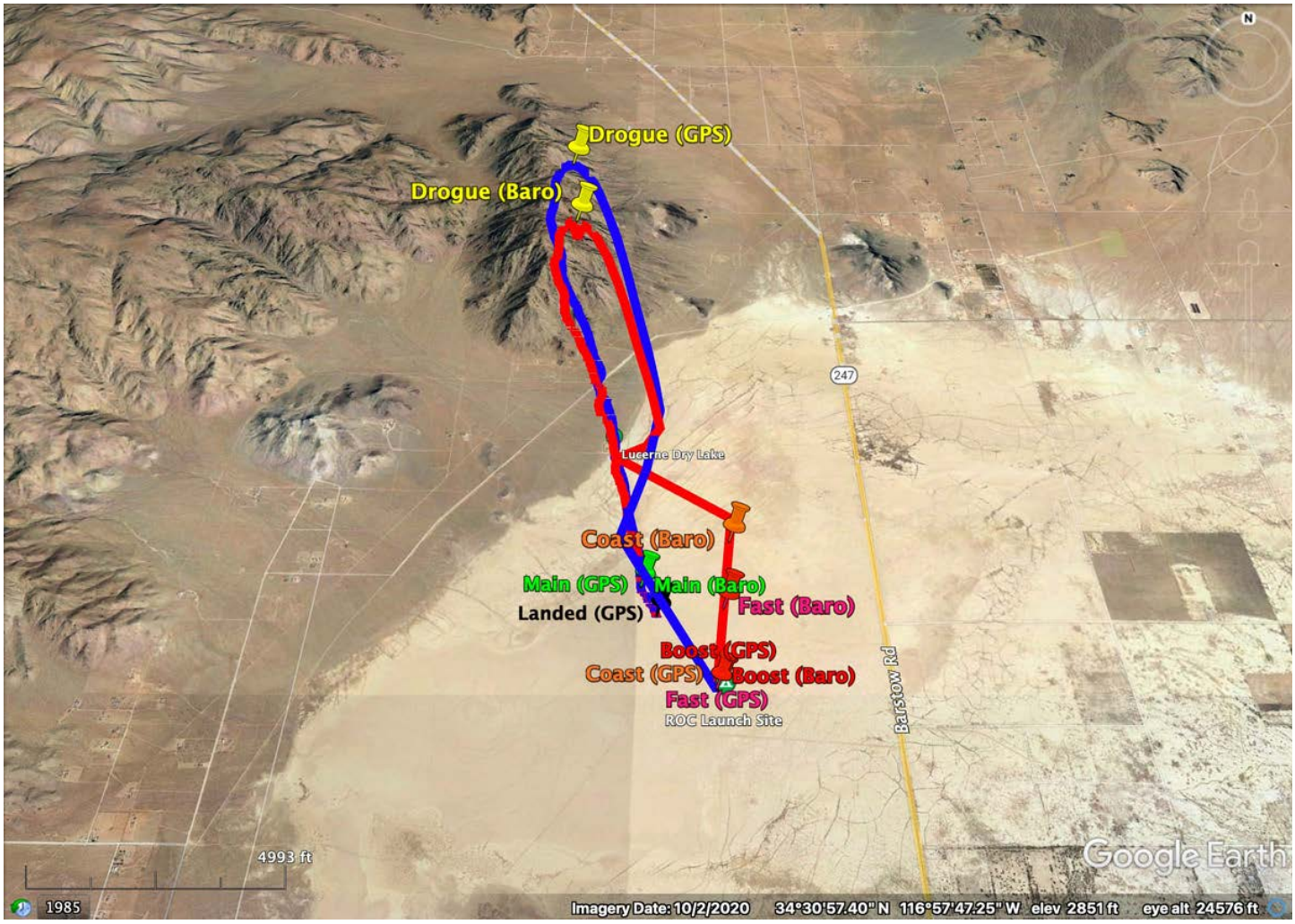
Up it goes (upper right). The rocket motor burned for 5.5 seconds, propelling the rocket to a maximum speed of 335 meters/sec. Keep in mind that the speed of sound is 333 meters/sec. Hence the rocket broke the speed of sound. If you were a bug in the nosecone, you would not hear the motor. Mach 1.0! If you look carefully you can see the vapor forming around the nose.

Photo by Dane Boles.

The rocket reached a quasi-stupendous altitude of 13,543 feet (4128 meters) or 2.56 miles. That's still less than half of what jet aircraft typically do, but it is still impressive for such a small object. It coasted for 19.3 seconds to that altitude after the rocket motor burned out. Near the maximum altitude, a smaller chute - a drogue - opened and the rocket drifted down for 197 seconds. Then a main parachute opened and the rocket took another 48 seconds to softly land on the desert floor, descending finally at 5 meters per second.

This is what a typical rocket flight at a Tripoli LDRS (Large and Dangerous Rocket Ships) event goes like. This particular rocket was well-suited to the wide desert because of its high altitude and potential to go astray. You can use the instrument data to plot the flight on a map.

Here it is:



Flight path screen capture by Gary Rosenfield.

You can see that the rocket took off and headed northwest, and was for a short time above the mountains to the northwest of the lake bed. But the parachute opened and the device carried by the west wind blew back toward the lake bed, landing close to the launch site. The presence of the mountains caused a difference between barometer-measured heights and GPS heights.

Lunch Pad 6 Coordinates: North 34° 29' 50" Longitude W. 116° 57' 30"
Landing coordinates: North 34° 30' 10" Longitude W. 116° 57' 46"

"The Bigger the Rocket, the Bigger the Adventure" -- ***Francis Graham***

TRIPOLI ROCKETRY ASSOCIATION, INC.
2022 TECHNICAL CONFERENCE AND SUMMIT
TRATECH

After an auspicious start at last year's LDRS-39, TRATech continued for LDRS-40. Ten presenters brought excellent information to the attendees, maintaining our new tradition of offering unique insights to our members. The presenters and their topics are pictured below. Thanks to all who all who stepped up to provide their expertise.

Austin Sennot

Professional Websites for Amateurs: How to Make Technical Resources Accessible and Exciting

Bruce Chanes

What Motor Did I Just Fly?
A Tutorial for Converting Flight Data into a Thrust Curve

Curtis Heisey

Building and Flying an Upscale Deuce's Wild! and High-Power Clustering Techniques

David Smith

Tracking Rockets with On-board Radio Transmitters

Francis Graham

Monocopterics

Jim Jarvis

Lessons Learned in the Development of a Practical Vertical Orientation System

Steve Thatcher

Modular 3D Printed Avionics Bay Design

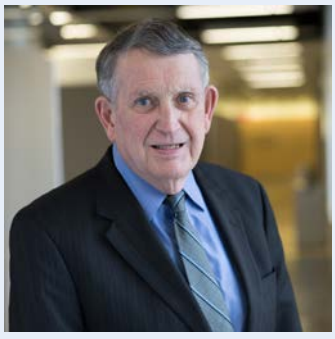
Paul Trainer

Designing and Building 3D Printed High Power Rockets

Using Virtual Reality 360 Degree Cameras

Jim Wilkerson

Rocket Photography



Pat Artis

Mentoring College and International Teams

THE SPECTACLE OF STAGING

Part 3: Multistage Avionic Systems

by Fred Taverni, TRA# 7716

This is the third installment of my series on multi-staging high-power rockets. In the previous installments I described my passion for The Spectacle of Staging along with the safety issues unique to multi-stage rockets. I went on to describe what I consider the prototypical multistage design and my rule for staging avionics: each stage separates itself from the previous stage, ignites its motor, deploys its recovery system, and provides tracking to aid in its retrieval. I described how the interstage of one stage couples with the motor mount of the next, how I route wires from the avionics bay through the motor mounts, and the modular design of my avionics sleds.

This installment focuses on the avionic systems themselves. I start by listing the capabilities of flight computers I find important for multistage applications. After that, I describe the avionic systems in each stage of my *American Karma* using pictures, diagrams, and words. *American Karma* is a rocket I have flown dozens of times and in configurations up to five stages. While each is based on my modular sled design (see *Avionics Sled Design Overview* in Part 2), they use different components and illustrate interesting variations.

The author with his five-stage American Karma

Important Attributes for Multistage Avionics

There are many altimeters and flight computers from which to choose. Picking a particular one to use in your project is a personal choice. However, there are capabilities that I find particularly important for multistage projects:

- **Verticality Safety Check:** It is vital that an altimeter has some way to inhibit motor ignition if the stack is in an unsafe orientation relative to vertical. Inertial Measurement Units (IMU) are best because they report actual deviation from vertical and are easiest to use. However, they tend to be the most expensive. Another viable alternative are units that support This-High-by-When criteria.
- **Motor Burn-out Counts:** An altimeter with a built-in accelerometer can sense a motor burn as period of positive acceleration followed by a period of deceleration. But just because a device has an accelerometer does not mean it includes the logic to count these events and use it as a criterion for stage ignition; check the documentation.

- **Remote Arming:** Multistage rockets tend to be tall, and the safety code requires they are armed only when on the pad and in launch orientation. Remote arming capability provides the option to arm avionics out of harm's way.

- **Data Logging:** It's no surprise that flights don't always go as planned. When they don't you need data to figure out why. I have found that altitude and acceleration versus time traces are indispensable to analyze flight abnormalities, but this data alone is not sufficient; the more data the better.

- **Computer or Smartphone Configurability:** I prefer flight computers that use a computer or smartphone for configuration. This is so I can save a screen capture of its flight configuration for later review. That way, I will always have a record of its configuration even if it is destroyed during a flight.

- **Functional Test Capability:** A good flight computer provides bench testing capability to assure it is in proper working condition without the need for a vacuum chamber or other complicated apparatuses. You want to be able to prove its sensors are operational and its pyro circuits will fire an e-match only when appropriate.

Airframe Structure and Configuration

American Karma is a rocket I designed and built to see how many stages I could fly. It started with two-stages, and I just kept adding stages between the booster and sustainer over time. It is built from 2.56-inch fiberglass tubing with a 54mm motor mount in the booster and 38mm in all others. The sustainer has redundant electronic dual deployment. Lower stages use single deploy electronics for apogee and motor deployment as backup. The first and second stages are designed for manual arming at ground level, while the sustainer and all other stages utilize remote arming. The avionic system of each of the five stages, working from the booster up, are described below.

Booster Avionics

The booster has the simplest avionics system as there are no staging functions, just apogee deployment and GPS tracking. A PerfectFlite StratoLogger does the deployment and an EggFinderTX Mini handles tracking. I take this simplicity one step farther by using a single battery through a single switch to power both. While this stage is GPS capable, I often fly it without the EggFinder when the flight profile makes booster recovery a gimmie. Figure 1A is a photo of the front (component) side, Figure 1B is the back (power) side, and Figure 1C is a stylized wiring diagram. The wiring is straightforward; I don't think it requires explanation.

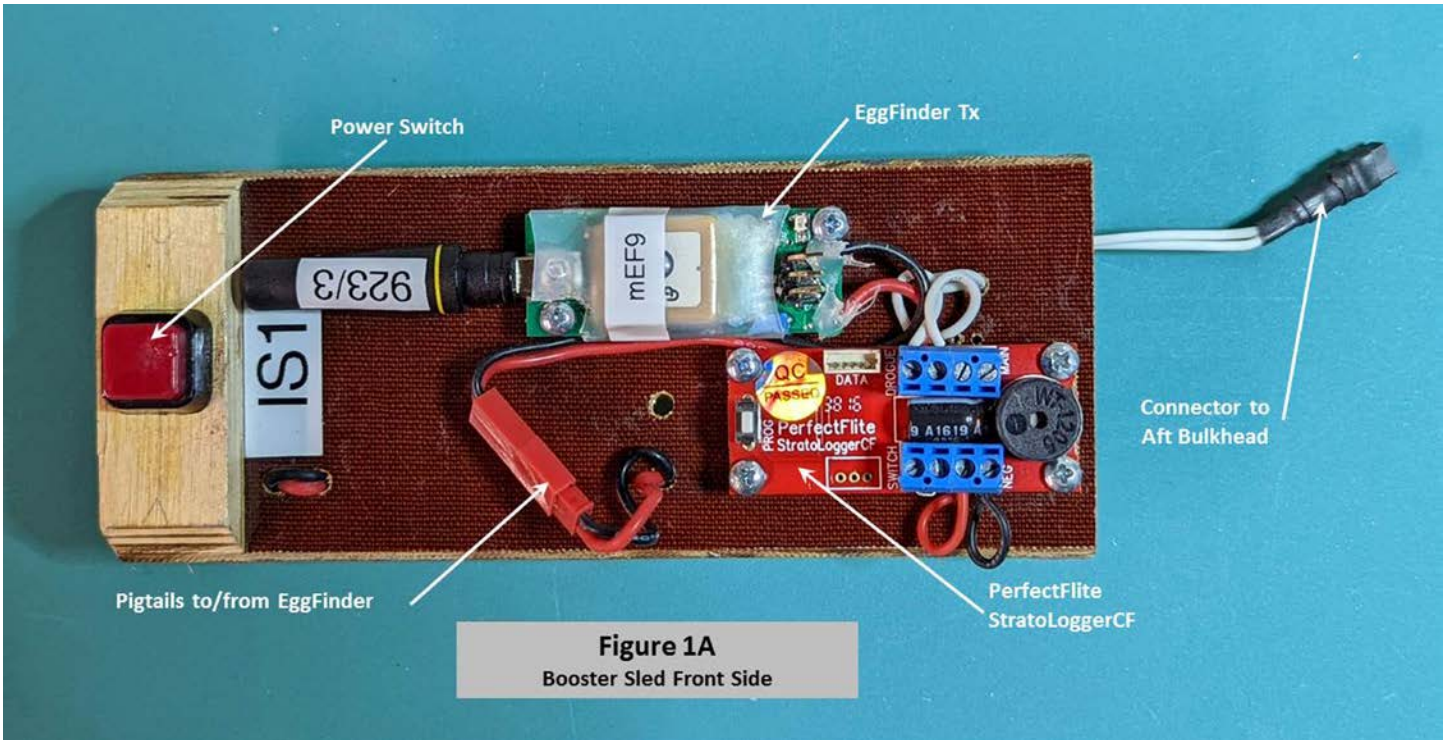


Figure 1A
Booster Sled Front Side

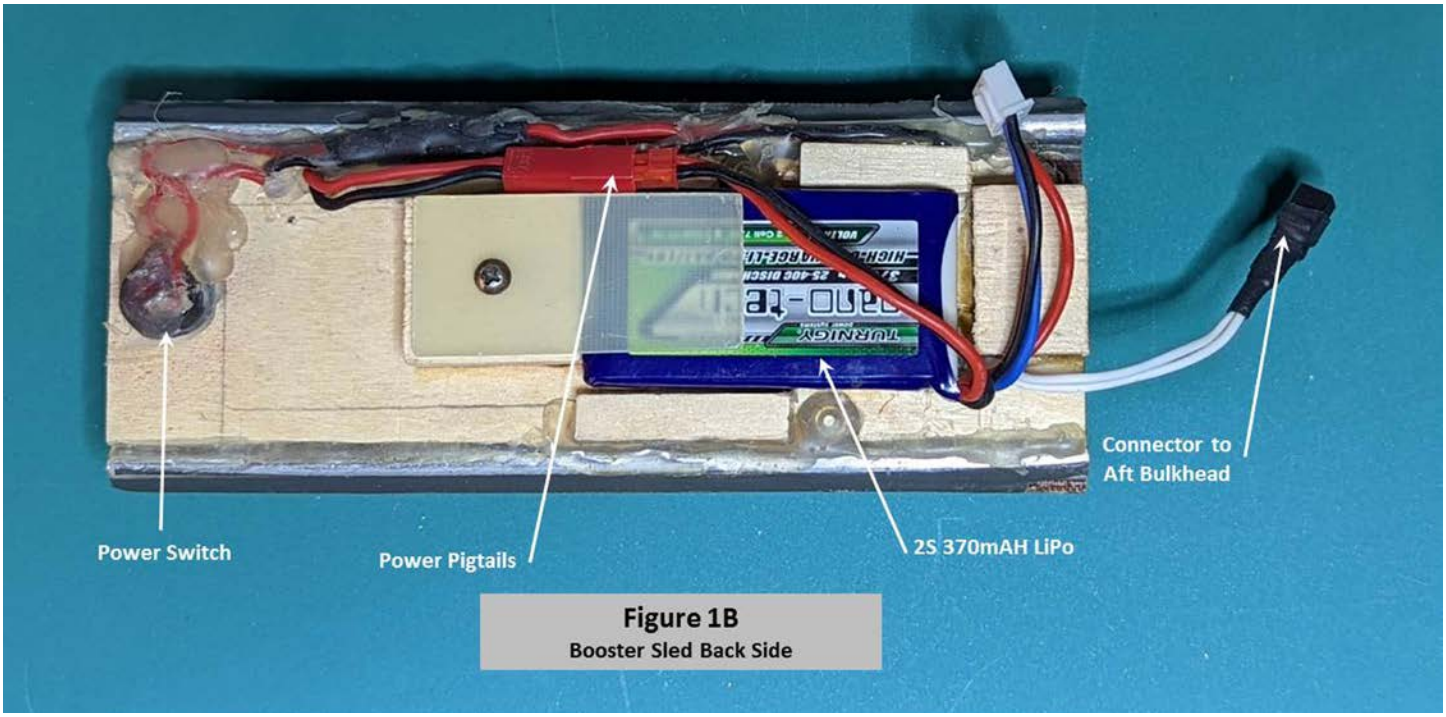


Figure 1B
Booster Sled Back Side

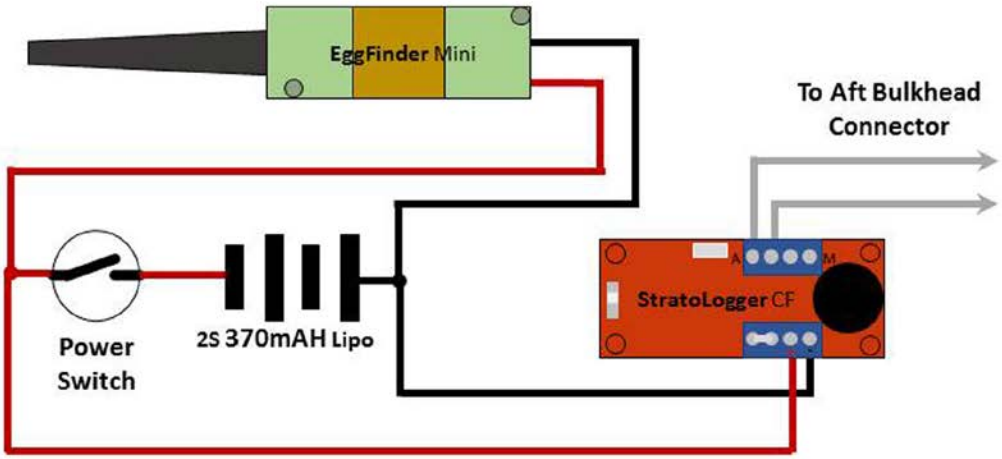


Figure 1C
Booster Avionics Wiring Diagram

Second Stage Avionics

Surprisingly, the second stage avionics package is one of the most complex. It has a FeatherWeight Raven 4 for staging and deployment along with an EggFinder Mini for GPS tracking. The front, back, and wiring are shown in Figures 2A, 2B, and 2C, respectively.

A single 2S 460 mAH LiPo battery powers both devices through a single switch. While this simplifies on-pad setup, it complicates wiring since the two devices have different voltage requirements. The LiPo directly powers the EggFinder, but a 5-volt Battery Elimination Circuit (BEC) is needed to reduce the LiPo output voltage to match Raven requirements. The BEC's output goes to the positive terminal on the Raven and serves as the common lead for all its pyro channels.

I use the Raven's Apogee channel for primary apogee deployment (duh), Channel 3 for stage separation and Channel 4 for stage ignition. The Raven's Apo and + terminals connect to a pair of pins on the aft connector that feed the apogee deployment charge. I don't use the Raven's Main channel, but in Figure 2A you'll notice there is a lead going into it. This is just a dummy lead, just a piece of wire insulation. It's there so there are 6 leads aligned to match the 6 Raven terminals; this helps prevent accidental miswiring.

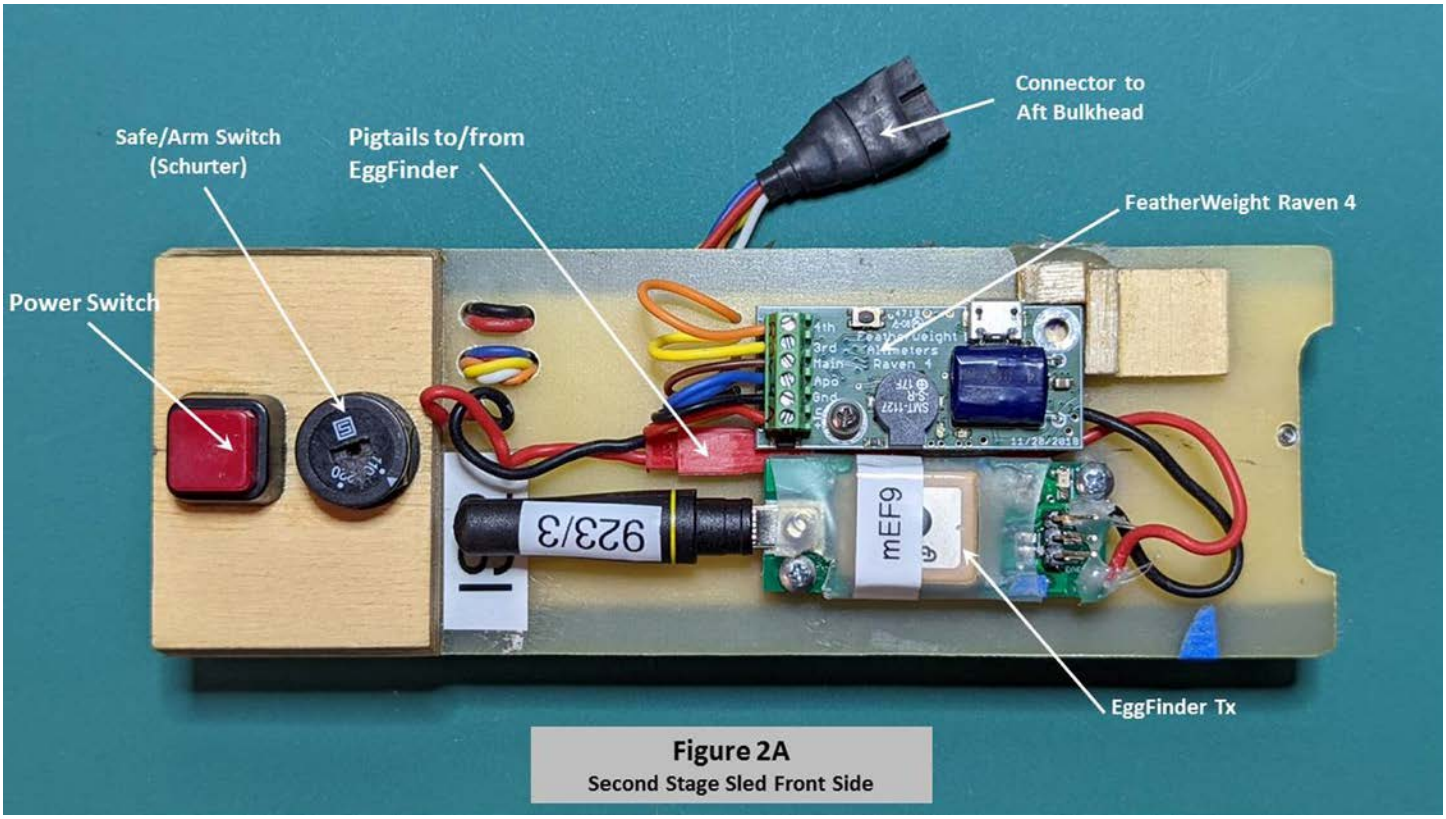


Figure 2A
Second Stage Sled Front Side

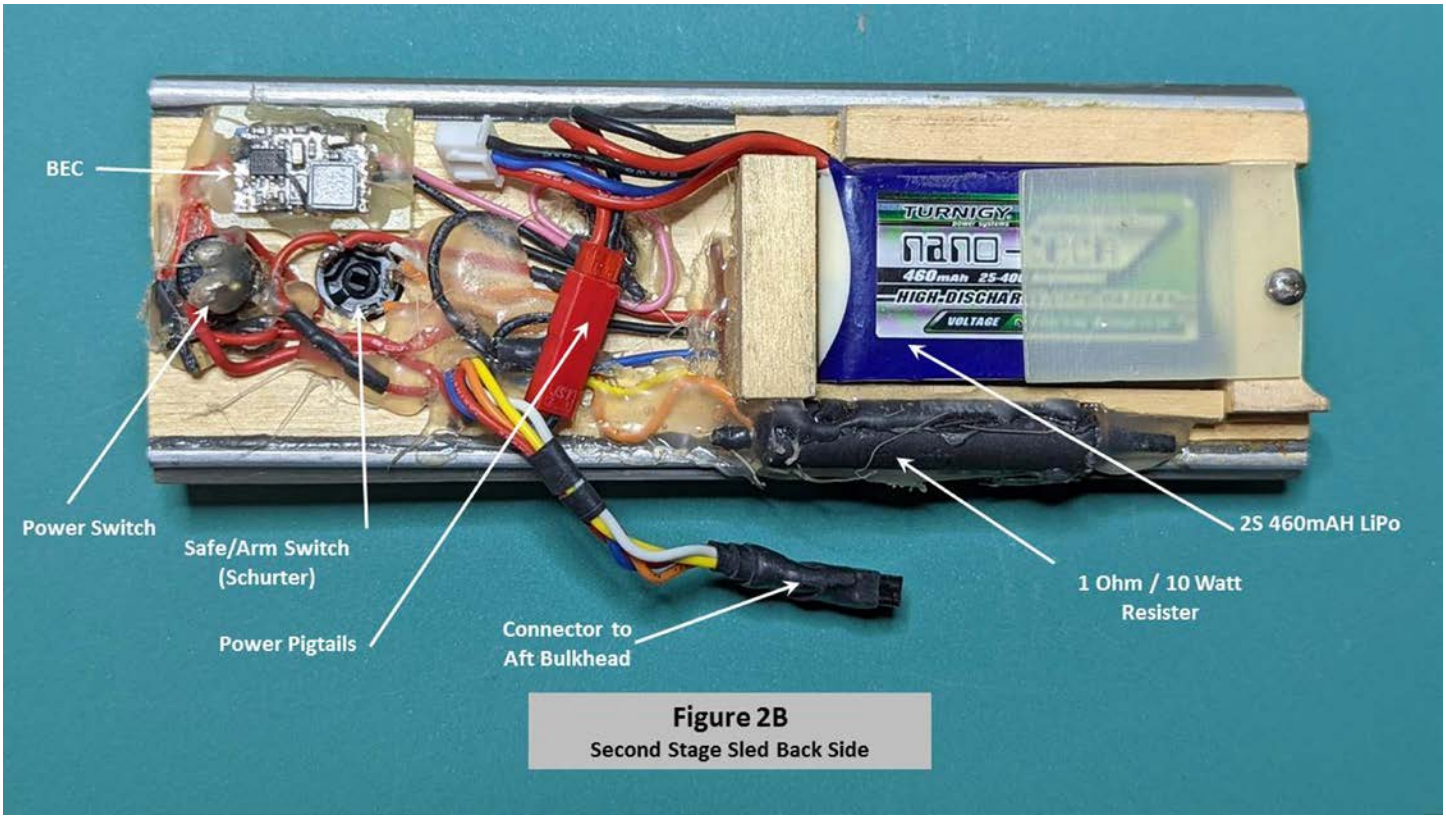


Figure 2B
Second Stage Sled Back Side

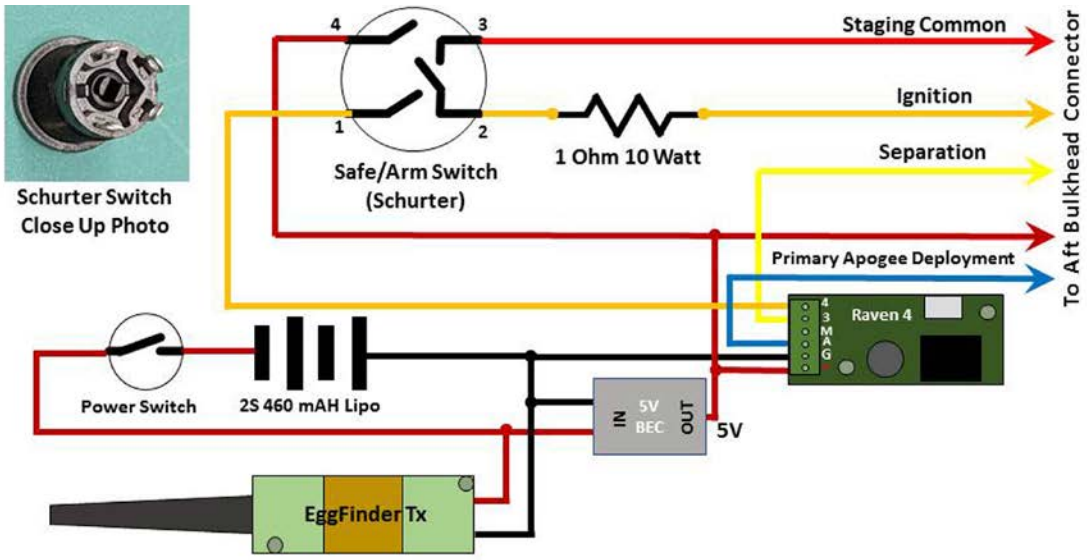


Figure 2C
Second Stage Avionics Wiring Diagram

Staging circuits are routed through a Schurter Rotary Switch which serves as a Safe/Arm switch. This switch is designed for use as a voltage select between 110 and 220 volts for consumer products, consequently it has unique internal wiring. It is like three switches in one. I tried to capture this fact on the wiring diagram in Figure 2C. When the Schurter is in the 110-position (Armed) the switches between terminals 1 & 2 and 3 & 4 are closed, but the switch between terminals 2 & 3 is open. In the 220-position (Safe), the connections between 1 & 2 and 3 & 4 are open and the 2 & 3 connection is closed.

In Safe position both sides of the motor igniter are disconnected from the firing circuit and shorted to each other. The separation pyro is disconnected from its 5-volt source so it can't fire either. When the Schurter is set to Arm the staging, common is connected to the 5-volt source and ignition pyro is connected to the Raven.

The Safe/Arm switch has two purposes: it gives peace of mind when I arm the second stage and a safe launch scrub option should I encounter a problem remotely arming any of the following stages. As a last resort, I could switch to safe mode, effectively disabling ignition of all upper stage motors and fly the stack off the rail with the booster motor and let the combined recovery systems bring it all down.

The Raven tends to fry its MOSFET in motor igniting applications when using other than the recommended battery as I do here. The motor ignition process can result in a prolonged short across the ignition circuit due to the plasma generated by the burning motor. This doesn't happen with black powder deployment charges, just motor ignition. FeatherWeight documents this risk and warns against using other than recommended batteries. This doesn't happen often, but it happened once and I decided to add protection in the form of a 1-Ohm, 10-Watt resistor in the ignition circuit to protect the Raven. My choice of 1-Ohm and 1-Watt was arbitrary. It seems to have worked since I haven't damaged a Raven on dozens of flights since. Still, if I were to do it again, I might go with 5-Ohms and ½-Watt.

Third Stage Avionics

Happily, the avionics in the third stage are much simpler. Here I use an EggTimer Proton for staging and deployment along with an EggFinder Mini for tracking. I power both with a single battery through a switch. Because I arm the Proton remotely, there is no need for a physical Safe/Arm switch. The front, back, and wiring are shown in Figures 3A, 3B, and 3C, respectively. Although simple, there are a couple of things I need to explain.

Although I trust the push button switch, I do not believe it to be immune from momentary jitters under flight conditions. The Proton has no internal brown-

out protection to protect it from such an event. The loss of power for just a few milliseconds would reset the Proton mid-flight. This wouldn't lead to a good outcome. So, I installed a 6800 µF capacitor across the battery downstream of the switch. This is enough to power the Proton and EggFinder for about a half second, enough time to get through a transient power glitch. You can see this capacitor in Figure 3B and its position in the circuit in Figure 3C.

In Figure 3A you can see three white wires connected to the one side of each of the pyro channels I use. If you measure the resistance across these terminals while disconnected from external wiring, you will see they are shorted together. These three terminals are common to all pyro channels. I could have connected my circuit to just one of them. But I decided to connect to all three just so there is a one-to-one correspondence between wire lead and terminal.

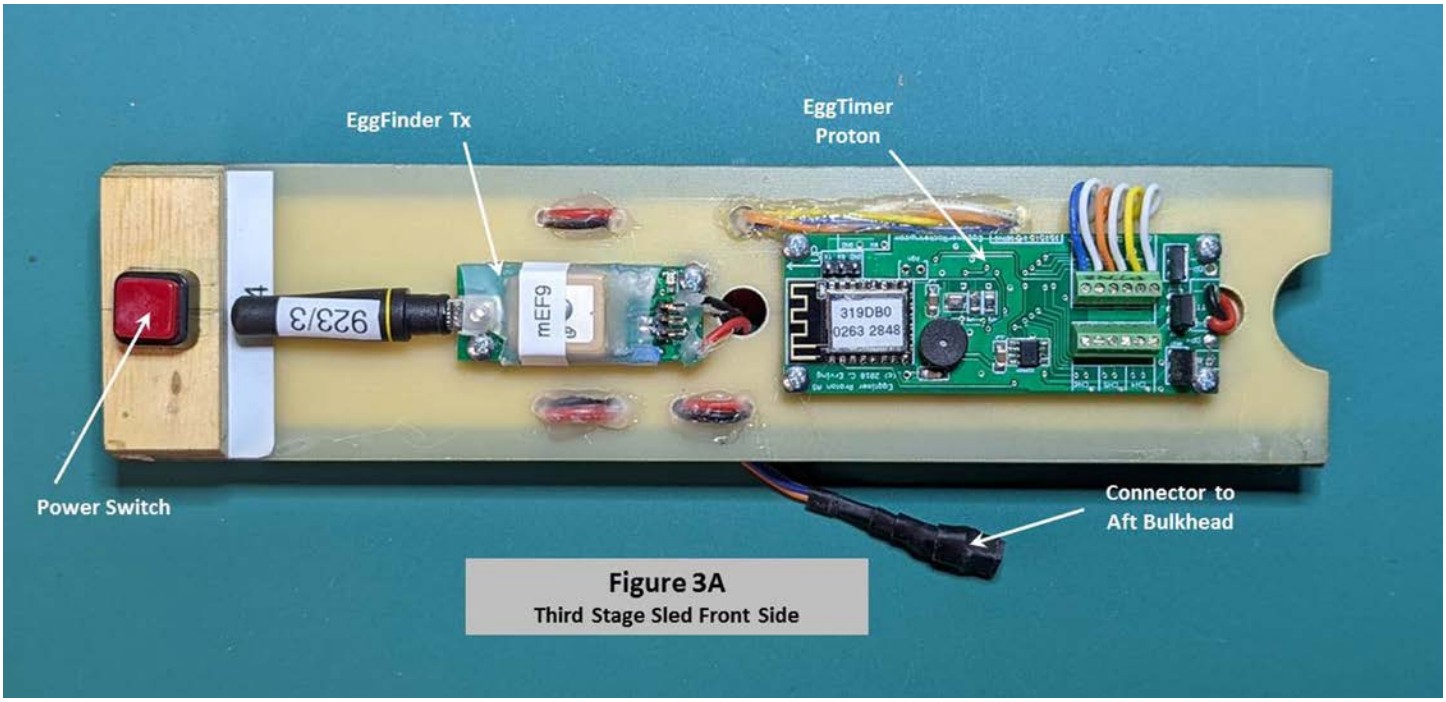


Figure 3A
Third Stage Sled Front Side

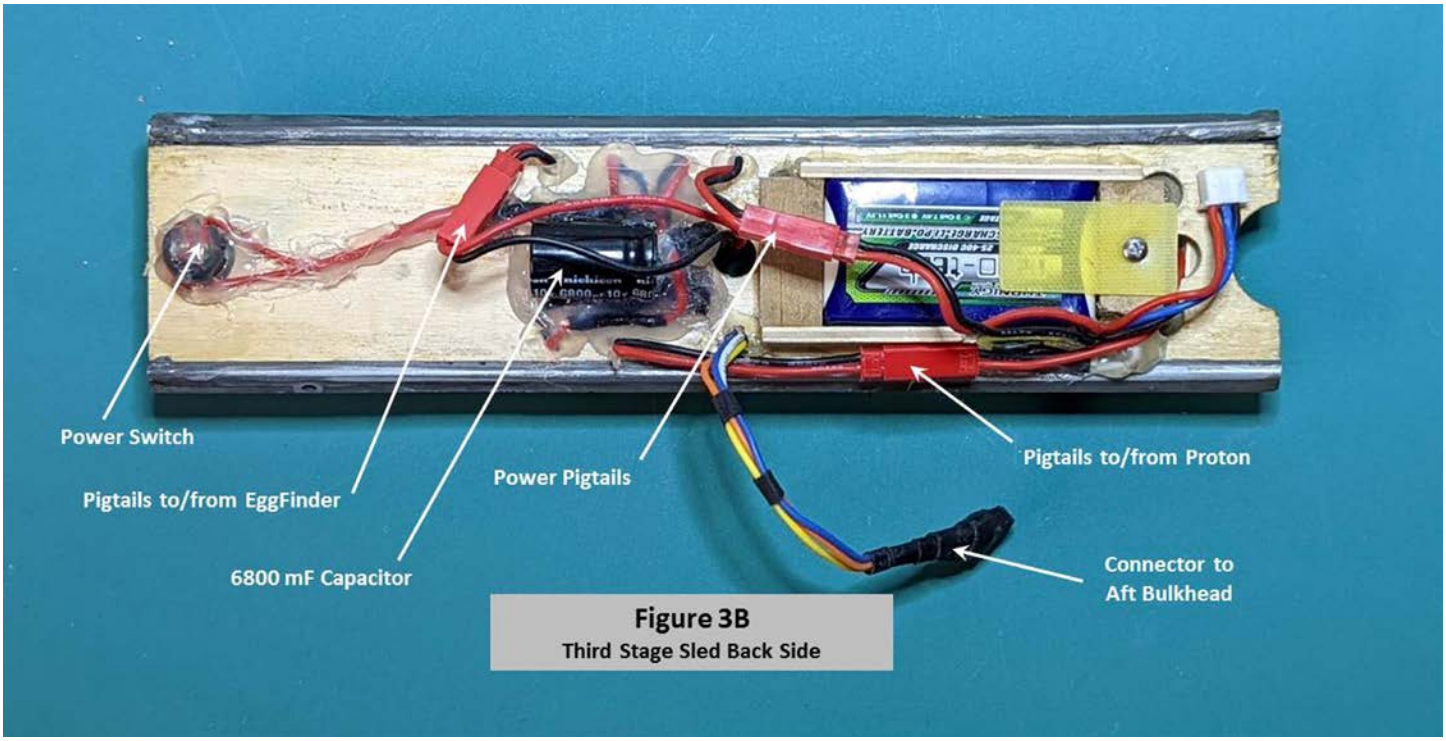


Figure 3B
Third Stage Sled Back Side

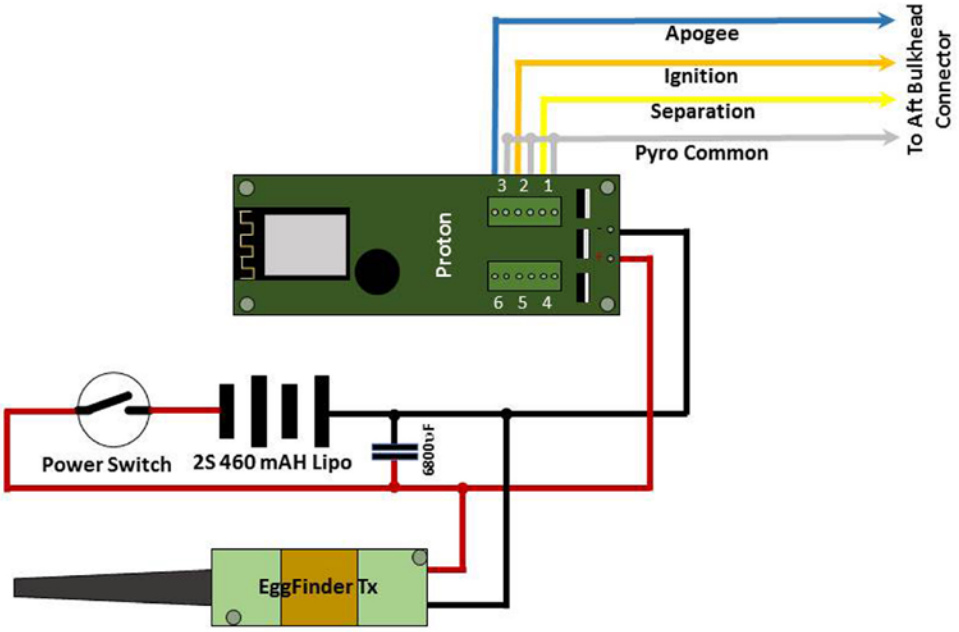


Figure 3C
Third Stage Avionics Wiring Diagram

Fourth Stage Avionics

The fourth stage avionics is the simplest yet. An Altus Metrum TeleMega does everything—tracking, staging, and recovery deployment. Not only that, but it can also be remotely armed. Can't get easier! The front, back, and wiring are shown in Figures 4A, 4B, and 4C, respectively. Still, there are a few special details on how I use it.

To get maximum downlink range, the telemetry antenna - that's the black wire extending from it in Figure 4A - must be fully extended. This means the sled and avionics bay is a little longer than usual. No big deal. I secure the antenna with bit of masking tape to keep it in place during flight.

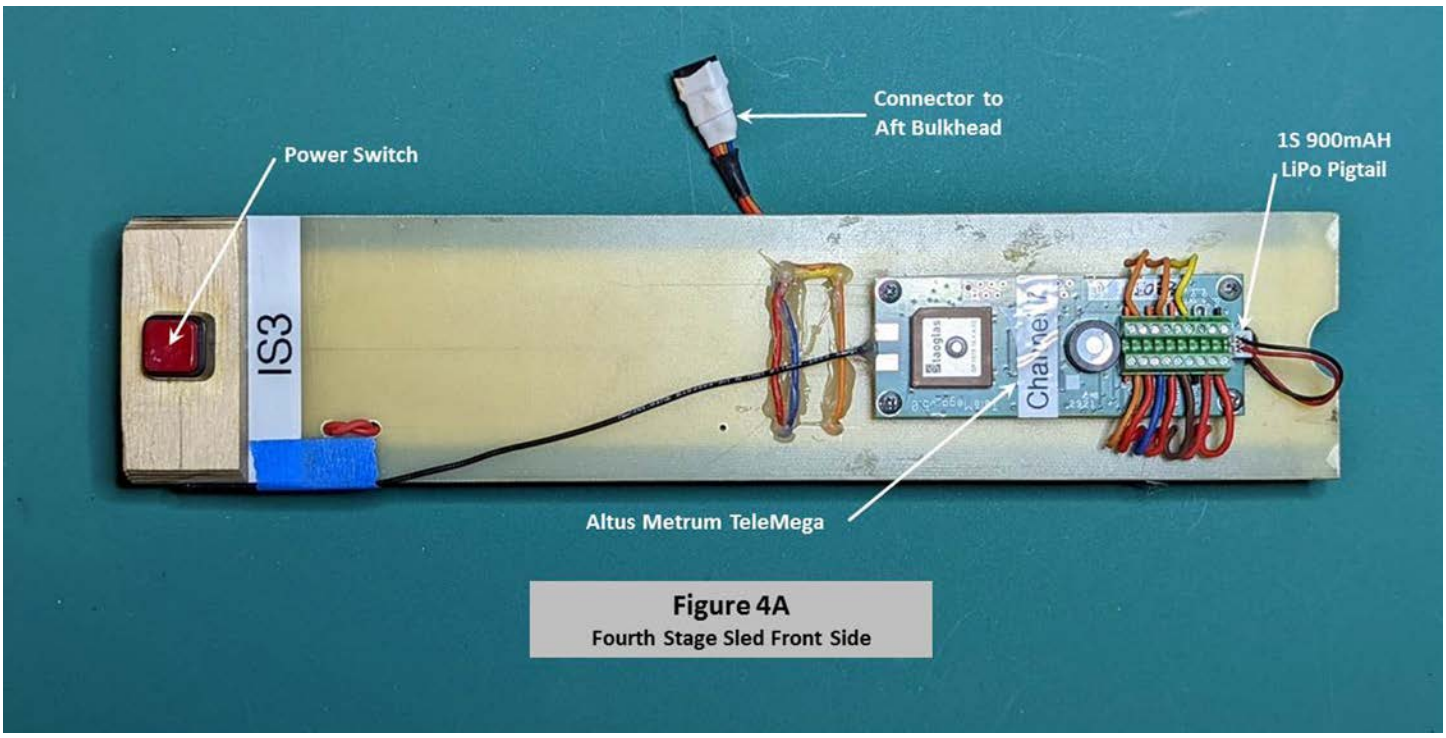


Figure 4A
Fourth Stage Sled Front Side

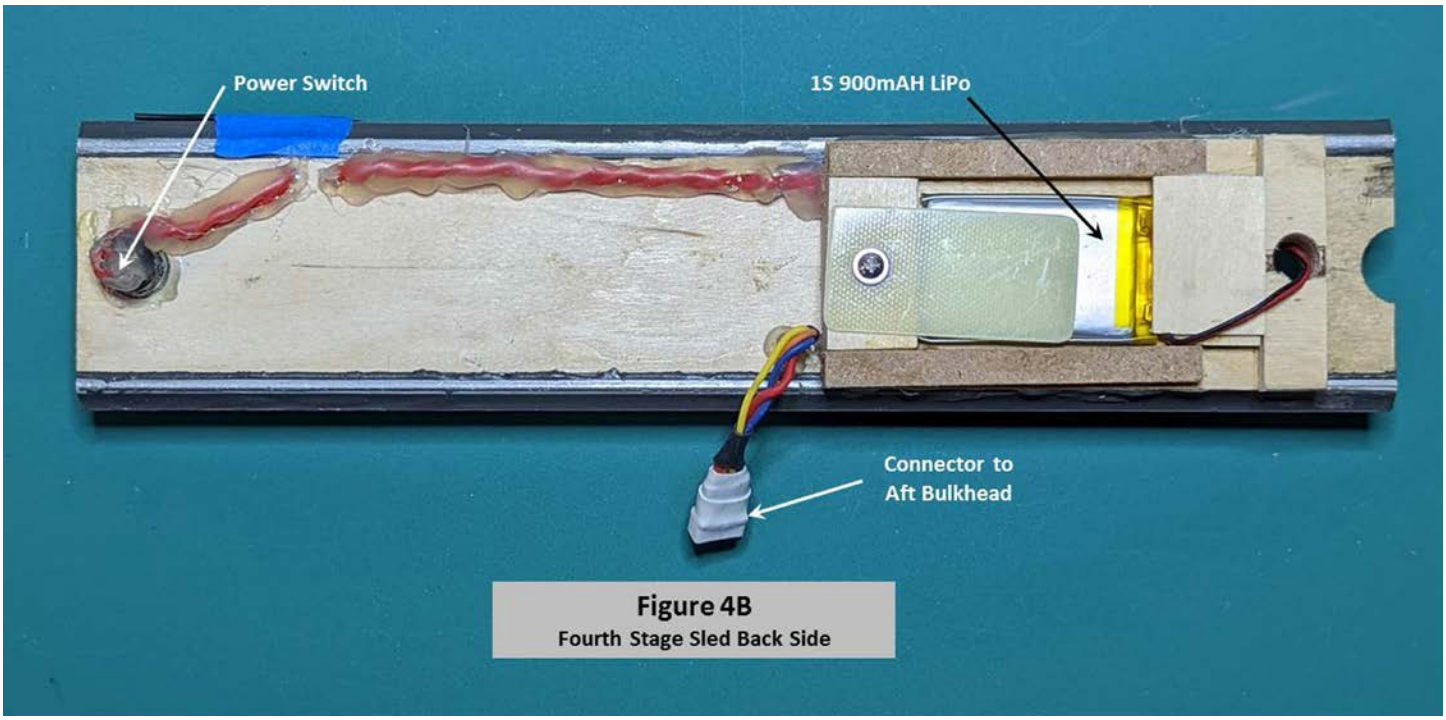


Figure 4B
Fourth Stage Sled Back Side

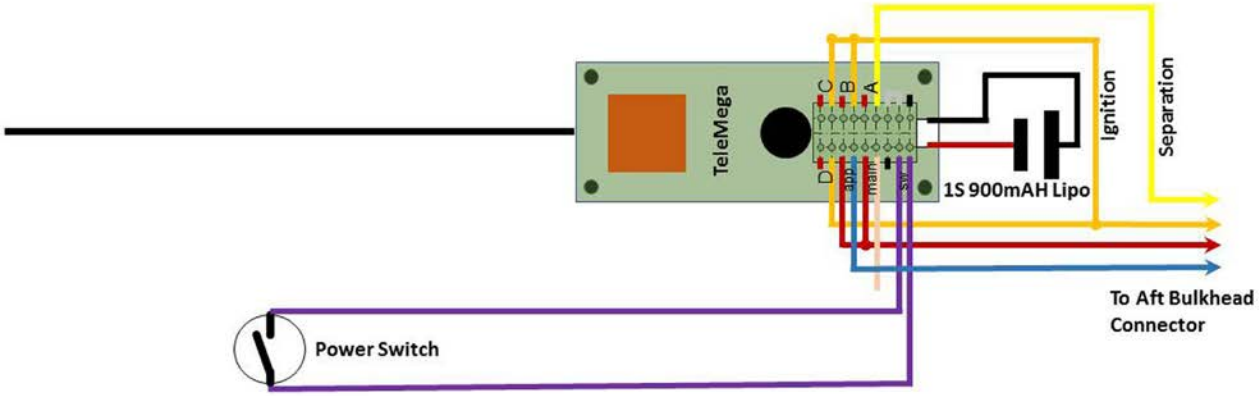


Figure 4C
Fourth Stage Avionics Wiring Diagram

There are some special things about the wiring. Altus Metrum recommends twisting wire pairs together to prevent electrical interference. I also merge the pyro common from all channels to a single lead to reduce the number of wires routed to the aft bulkhead.

The TeleMega has six pyro channels. Two are dedicated to apogee and main deployment. The other four can be used for most anything. I use channel A for separation. I use the other three, channels B, C & D, for motor ignition. This means I can set three different criteria for motor ignition, any of which will fire the igniter. I will discuss how I use this feature in the next installment. Even though there are three channels for ignition, it is not necessary to have three igniters. They can all drive the same igniter. So, I just merge them on the sled to reduce the number of wires to the bulkhead.

All this means there are several terminals that are not wired. Instead of having dummy wires like I did in stages two and three, I put small pieces of wire insulation to occupy unused TeleMega terminals to prevent miswiring.

Sustainer Avionics

The sustainer avionics system is unique in my stack; it is the only one with redundant electronic dual deployment. Primary deployment is done by an Altus Metrum TeleMega which also performs staging and tracking. Backup deployment is by a PerfectFlite StratoLoggerCF. The StratoLogger does not support remote arming, so, I power it through an EggTimer WiFi Switch. I power-on the WiFi Switch on the pad just before raising it to launch position. From there I can use my smartphone to power on the StratoLogger and check pyro continuity. Figures 5A and 5B show the front and back of the sled. Figure 5C shows the TeleMega wiring and Figure 5D shows the WiFi Switch and StratoLogger wiring.

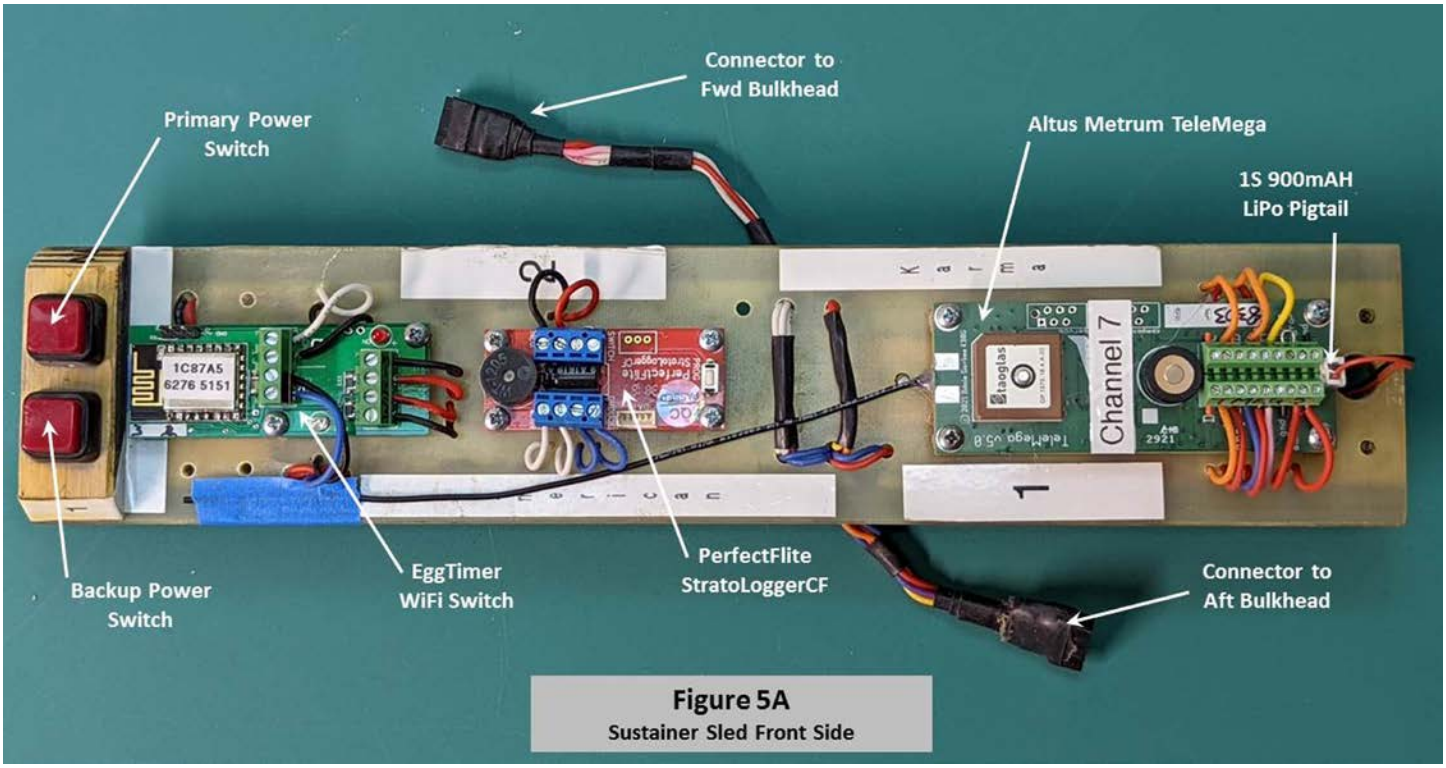


Figure 5A
Sustainer Sled Front Side

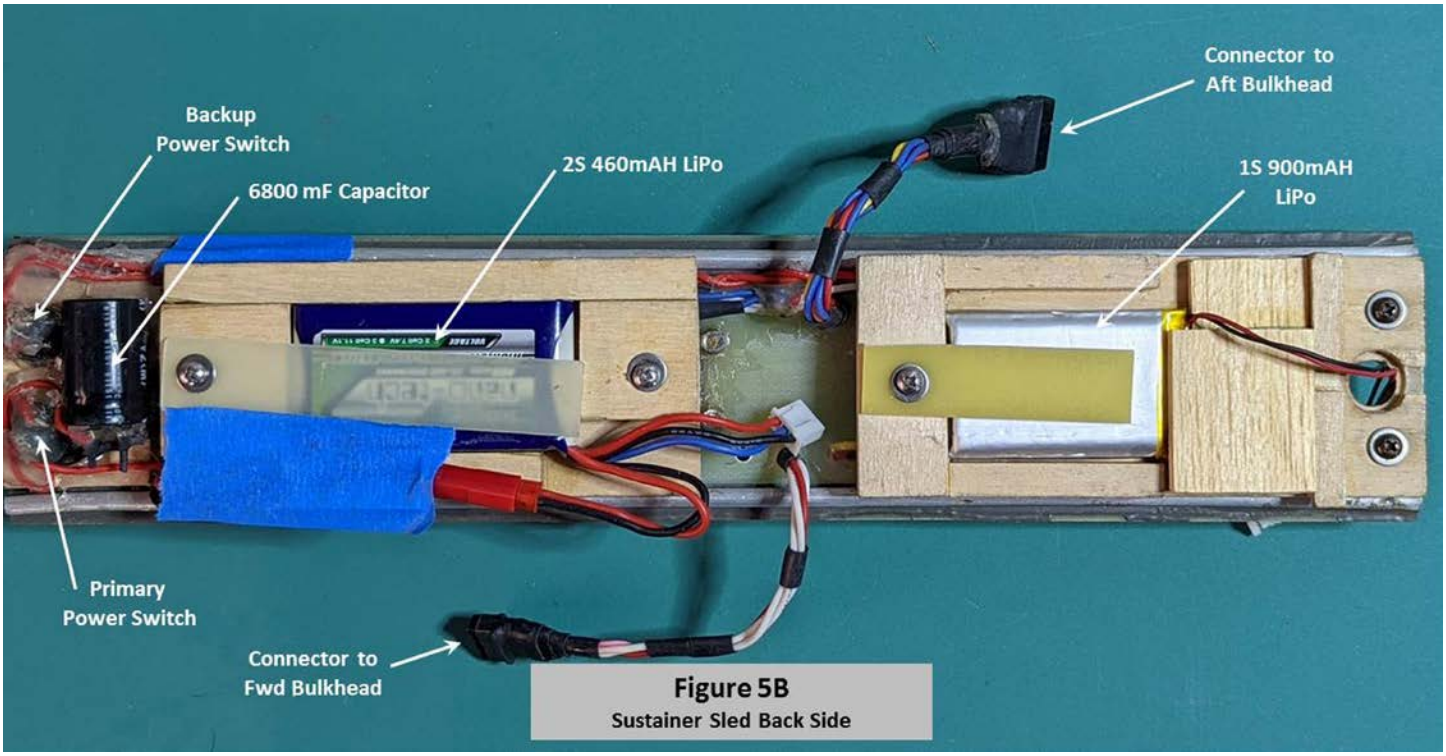


Figure 5B
Sustainer Sled Back Side

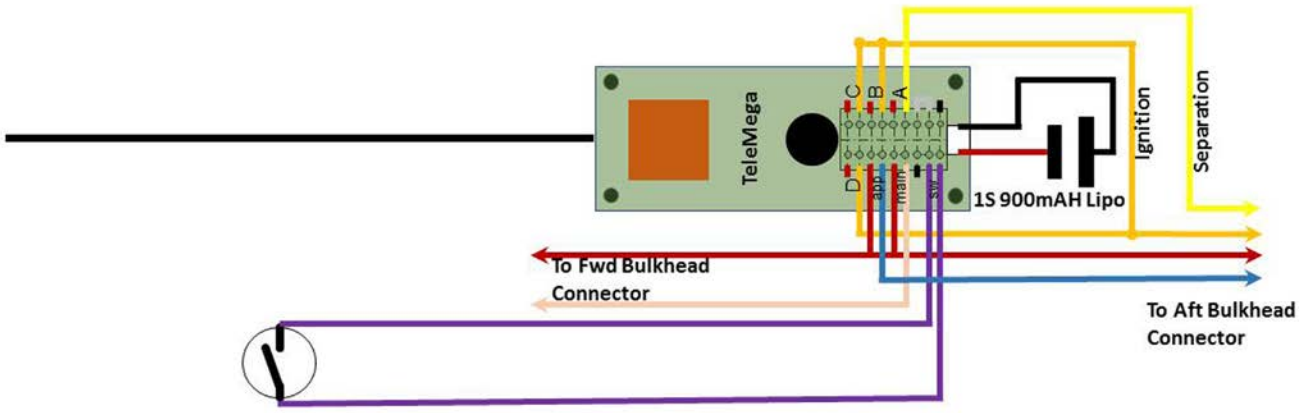


Figure 5C
Sustainer Staging, Tracking and Primary Deployment Wiring Diagram

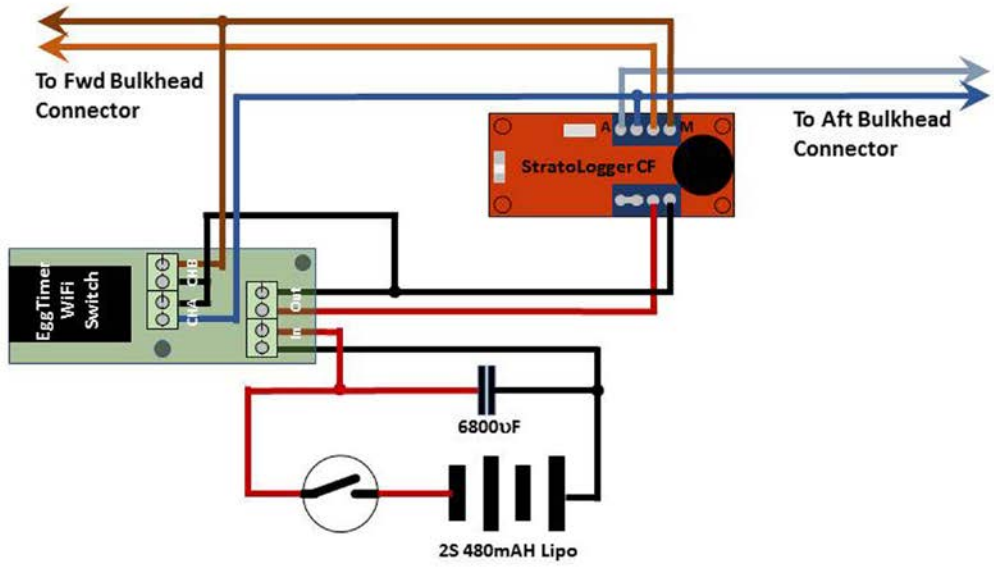


Figure 5D
Sustainer Backup Deployment Wiring Diagram

TeleMega wiring is not much different than that of the fourth stage. The only difference is extending the main and pyro common to a connector for routing to the forward bulkhead.

The backup system is a little more complicated due to the WiFi Switch. Just like the Proton in stage 3, the WiFi Switch does not contain onboard brown-out protection. It will reset and shut off power to the StratoLogger from a momentary loss of power. Just like with the Proton, I provide external brown-out with a 6800 µF capacitor. StratoLogger pyro outputs must be coupled to appropriate inputs on the WiFi Switch so it can sense and report the continuity of those circuits. This wiring is straightforward and shown in Figure 5D. I should note that I built this sled before the advent of the EggTimer Quantum. The Quantum is a dual deployment altimeter with built-in WiFi. Functionally it is like a StratoLogger and WiFi Switch in one unit. I have used it in later designs.

Double Raven Sled

There is one more sled design I'd like to describe even though it's not used in *American Karma* and doesn't support remote arming. However, it demonstrates an interesting technique. It uses two FeatherWeight Raven flight computers: one arms the system shortly after lift-off and the other implements this-high-by-when logic to ignite the motor. My motivation for this design was the extra level of safety it provides during system power-on prior to launch.

The Double Raven design makes use of the Raven's latching feature. Normally, pyro circuits close for just an instant to fire an e-match. However, a latched circuit, once triggered, remains closed until the device is powered-

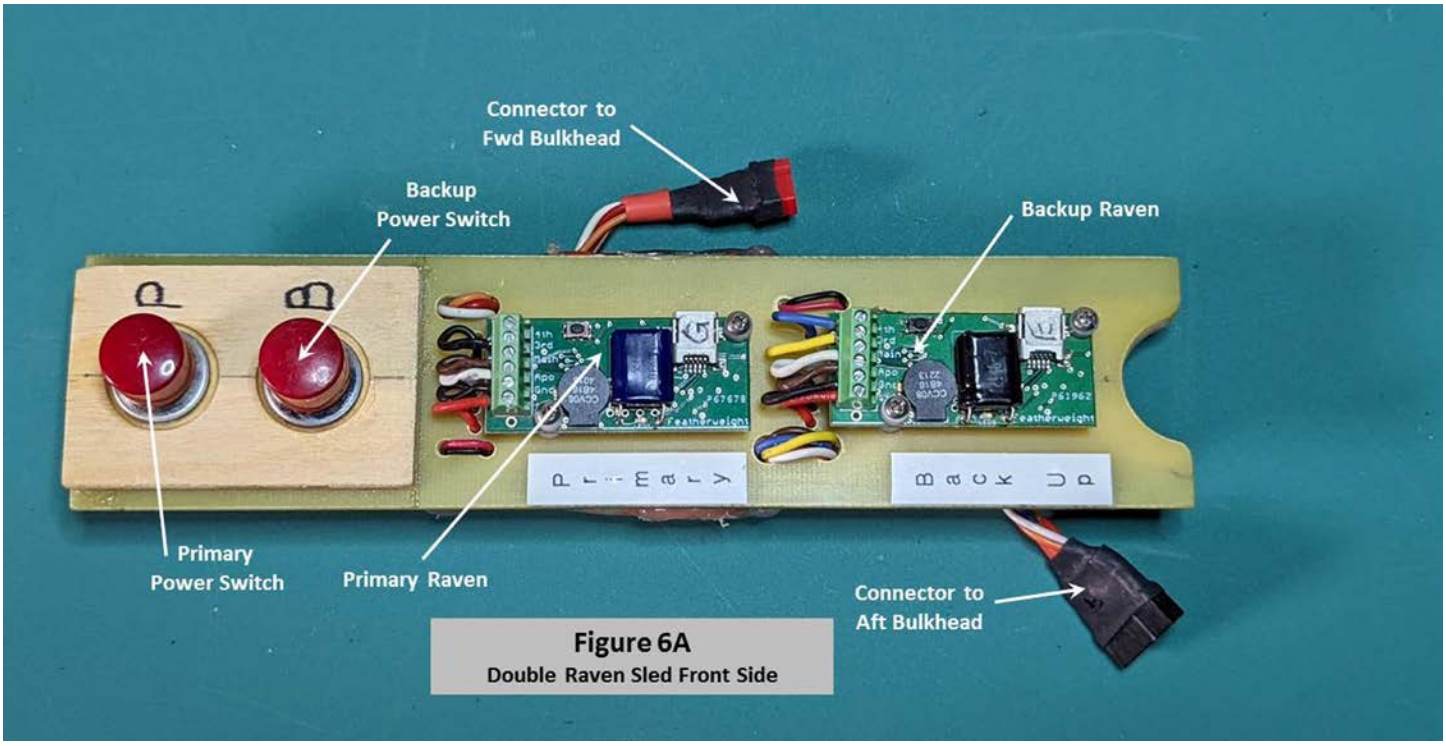


Figure 6A
Double Raven Sled Front Side

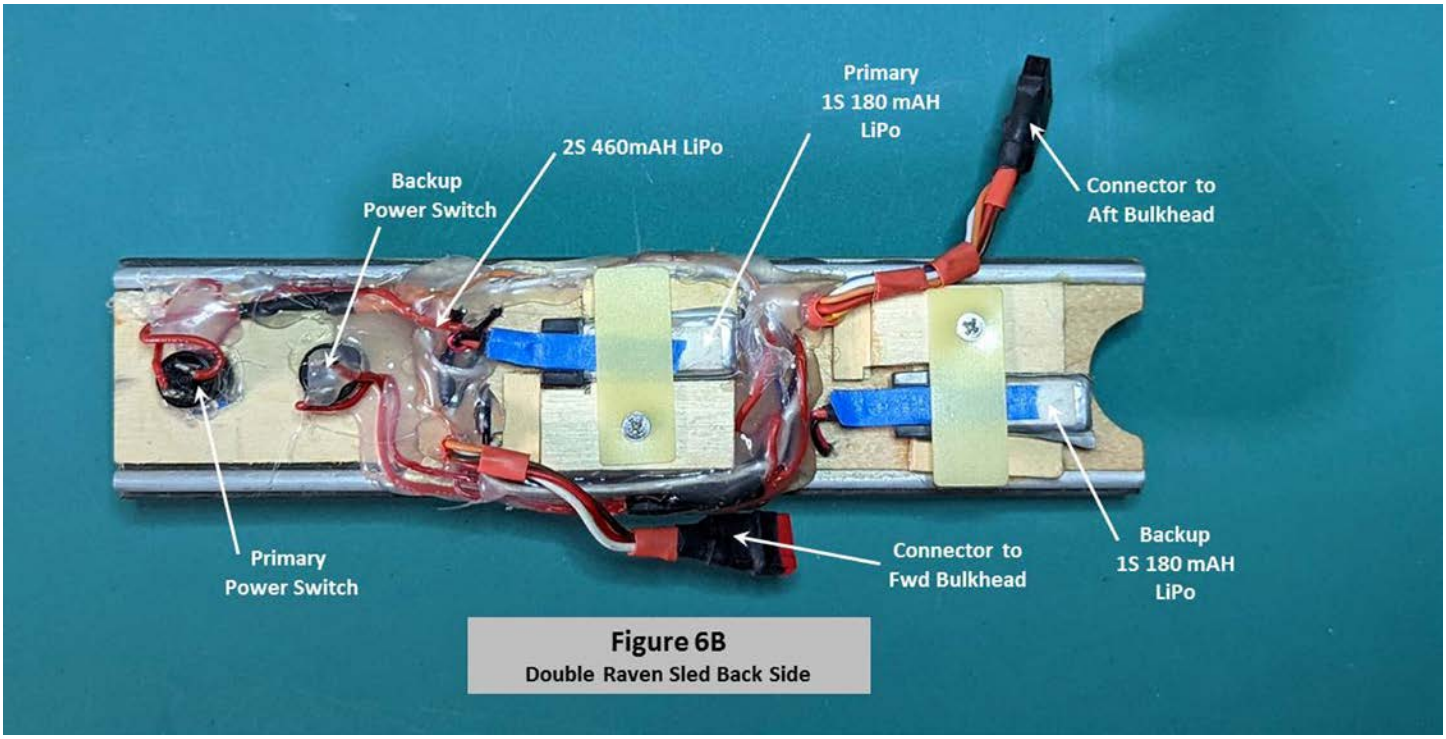


Figure 6B
Double Raven Sled Back Side

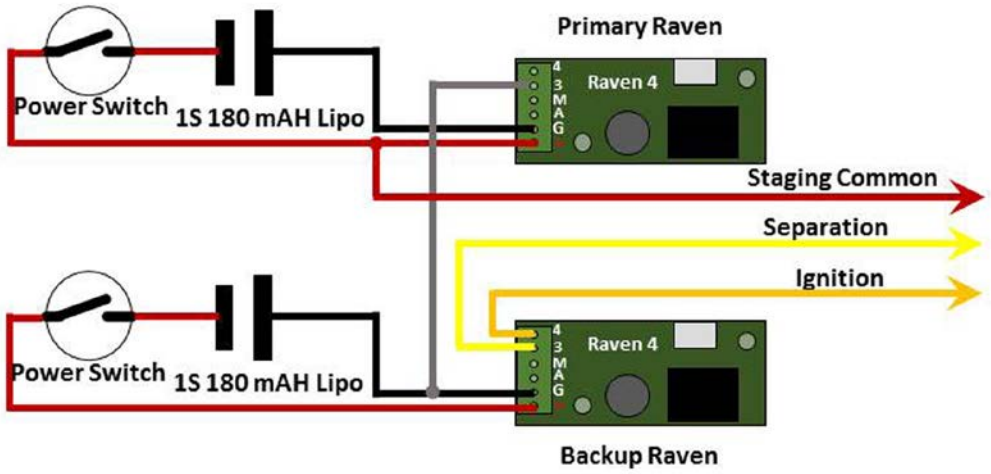


Figure 6C
Double Raven Wiring Diagram

off. Misuse of this feature can damage an altimeter, so be careful.

The two Raven flight computers provide primary and backup recovery deployments. The backup triggers separation charge and motor igniter firing. The primary implements a latching circuit which enables the staging functions of the backup. Figures 6A, 6B, and 6C show the sled front, back, and wiring diagram, respectively. Note, I left out deployment circuitry in Figure 6C for clarity.

You can see how this works by examining the wiring diagram. Each Raven is powered by a dedicated battery and switch. Because I use manufacturer recommended batteries, additional circuitry to protect the Ravens is not needed. Even though the staging circuits are controlled by the backup unit, the staging common is from the primary's battery, so it is the primary's battery that provides the power to staging e-matches. Because the systems are isolated, neither staging e-match will fire. That is where the latching circuit comes into play. As shown in the diagram, pyro channel 3 of the primary Raven connects to the backup Raven's ground. This couples the two Ravens providing a path to ground for the firing current. Even though I haven't used this design in recent projects, I think it's cool and I want to share the idea.

Testing

I cannot overstate the importance of testing sleds once built and before each use. The modular and compartmented design of my sleds facilitate standalone bench testing, a major design goal. After construction, I use an ohmmeter to verify circuit continuity and absence of unintended shorts. Finally, I conduct an end-to-end test with all avionics installed and Christmas tree lights to simulate e-matches. I will describe the functional testing I do before each flight in part five.

Summary

In this installment I've listed the attributes of altimeters and flight computers important to multistage applications. I described avionic system wiring in each of *American Karma*'s five stages and the rationale behind my decisions. I hope this information helps you choose avionic components for your multistage project and enhances your ability to design the necessary support wiring.

But buying components and wiring them together isn't enough. You need to know how to set flight parameters and, more importantly, how to determine their appropriate values. This is a process I call flight design. It is the topic of the next installment.

- Fred Taverni

Rocket Graveyards

By Mark Clark TRA # 414

I believe there are special places where the rockets go when they are lost. I have a vision of places downwind, maybe east of Lucerne, or in a big stand of trees between the corn fields of Kansas, or past the dunes at Black Rock, where there is a fence with all the lost rockets caught in it.

On the bottom dissolving into the soil are the Laser-LOCs with the wooden nosecones, the fiberglass casings of Tealing, Vulcan and Aerotech motors unwinding as the sun bakes the epoxy out of the glass.

Higher up there are the Dynacom Scorpions, starting to have reloadables, a Kosdon or maybe an APS case with its purple faded away on the parts that cannot hide in the shade. There is a BlackSky Optima that has a place there, inside a Timer2 that did its job but was too high and was taken by the winds aloft.

Spray can paint jobs give way to those done by pros in body shops. Up through the layers I see altimeters starting to appear, Rocketman chutes, AMW cases, video cameras, the GPS systems that lost their satellites, and beepers that have long ago fell silent. As I near the top of the pile I see hybrid motors, long and lean, never to make that rumbling sound again.

Photo by Ken Good

I stand here and I look up into a strong wind from the west, out of the sun is another coming to join this special clan, carbon fiber glistening in the sun, the main must have deployed at apogee, the only way anyone gets here these days. It lands short of me; the wind drags it by to become entangled in the fence with the others.

Photo by Darryl Paris

I know miles away someone is looking for this beauty, I could pick it up and return it to the RSO table to be greeted by its smiling owner who will listen to the beeps, brag about the altitude, download the video and show it to the guys at work. But I walk away; this rocket is where it belongs, to become another page of the history of the hobby that most who launch now do not know of and would never understand.

There is one of these places at every launch site, just over the next hill, past the place the strongest walkers stopped, scanned the horizon, kicked a termite eaten centering ring out of the ground and said, “never could have gone this far” and turned around.

VIRTUAL PREFECT MEETING

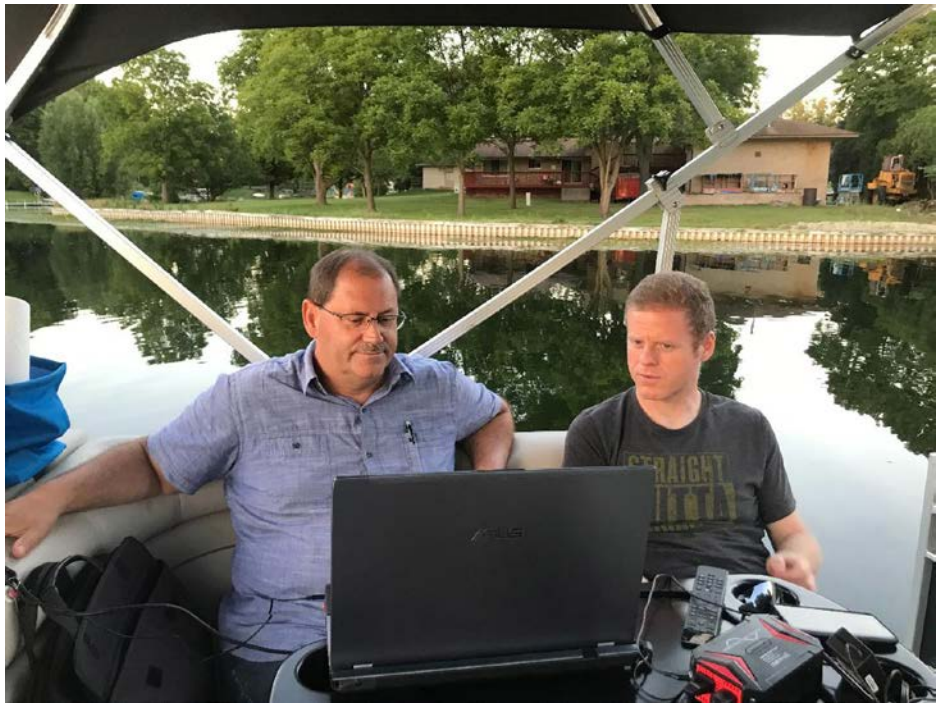
The Pure Michigan Way

Michigan Team-1's three-person Board of Directors meets informally once a month, to discuss prefecture business and prepare for our launch events. In August 2022, that meeting occurred just before a TRA Virtual Prefect Meeting scheduled for 8:00 PM via ZOOM that evening. Prefect Norm Nazaroff is known for having inspired epiphanies, and this was one. Why not kill two birds with one stone, and have back-to-back meetings? And, since the weather is drop-dead gorgeous, why not hold them on Secretary/Treasurer Bob Schultz's pontoon boat *Color Doppler*?

Above: The Color Doppler.

Right: The virtual Prefect Meeting underway on board the boat, complete with scenic background!

Color Doppler has on-board 110VAC power. We brought aboard a 24" TV for use as a monitor, hooked it up to Norm's laptop, and used Norm's smart phone as a hotspot. Vice Prefect Jeremy Smith, an IT professional, took care of the technical issues. Voilà! Instant aquatic Tripoli meeting karma! As the boat slowly circled Lake of the Pines, we joined the Prefect meeting as the sun slowly edged toward the horizon.



About 15 minutes into the meeting, meeting facilitator Gerald Meux incredulously asked about the continuously-changing background "is that real lake scenery passing behind you guys?" We assured him it was not computer-generated, it was the real deal, complete with boats, kayaks, kids swimming, and lake front campfires. Skippy was suitably impressed, and so were others on the ZOOM call.

In this hobby, you gotta get your kicks any way you can!

Robert W. Schultz
Secretary/Treasurer
Michigan Team-1
TRA Prefecture #9

Michigan Team-1

HIGH POWER ROCKETRY IN EUROPE

Johann Peter Marx's L-3 Certification

Johann Peter Marx (aka "Marxi"), from Deggendorf, Bavaria Germany, has gained his TRA Level 3 certification, and has submitted these photos of his successful L3 flight. The flight was conducted at a launch in Cernier, Switzerland on March 26, 2022. His TAPs were Juerg Thuering (Prefect, Tripoli Switzerland) and Andreas Müller.

Johann is pictured on the left with his L3 rocket, a fine-looking Black Brant II (6" fiberglass) before the flight. In the flight sequence photos we see a strong take-off and straight boost on an AeroTech M1297W motor. The rocket then comes in for a perfect recovery on a Rocketman parachute.

Last year, we reported on Johann's successful L2 certification after several years' gap from an earlier attempt. It is good to see that he has continued his progress this year with his L3.

Congratulations, Johann on your successful L-3 certification!

THE DRAKE SAGA

A Retrospective Look at the Development of the First Motor-Feed-Staging Rocket

By Ken Good

Black Rock Dry Lake can be a very unforgiving and cruel place. This applies not just to the environment and to those who may be ill-prepared to wander about on the playa, but specifically, to the annual BALLS events – Tripoli Rocketry Association's premier research rocketry venue. Those who attend, and attempt to fly something adventurous, frequently find out why a sense of humility and a tough skin are important ingredients in the mental outlook of a TRA research flyer. Having been involved with high power rocketry from its beginnings, I have always advised newbies that "if you can't handle setbacks and failures, better look for something else to do with your time." My personal quest to succeed in flying the first "motor feed staging" rocket has reinforced and boomeranged my own words far more strongly than I would have preferred.

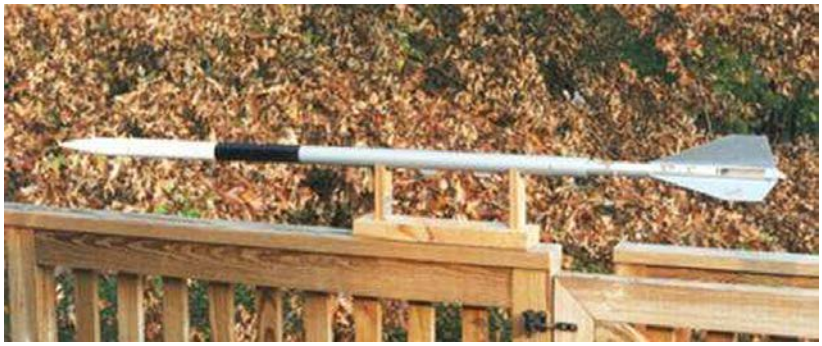
Rack-Rockets and Motor-Feed Staging

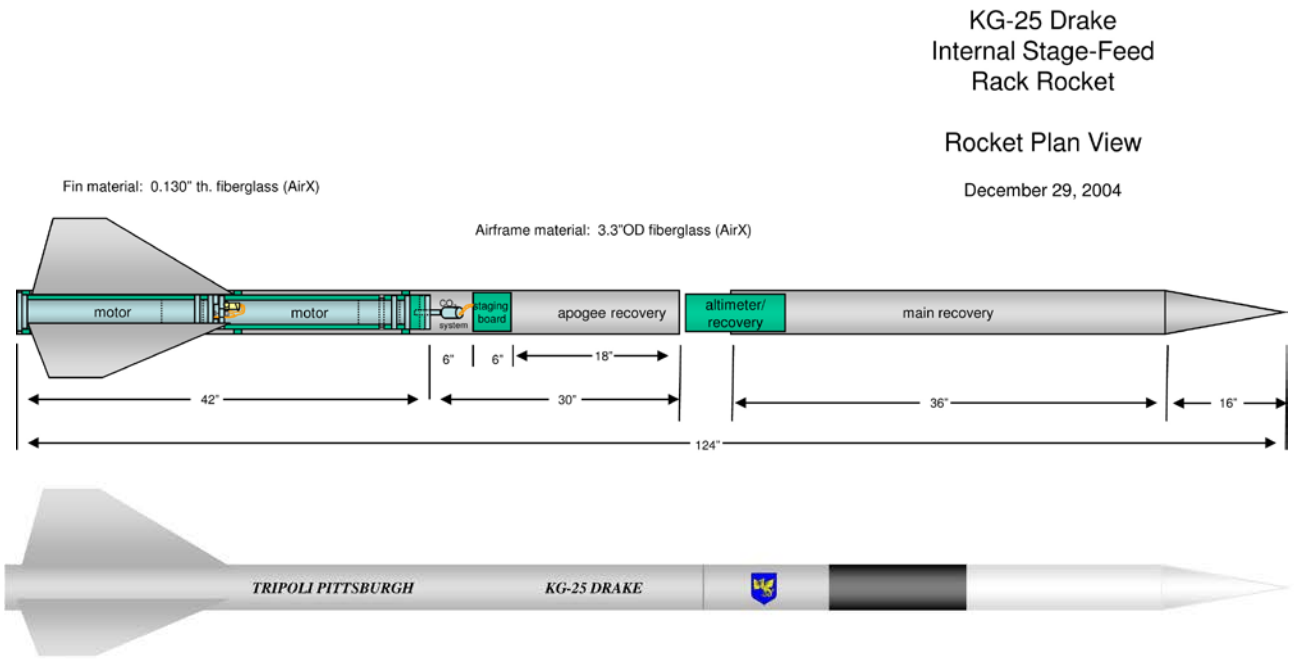
The concept of a motor-feed staging rocket was a personal idea, dating back to my high school days several decades ago. So what is it exactly? Motor-feed staging is, simply put, a means to make a one-piece airframe perform as a two-stage (or more) rocket. The design grew out of my original "rack-rocket" concept, also a staging method to make a one-piece airframe act as a multi-stage rocket. In a rack-rocket, the first of which was the KG-4 Achilles launched in February 1970, the rocket motors are held in-line in an open airframe, each motor/stage being ejected after it is spent, with the next stage firing, in-situ, further forward in the airframe. The rationale behind rack-rockets was to ensure multi-staging/massive-staging could actually work, without the weaknesses of multiple airframe couplings and excessive requisite fin area. Indeed, the Achilles was a six-stage rocket that flew successfully at a time when there were few, if any, successful rockets with that many stages. Several subsequent designs from the likes of Tom Blazanin, Korey Kline, and me flew well with 3, 4, or more stages.

While rack-rocket staging works reasonably well for low to mid-power rockets, there are design limitations. The open airframe, which originally was built up from dowel rods (hence the "rack" nomenclature) and later evolved to drilled or slotted tubes, results in airflow issues and drag. And the rack-structure must be made heat resistant, to prevent structural damage from the exhaust of the motors further forward in the rack. To avoid these problems, it seemed logical to explore a means by which an

Above: The Bellerophon – a three or four-stage aluminum dowel rod rack-rocket designed to fly on single-use 24 mm D/E/F motors.

Below: The Exeter II – a three stage rack-rocket designed to fly on single-use 29 mm F/G motors. In this case, the dowel rod "rack" is replaced by an aluminum tube, with 5/8" wide slots cut into the tube to open the motor stack area and defeat the "Krushnik Effect. "





upper stage or stages could be fed aft and locked to a firing position in a conventional enclosed airframe, ejecting the lower stage/stages as they are expended.

Of course, the idea is reasonably simple, but how it could be realized as a practical, flying rocket was not especially easy to discern. The mechanical difficulties were above my ability to resolve those many years ago, although some spring-driven, ejection gas triggered contraptions were sketched, and quickly discarded. I mentally shelved the idea for a long time, but by the mid 1990's, it was starting to re-emerge in my thinking. By that time, I had some fairly grandiose ideas on where this could lead, including a two-stage O/P/Q-motor rocket (don't laugh, Tom B.!), designed and dubbed Terra Nova. But before anything of that scale could be seriously contemplated, it would help to actually fly a proof-of-concept rocket first, using some type of actuation method that could be scaled up. Brainstorming sessions about motor-feed staging with Tripoli founder and friend, Francis Graham, resulted in him having separate subsequent discussions with Tripoli Pittsburgh member Richard Dietz. Richard assembled a possible motor-feed actuation device, largely reliant on spring tension and using single-use G-motors. It was presented to me for evaluation, and while it looked as though it could be integrated into an airframe, and possibly made to work, I felt it was not likely to be scalable to high-power motors, and thus was a design dead-end

It was clear that a more practical way had to be considered to force a "stack" of potentially weighty motor stages to move in the direction and distance required. An obvious method to move something within a flying airframe is one we all use to push out recovery devices – gas pressurization. Ejection gas is most commonly generated by black powder charges, but a cleaner and more measurable method was seen with Tom Rouse's CD3 CO_2 recovery system. This was determined to be a preferred direction early in the design concept phase. Also, while the old rack-rockets of years ago happily spit out single-use motors to tumble freely to the ground, clearly we couldn't just start ejecting J, K, L or larger motor cases out of an airframe. Each ejected stage's motor would need to be enclosed in a recovery tube – essentially a modified motor adapter with a re-

The most essential element of the first Drake design, as fabricated by Eric Haberman. Three steel rods form the motor/sabot rack. The actuating piston and Rouse CD3 unit are on the upper right.

covery device, and which I referred to as a "sabot." It seemed feasible that a proof of concept rocket could be 3" in diameter, using two stages of 54mm reloadable motors in the J-K impulse range, and employing the Rouse CD3 CO_2 system as the actuation method. Thus was born the KG-25 Drake, as a precursor to the larger and more ambitious Terra Nova.

The Drake Moves from Concept to Reality

By 2003, fairly detailed drawings of Drake were taking shape, and in 2004, Eric Haberman, of Dynacom/AirX fame, agreed to be the principle engineer and component fabricator for a finalized design. As the project progressed, additional members of the Tripoli Pittsburgh prefecture formed a project team, with an initial test flight targeted for BALLS 15 at Black Rock, NV, in September 2006. Eric and I exchanged several iterations of detailed designs and conducted extended discussions to address perceived problems before agreeing to a firm direction, based upon a three-rod framework enclosed within a 3.3" Dynacom fiberglass airframe. Sliding on the framework would be two motor/sabots, one for each stage. Forward of stage two and attached to it would be a locking piston, which would be driven aft when a Rouse CD3 unit - triggered by a G-Wiz flight computer - pressurized the airframe space forward of the piston. When the correct position was reached, the stage 2 sabot would lock in place with a ball/detent mechanism designed by Eric; a simple switch connected to a battery and an igniter would be tripped and fire the stage 2 motor. The stage 1 sabot would be ejected by this movement of the sabot-stack, recovering on its own parachute.

By the late summer of 2006, the assembled airframe was available for ground testing, which turned out to be more challenging than expected. The inner framework had some inherent friction, exacerbated by a need to lengthen it to accommodate higher impulse motors than originally envisioned; an AeroTech K-1100 for stage 1 and a K-550 for stage 2 were the final motor selections. A great deal of trial and error ensued, not least of which was identifying the correct-size CO_2 canister to ensure reliable movement of the motor/sabot stack. But in the end, the Drake was ready for transport to Black Rock for its test flight at BALLS 15.

First Flight Test – BALLS 15

The events leading up to the Drake's maiden flight at BALLS could be viewed as a case study in how not to prepare for the flight of a complicated rocket which employs a novel flight profile. I had run many simulations, and knew generally what to expect…. or at least I thought I knew. My most nagging question was one that couldn't be simulated – would the rocket remain stable when the motor/sabot stack made its transitional movement from a stage 1 to a stage 2 firing configuration? Both configurations were stable, in and of themselves. But no one had really tried this actuation method before, so there was no reference data for how a moving rocket would react when a sudden internal mass-shift would alter the CG/CP relationship in quite this way, while the rocket was still ascending.

It would turn out that this wasn't the most serious worry – it was flight prep that would become the real issue. The context of BALLS 15 for the Drake team was this: I was TRA president at the time, and as such, many people wanted to speak with me while I was trying to focus on preparing the rocket. This was usual any time I attended an event and actually attempted to fly something. Also, we had a reporter on hand – Patty Brown from the New York Times. It was my responsibility to work with her, and to try to "manage" a story about TRA, BALLS, HP rocketry, the ATF litigation, etc., and it appeared at first that it may not have been Ms. Brown's intention to be especially flattering to us. (see the NYT's "**A Cult of Backyard Rocketeers**").

The first Drake, assembled and ready to fly.

This meant I was pulled away numerous times to assist with her fact-gathering effort. The Drake team, no doubt relying on me as the project manager to be present and available, tended to go off somewhere else when I was otherwise engaged, and it was difficult to have the people on hand who were needed when I could get focused again. All of this may seem to be an excuse for what occurred, but analyzing the facts afterward leads to a firm conclusion that errors were made because focus was lost.

After many long hours of getting the Drake ready, it was finally taken to the pad on the morning of October 1, 2006. When the LCO pushed the launch button, it flew briskly upward on stage 1…. and just stage 1. After a modest boost, Drake arced over and pushed out its drogue parachute, followed by the main at 1000 ft. While we were contemplating why stage 2 never fired, an even more unexpected event happened – just as the main 'chute fully inflated, stage 2 ignited! The BALLS crowd was then amused by a comical "fire dance on a parachute." After motor burn-out, the Drake's smoking airframe drifted in for a landing.

The post-mortem wasn't pretty. It was clear that the sliding motor sabot sequence did not fully take place. The first stage sabot had fallen free at some point, but the second stage had not locked into firing position. However, in the recovery phase, the main parachute deployment had jostled the second stage sabot such that although it was not locked in place, the firing switch was triggered, resulting in the sabot shooting back forward into the airframe with the motor burning out the guts of the rocket - all while twirling furiously on the parachute. After cursing the G-Wiz board for not firing the Rouse CD3, I disassembled the CO_2 unit and found the trouble. The CD3 arming charge had fired, but I had failed to block the extra, unused e-match hole (although I had done so many times during ground tests), and the pressure needed for the puncturing piston to hole the CO_2 canister had been lost. No CO_2 pressure, no motor-feed staging. As a result of the stage 2 motor actually burning well inside the airframe, the main internal components of the design were destroyed. Too many distractions coupled with too little verification of prep steps meant that the project manager had killed the project.

The original Drake team – Christine Rial, Dave Rose, Joe Pscolka, Ken Good, Ernie Marsh, and Tom Blazanin (Eric Haberman and Francis Graham not pictured). All trusting that the rocket is ready for flight.

It could have all ended there. It was a sore disappointment, especially since we had every reason to believe the Drake would have flown as designed, but for the simple mistake of not blocking a tiny hole. But there were more lessons learned. As designed, there was no easy way to "safe" stage 2 if it didn't fire. That parachute dance showed how dangerous such design naiveté was. If the Drake was to be revised and rebuilt, a fail-safe method for stage 2 had to be part of the design.

Drake takes off, headed for what we hoped would be an historic flight.

But immediate renewed effort did not occur. Years passed, and the original project team, or many of them, went their own way onto other projects. Critically, the often-elusive Eric eventually "got out of rockets" for a period of time, and the original design would be difficult to replicate without his expertise and access to the machining equipment used to fabricate vital components. Although the team discussed a Drake II and how it could be built, other priorities got in everyone's way, and 2007 – 2009 passed with no real activity.

Reboot – Drake II

Maybe it was stubbornness, persistence, or just plain foolishness, but I couldn't let it go. We hadn't given the motor-feed staging concept a realistic flight test, and I was chiefly to blame. I had held some misgivings of the complexity of the original design, including the nicely engineered framework and locking mechanisms, and I felt a simpler approach could be made into a more reliable flight vehicle. In late 2009, a project team was re-formed around several revised design directions, which included:

- Elimination of the internal rack structure, but retention of the Rouse CD3 unit.
- Two 54 mm motor sabots, fitted with centering rings to slide along the inside diameter of the 75 mm ID airframe. A K-1100-stage1/K550-stage2 combination was retained (for this and all other Drake II flights).
- Both sabots notched to match an anti-rotational guide, screwed to the inside of the airframe
- Stage 2 sabot using a special spring-pin assembly to lock it into the firing position. Two pins are oriented at 180^{o} of each other, and extend into two corresponding locator holes in the airframe when the sabot is pushed to the lowermost position.

The question remained of how best to trigger the CD3 unit, but also provide stage 2 ignition with a "safe mode" to defeat ignition in case the stage 2 sabot did not lock into firing position. A simple staging board would not meet both requirements. After several tentative electronic possibilities were considered, involving off the shelf flight computers/boards, timers, relays, switches, etc., no combination of which seemed to be ideal, Tom Blazanin suggested contacting Tripoli Pittsburgh member Dave Cooper about burning a custom board to meet the exact requirements. "Coop" was eager to join the team and to provide the needed custom board. The "Cooper board" was quickly fabricated; its design features included:

- G-switch triggering
- Programmable timing to initiate an output to fire the Rouse CD3 unit
- Programmable timing to initiate an output to fire stage 2
- Connectivity to an interlock switch (on sabot #2) that would only close if/when the sabot was in firing position – no fire of the stage 2 output unless this switch is closed.
- Programmable timing to shut down all outputs after the specified time if continuity to the interlock switch is not sensed.

This board addressed all flight profile requirements, including the safe mode to ensure stage 2 ignition could not be triggered outside the desired ascent phase timing window. Ground testing proved that the board functioned perfectly.

Drake II is built – a new motor-feed process is tested

In early 2010, work was initiated on constructing the Drake II rocket in accordance with the new design. To achieve the goal of having the rocket ready for a flight test at BALLS 19 (Sept. 24-26, 2010), the project team was tasked with specific responsibilities and associated due dates, all tracked on a proper project plan. The Drake II team was comprised of:

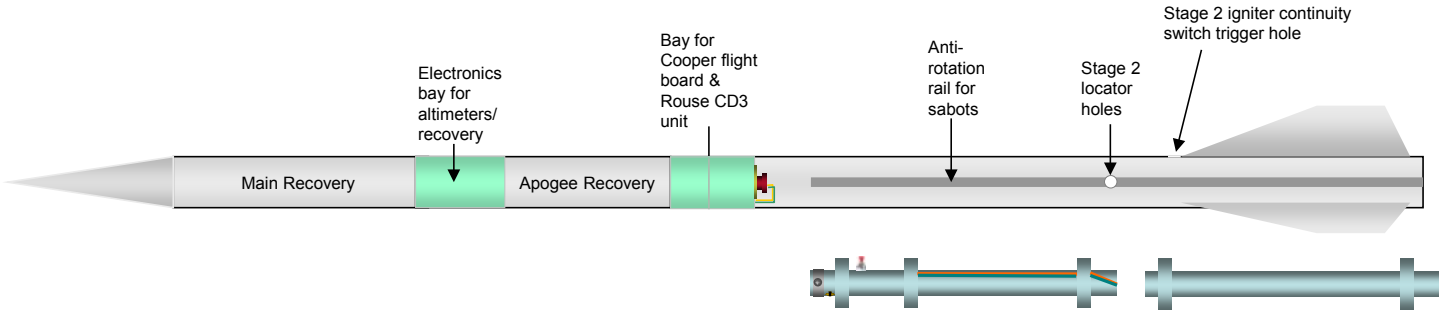
Ken Good – project manager; Tom Blazanin – fabrication/finishing; Dave Rose – fabrication/graphics; Dave Cooper – electronics; Francis Graham, Larry Benek, George Pike, Jim Callahan – testing/consultation.

By late July, Tom and Dave had provided a completed airframe, ready for ground testing. Time was tight, but the project was moving along, until ground test #1 revealed the first obstacle. This test focused on verifying the revised motor feed actuation configuration. The Rouse CD3 unit would be manually fired and the sabot #1 ejection/sabot #2 locking actions would be confirmed. It had been assumed that the spring-loaded locking pins would extend outward once the airframe locating holes were reached by sabot #2, locking it into place. But in our first test, not only was sabot #1 energetically ejected, sabot #2 went sailing right out of the airframe as well! Repeats of the test, including adjusting the locking pins' spring tension, yielded the same outcome. Clearly, the pins just couldn't spring out in time to arrest the aft-ward motion of sabot #2. Time for a re-think.

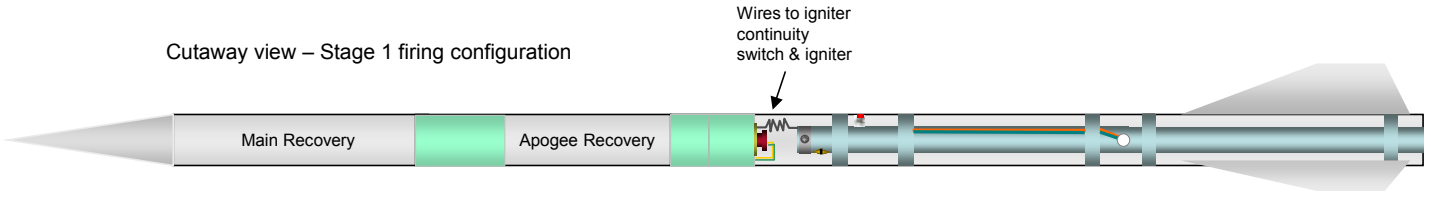
It was clear that we had to ensure a positive stop of sabot #2. We arrived at the solution of building up a reinforcement point behind the internal nut for the lower rail button, notching sabot #1's centering rings

DRAKE II - 2009-2010 DESIGN DRAWINGS

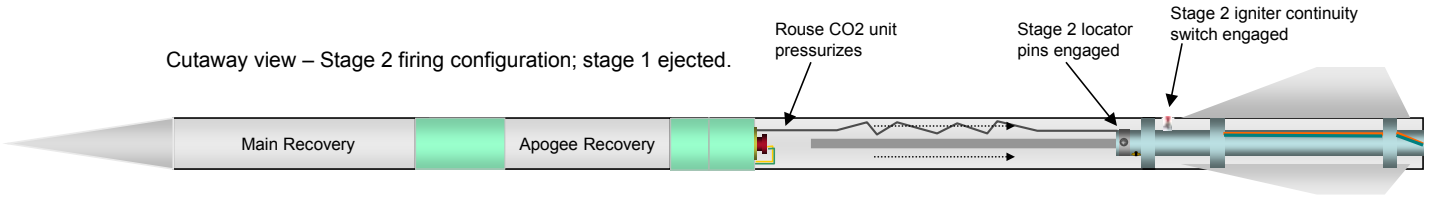
Components & orientation - cutaway view



Cutaway view – Stage 1 firing configuration



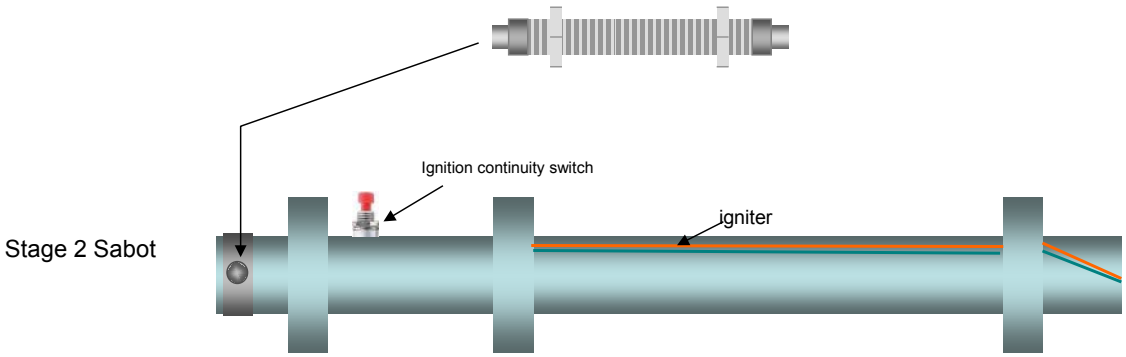
Cutaway view – Stage 2 firing configuration; stage 1 ejected.

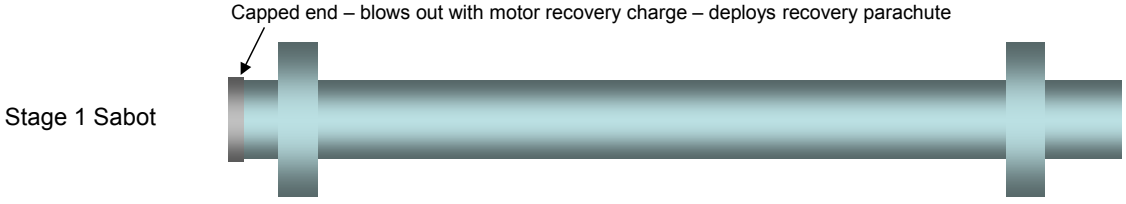


Staging sabots – detail view

Stage 2 Sabot locking assembly – exploded view

Stage 2 Sabot locking assembly – assembled view





Drake II, assembled and painted, prior to adding graphics, but tested and ready.

to clear it, but not sabot #2. Sabot #2 would have to be loaded from the forward end of the airframe, and when the stack was pressurized, sabot #2 could only go aft as far as the stop. Tom made the changes, and further ground tests (some necessitated by a nagging issue with the Rouse CD3) eventually confirmed that this change permitted sabot #2 to lock in place with the spring-loaded pins, and also that the pop-up interconnect switch to arm the stage 2 firing circuit functioned correctly. In the few remaining days, Drake II was readied for the trip to Black Rock.

BALLS 19 – Drake II's first flight test

I had certainly learned some lessons about prepping a complicated rocket while in the presence of many rocket friends, not least of which was to get as many prep steps out of the way in the cramped solitude of my room at Bruno's! This version of the Drake was actually easier to prepare, and the distractions of BALLS 15 just weren't on my plate this time around (I wasn't even TRA president by then). Also, a very detailed checklist was followed to ensure nothing was missed.

Accordingly, the Drake team had every expectation of a successful flight. The rocket was ready to fly on the fine, clear morning of September 25, 2010. We did not envision a repeat of the BALLS 15 fiasco, and we didn't get one. What we did get was another strong boost on stage 1's K-1100 motor, followed by a clear ejection and parachute deployment of that stage's sabot, followed by.… nothing from stage 2. The Drake II recovered perfectly, and as we trudged out to retrieve it, we were perplexed about what could have happened. When it was examined, it was clear the mechanical actuation had worked as designed, but we failed to light the stage 2 motor. The post flight assessment was summed up in a message I sent to the project

The Drake II project team readies the rocket for its first test flight.

team and interested parties on September 27:

Drake II Project Team:

Drake II flew as planned at BALLS 19. The staging mechanism and scheme worked perfectly. However, stage 2 did not ignite, and I think it was because the igniter we selected, despite passing direct 9 volt ground tests, did not get enough current or duration to fire when driven from the flight

board. An enhanced e-match should have been used, but was not.

What was learned:

1) The mechanism and scheme works very well.

2) Stage 1 ejection and recovery was perfect.

3) Stage 2 movement and locking was perfect.

4) No disturbance to flight trajectory, or any flight path anomalies at all, were observed by the motor feed process. A normal upward flight path was all that was observed.

My thanks to all who worked hard to make this flight happen. Clearly, it was a partial success, and a partial failure. We proved "motor feed" but not "staging."

Future plans for Drake II or Drake III???? Don't know. Much disappointed at the moment, and not convinced of any future plans for this or other of the KG series.

Ken

I was obviously very upset, and was initially ready to just walk away from this project and others, and follow my own advice of "better look for something else to do with your time." I needed some time to cool off and mentally heal. It is at times like these that one realizes how much emotional investment can be plowed into making dreams into realities, and just how deflating it can be to experience a reality that falls far short of the dream.

Drake II, 2011 – Trying it again

Through the winter and spring, I regained the desire not to let the project die, and the Drake II project team agreed that there was no reason not to give it another try. The BALLS 19 flight had proven most of the design, including the safe-mode for stage 2. Actually, the rocket had suffered some minor landing damage, and the reinforcement material of the sabot stop point was also found to have cracked. This latter issue appeared to be the result of the very energetic way that sabot #2 slammed home and locked in place (no doubt repeated ground tests and the actual flight had not helped). Tom made repairs to both areas, and added additional internal reinforcement for the stop point. Limited ground tests were conducted, if only to preserve the components, but everything looked promising for another flight at BALLS 20.

So on yet another October 1, a Drake flight vehicle made a test flight at a BALLS event. Hopes were high that we would nail it this time – there appeared to be no reason it should fail. Repairs had been made, a lower current stage 2 igniter had been selected, the rocket was thoroughly tested and carefully flight prepped. Surely, this iteration of the project should see success. But once again, we experienced almost a repeat of the flight of the previous year. The boost on stage 1 was fine, that stage's sabot ejected (but stripped its recovery parachute), and again stage 2 just didn't fire.

The Drake II takes off at BALLS 20.

The team frustration, and mine especially, was tangible and vocal – some of our expressions are not fit for print! When we recovered the rocket, a brand new failure mode was detected. In this case, the "impact zone" on the sabot #2 centering ring had cracked when the sabot hit the stop point, which had been strengthened with an aluminum block as part of the rebuild. This damage permitted the sabot to slide just a few

millimeters too far aft, bending the locking pin tube. The pins stayed locked and likely would have held had the stage ignited, but the excessive travel meant the stage 2 interlock switch went past its pop-up hole, jamming the switch in an open position. Thus, the Cooper board never sent the output to the stage 2 igniter, since it sensed that the sabot was not correctly locked.

After my return home, I once again questioned whether this was a fruitful endeavor. An excerpt of a message to Francis Graham is telling: "I am just not sure whether the time spent on this project, or on anything in rocketry, has a point, or is important enough. Maybe I'm spinning my wheels and wasting time I'll never get back."

Drake II, 2012 – "Grim determination"

I suppose it may be most accurate to say I got extremely annoyed. This damned rocket just wasn't going to beat me, and I became willing to wrestle with the beast until it behaved as it was supposed to. Fortunately, every failure offered something new to be learned, and a path toward an improved design was revealed. In particular, it seemed to me that we were beating the innards of the rocket to death with the CO_2 pressure actuation. I became convinced that the generated pressure was likely too high, and the shear pin we were using to retain the sabot stack before sabot 1 ejection may have been too strong, thus exacerbating the violence of the movement when the pin finally let go. These would be the improvement points on which a renewed Drake project would be based, with the intention of another flight test at BALLS 21.

The first efforts for the next try were conducted by Tom, who repaired/rebuilt the sabots. The project team was then able to focus on a series of ground tests from late July through early September to verify the results of the changes we felt were needed. All aspects of the flight profile were tested as much as was possible. The salient changes from the last flight attempt, confirmed through testing, were:

- Research into the actual atmospheres of pressure generated by 12 gram versus 16 gram CO_2 cartridges revealed that the 16g ones, used consistently from the time of the first version of the Drake, were excessive for the calculated volume which would be pressurized. A switch to 12g cartridges verified that they were more than adequate.
- A lighter duty plastic shear pin was selected to retain the sabot stack prior to the actuation sequence, this pin failing at a lower internal pressure than the previous type used.
- Inconsistent lighting of the stage 2 igniter in testing revealed that only a low-current type would be the correct selection for the output current level and duration of the Cooper board.

Final preflight work was completed several days before the Tripoli Pittsburgh trailer left for Black Rock. We all believed that the changes and exhaustive testing regimen had positioned us to see success with the Drake II this time around.

BALLS 21 – The Drake II fulfills its promise

It was both startling and somewhat intimidating to realize that we were now going to flight test the motor-feed staging rocket concept for the fourth time, including the first version of the Drake. I think I was acquiring a "whipped dog syndrome" - sort of just waiting for my next beating. Of course, having a healthy degree of pessimism going into the flight test guaranteed that at worst, I wouldn't be excessively disappointed, and at best, I would be overjoyed. My logical side told me that we had been thorough, and if the rocket was properly prepared, it should work. But it's hard to wholly trust logic when we had found so many fluky ways for the project to stumble.

The Drake II arrived as planned with the Tripoli Pittsburgh trailer in advance of my arrival at Bruno's on Thursday September 20, 2012. Drake team members who had made the trip were Larry Benek, Tom Blazanin, Dave Cooper, George Pike, Dave Rose, and me. Preliminary flight preparation work was conducted as soon as we arrived at the BALLS 21 launch site on Friday, September 21. We determined that although Friday's flying weather was excellent, we should not rush the preparation, and would regard Saturday as the likely launch day. In any case, several members of the Drake team were also engaged with the NASSA Q-motor Phoenix project, which likewise was intended to fly on Saturday.

The author with Drake II, ready for flight at BALLS 21.

As part of initial flight prep, it was deemed wise to conduct ground tests of the Cooper board to verify functionality, in case any shipping issues had occurred. Accordingly, the board was prepped to fire the stage 2 igniter through the wiring harness, and a test bulb was fitted to the circuit #1 output (Rouse CD3 unit). This test failed - the Rouse output circuit bulb lit for about 1 second as expected, but there was then a no-fire of the stage 2 igniter circuit, followed by a steady flashing of the circuit #1 bulb until the Cooper board timed out.

This was a most troubling situation, since the symptoms actually mirrored a similar test fault observed by Tom Blazanin and me in August, prior to the board having been submitted back to Dave Cooper for rectification. Coop was consulted and was unsure of the cause of the error, since the behavior of circuit #1 was not in keeping with the logic of the board. It was not possible for him to troubleshoot this fault without reference to the board's code, which he did not have on site.

After much consultation, it was theorized that the characteristics of the 12V automotive bulb may have been spoofing the board logic, perhaps due to the bulb sustaining continuity. In any case, Coop and I agreed that running a full test with actual igniters/e-matches, as would be flown, was in order. When this test was conducted, it performed as designed. The test was repeated to verify results, and again, the board functioned as designed. Accordingly, the decision was made (not without some worry) that the test flight should proceed.

The remainder of the day was spent in fully prepping the rocket, the only remaining operations needed before flight would be the insertion of both sabots, bolting in the Rouse/Cooper avionics bay, and joining both airframe sections.

Tripoli Pittsburgh/NASSA attendees arrived at the launch site early on Saturday, with the intention of focusing on final prep work of both the Drake II, and the NASSA Phoenix. Both projects were flight ready by 9 AM. It was agreed by all that as soon as the FAA window and flight conditions permitted, the Phoenix should be given priority, since Drake II could fly with less optimal conditions. However, cloud cover was an issue for the NASSA rocket all morning, and although partial openings materialized, BALLS flight operations could only obtain a 16K FAA window by about 10 AM. Re-conferring on the situation, the decision was made to proceed at once with the Drake II, since it was not clear when any higher flight windows would be available for the Phoenix – and it appeared such a wait could be lengthy.

The Drake II was then cleared through the RSO and LCO, and walked to one of the 1000' pads by Dave Rose, George Pike, TRA Board Secretary David Wilkins (acting as assistant and photographer), and me. There was a bit of a muddle due to the pad requiring some quick crescent-wrench work to tighten a loose assembly bolt, but once BALLS RSO Bill Robinson had provided tools, the pad was repaired, and the Drake II was slid onto the rail and erected to a vertical position.

Altimeter switches were armed, followed by the Cooper board. I inserted a special quick-light igniter for the first stage, kindly provided by Bill Good. With a call to the LCO, the Drake II was announced as ready for flight – at approximately 10:30 AM. Moving to a safe distance, a five second countdown was provided by the LCO, with the actual remote button being pushed by Dave. I attempted to capture a video, but lost the track not long into the flight.

Take off on the K-1100 motor was straight and rapid. After motor burn-out, the first stage sabot was seen to eject cleanly. A slight inter-stage delay of about 2 seconds then occurred, seeming much longer to all of us since we were all anxious about second stage ignition. But after the brief pause, the second stage K-550 was seen to ignite, to the cheers of all. The free falling stage 1 sabot pushed out its recovery parachute just as the Drake II was powering skyward.

Although we supposedly had 16,000 feet of clear air below the broken clouds, it appeared to those of us in the launch crew area that it flew into a cloud bank, and we all lost sight of it. However, we did eventually hear the apogee/drogue parachute ejection charge, so we assumed that we at least had one parachute out.

The Drake II takes off at BALLS 21.

As is often the case at such times, we stared at the clouds for what seemed far too long. I focused on the direction that the prevailing winds were blowing, and after some time, I finally spotted the Drake, apparently right after the main parachute deployed (at a programmed 1,100 feet). It drifted in for a landing approximately 2000 feet away from launch point.

Stage 1 motor burn-out activates Rouse pressurization.

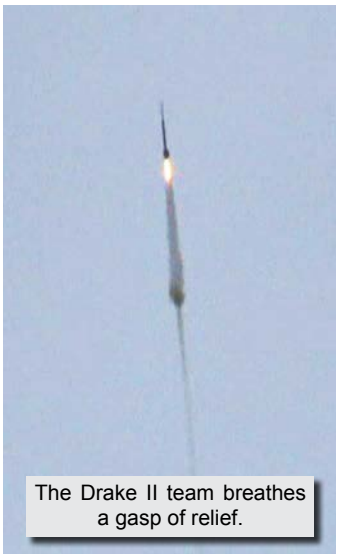
Stage 1 motor is forced out of the aft end of the airframe.

Stage 1 motor clears the end of the airframe.

Stage 2 motor locks down into firing position.

Onboard computer confirms lock and firing position.

Stage 2 motor ignites.



The Drake II team breathes a gasp of relief.

Drake II continues its flight into history.

The Drake II floats in for a perfect recovery.

David Wilkins retrieved the stage 1 sabot, and I walked on to gather up the Drake II. I received a welcomed lift from Rockets magazine's Bob Utley and photographer Ray LaPanse. We retrieved the rocket, which suffered only the usual minor landing scrapes from the Black Rock playa, but was intact and in excellent condition. It could clearly be flown again immediately.

Bob Utley recorded a brief video interview before driving me back to the Pittsburgh team canopy area. I was greeted with cheers and congrats from all – it was really gratifying that so many in attendance at BALLS were so supportive, with several people making special trips to our canopy to extend their personal congratulations.

Post flight examination of the rocket and flight data, and discussion among the team revealed the following:

- Larry Benek reported that the complete flight was better seen from the spectator area. He noted that the recovery had functioned perfectly, with the drogue at apogee and the main at a lower altitude (those of us out in the launch area thought initially, and incorrectly, that the main parachute had perhaps deployed at apogee, explaining what seemed like a long wait for the rocket to re-appear).
- The stage 1 sabot had recovered perfectly with no damage.
- The stage 2 sabot had locked into place correctly, was undamaged, and had not damaged the sabot stop point.
- Flight data was obtained from two Missile Works Mini RRC-2 altimeters that were aboard. One recorded an apogee of 10,272 ft, and the other recorded an apogee of 10,301 ft. Clearly, the true apogee was in this range. Due to wind and launch angle conditions, the Drake had flown at about a 2-4 degree inclination from vertical, thus slightly lowering the potential apogee. However, pre-flight simulations had predicted an apogee of only 9,900 feet at best. Thus, actual apogee was 4% higher than predicted, despite some angular trajectory.
- The maximum velocity recorded by the altimeters was 1040 fps, or 709 MPH. This too was better than simulated predictions, the fastest of which was only 645 MPH. Actual was therefore 10% faster than predicted.

The entire Drake team was extremely pleased and no doubt greatly relieved – I know I was! I gained a real appreciation for everyone's effort, support, and inspiration. I truly believe we pooled our best ideas and learned from our previous mistakes - it is never easy when forging new ground with a complex flight system. Despite the worries, Coop's board performed flawlessly. The rocket clearly wholly vindicated the expectations of the design concept, with a flight test that exceeded our predicted performance parameters.

The Drake II represents a new milestone in high-power rocketry - the very first successful motor-feed staging rocket ever. Also, this is the first rocket that falls (perhaps loosely) into the rack-rocket classification, in which all stages were of a high-power motor classification. Earlier rack-rocket efforts, culminating in the Exeter II of 2001, were high-power only as a function of total installed impulse, not by individual stage.

Future Directions

Where do we go from here? As noted at the beginning, the Drake series was always intended to be a precursor to a more extreme altitude rocket, the Terra Nova. But before we are ready for a leap to truly large motors, it will be best to transition to a larger Drake – the Drake III, tentatively envisioned to be a 4" diameter rocket using two 75 mm NASSA M-motors. Also, several options for an upgraded motor feed system are under consideration, including the possible use of an electromechanical method rather than gas pressurization (which may be limited in scalability). These options will be evaluated in the months ahead.

Concluding this narrative, it is no doubt fair to ask why motor-feed staging should be pursued further by me or anyone else, apart from my personal advocacy of my own invention. It's also fair to ask why one should consider staging in general for high altitude attempts versus just using one huge-motor, single-stage, minimum diameter rocket. Suffice it to say that single-stage efforts to very high altitudes (100K or above) have been successful in the context of TRA Research rocketry, but clearly, such successes, with full recovery, have not been numerous.

One main advantage of making such attempts with multiple stages is the ability to mix two (or more) separate motor thrust curves into one flight profile. Rather than have a monster-motor pushing a rocket to Mach 3+ in the densest part of the atmosphere, with all the flight stresses this imposes, a multi-stager can be configured to keep velocity sane at lower altitudes, while sustaining needed thrust to reach higher ones.

But conventional multi-stage rockets have their own issues as well, some of which I mentioned earlier in this article. Motor-feed staging provides a possible path of offering the advantages of multi-staging, while avoiding several of the disadvantages. A more thorough discussion along these lines must await a subsequent technical article.

My thanks to the Drake II project team, and all the fine members of TRA who have been so supportive.

Ken Good, TRA #00132

Thanks to David Wilkins, Mark Canepa, Ray LaPanse, and Rockets Magazine for the photos they submitted.

Postscript Notes

This article was originally submitted to the now defunct *Rockets* magazine in an earlier form, and was published in April 2013. Several edits have been made, and some photos have been substituted and/or made clearer through enhancement efforts by the author.

Subsequent to the time of the Drake II's successful BALLS 21 flight, significant research and testing has been undertaken for the development of the Drake III project, which will be based on two 75mm NASSA research motors, and a largely aluminum 3.5" airframe. The original Rouse CO_2 system will be replaced by a Prideaux prototype system that provides more control of gas release, and eliminates pyro-activation. The electromechanical option mentioned in this article was tested and found to be too slow. Other details, such as second stage stop point fabrication and fin attachments, will be upgraded as a result of Drake II experience. And electronics that will be used for staging, with anti-tilt logic, have much improved since 2009-12.

The Drake II project was an excellent learning experience, and as intended, laid the groundwork for higher altitude motor-feed staging rockets.

TRIPOLI Report

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FROM THE ~~PRESIDENT~~ SECRETARY

Okay, Bob's pretty busy this month (imagine that! Airfest, BALLS, etc.) and I had something to say (imagine that, me with something to say!)

A friend contacted me just the other day with the following question (which I have paraphrased):

Steve,

I see that the new Tripoli Unified Safety Code allows non-member children of non-members to fly rockets from the Model Rocket range, with the Launch Director's approval. However spectators are not allowed on the range at any time, so it appears that non-member parents cannot accompany children to help them put the rockets on the model rocket pads. Is that correct?

Because our Tripoli Unified Safety Code created a comprehensive approach to our safety rules, it has a lot of different parts. Most have been in existence in our old codes for some time, but some of them are new. Sometimes, you have to put the various pieces together like a puzzle. This is one of those cases.

First, here's the actual wording of 6-6 that allows uninsured children to fly model rockets:

6-6 *Launch Directors and RSOs may allow uninsured children to fly Model Rockets from the Model Rocket Launch Area as part of an organized Tripoli Launch under the supervision of an Adult Flier. Parents or guardians of these uninsured children must sign a liability waiver as a condition of participation.*

Look at the definitions to see what an **Adult Flier** is:

Adult Flier: An Insured Flier who is 18 years old or older.

So, an adult Tripoli member or adult NAR member would be just fine. Both are insured on our range. Tripoli members are covered by Tripoli insurance as long as they comply with the Tripoli Unified Safety Code and NAR members are covered by NAR insurance as long as they comply with the NAR Model Rocket Safety Code.

by Steve Shannon

But, what if the child's parent is not a member of either organization? In that case, the Tripoli Unified Safety Code created a new category of person on the range. In the past it was only Participants and Spectators; we tried to make that clearer. The new category is the **Range Personnel**, and its definition is as follows:

Range Personnel: Persons who are approved by the Launch Director to help with launch operations. Membership in Tripoli is recommended, but not required.

Just to be clear, Range Personnel are limited in what they can do. They certainly cannot fly rockets, but they can go places where spectators cannot.

Then refer to the following rules to see how that figures into the original question:

6-7 *Range Personnel may access any portion of the range as directed by the Launch Director or RSO.*

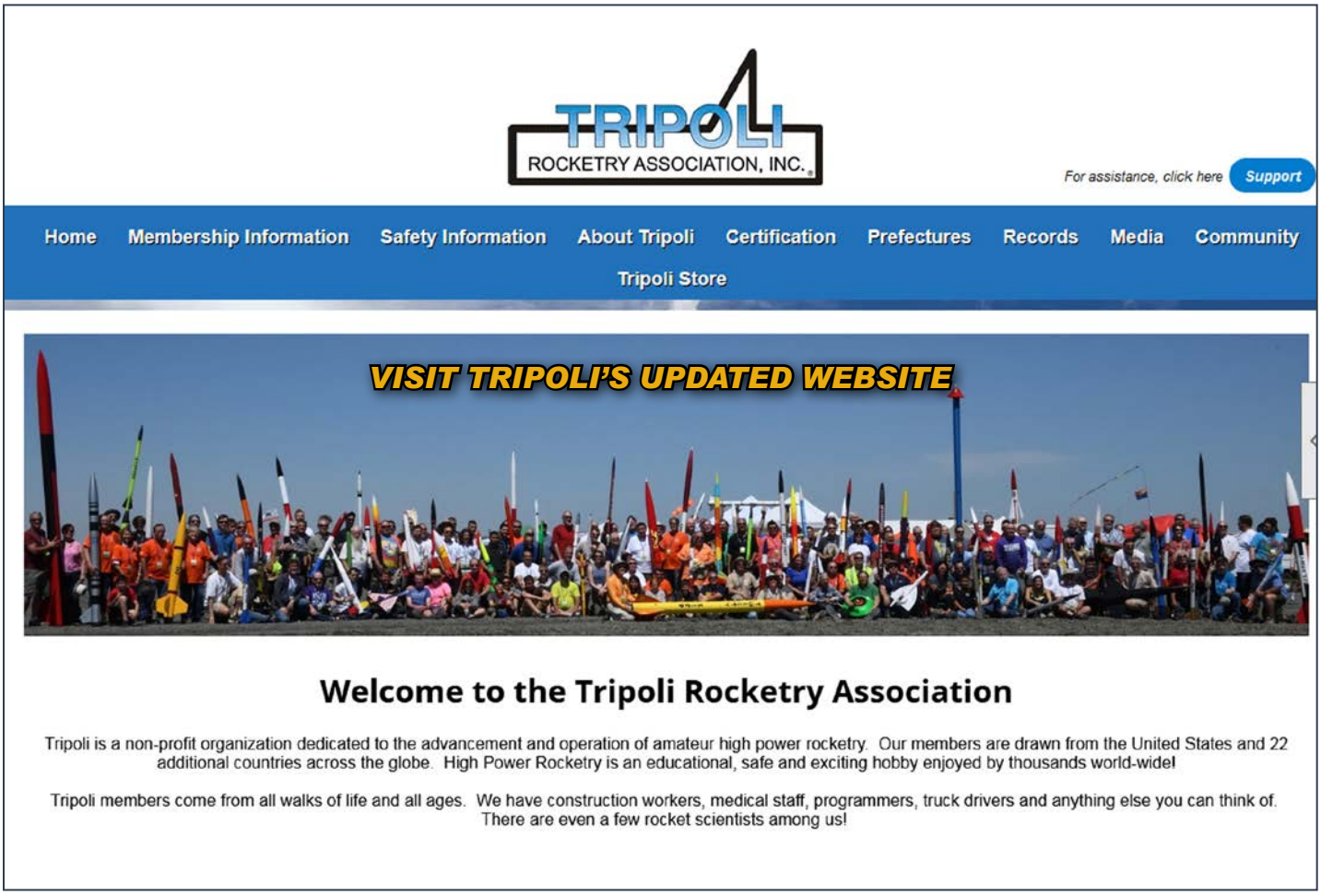
6-8 *A responsible adult may be designated as Range Personnel to help a flier upon approval of the RSO.*

So, the Launch Director or RSO could designate a parent as a **Range Personnel** to help a child place a rocket on the Model Rocket pad. Please note, this requires that the Launch Director or RSO truly designate that parent in a way that is recognizable to other Range Personnel; it's not just a wink, wink kind of thing otherwise you lose track of who is on the range, leading to greater risk. Also, the Launch Director or RSO must clearly explain to the Range Personnel where they allowed to be on the range and what their expectations are. To help a child place a rocket on the model rocket pad, the parent/Range Personnel only needs access to the model rocket pads. All such designations should follow the concept of least possible exposure to risk. Finally, this is completely at the discretion of the Launch Director or RSO. They are never required to designate a parent as a Range Personnel. They also are not required to allow uninsured children onto the model rocket range. It's at their discretion only.

There are other ways the Range Personnel can be used. An adult child of a Tripoli member, designated as Range Personnel, can help the Tripoli member carry a rocket out to the pad.

The genesis of the Range Personnel designation was a lady named Alice who used to accompany her husband George out to the pad at our launches here in Montana. She was never a flier, but she folded his parachutes and held the various items that her husband would need as he prepared to launch. Sometimes, having someone in your corner while you're prepping a rocket makes things easier, but our rules regarding spectators and participants made it difficult at a Tripoli launch. Alice passed a couple years ago, but I always thought there ought to be a way to safely allow a responsible adult to help on the range in a limited fashion. When I proposed this to the board they were supportive. The Range Personnel designation can also be used to allow former members to assist on the range, again in very specific situations, which can help a club secure enough volunteers to hold a launch.

Don't worry, Bob will be back next month.



FROM THE EDITOR

Changes - Keeping Things Going

This is the next-to-last issue before the end of my tenure as the editor of *High Power Rocketry/Tripoli Report*. It is that phase of transition when I am considering everything that needs to be addressed to make sure Mark Ketchum can proceed in his role as new editor with as few hurdles as possible. Of course, most of the procedural/technical aspect of producing this e-zine is being addressed between the two of us behind the scenes. But a significant challenge, and the one I expressed to the Board when they first tasked me to develop the new version of *HPR* magazine, is content.

High Power Rocketry Magazine Content

Yes, I know I have been addressing this topic in all my editorials of late. But there is a reason. Specialty publications such as this, run by volunteers, are always dependent upon submissions by interested people. And therein lies the largest single challenge. Since we revived the magazine, some excellent articles have been submitted by talented members. Often they are sent with high quality photos and graphics, but in some cases, they are more basic, and need to be enhanced and/or polished to a certain degree. Either way, I feel that everything that has been submitted so far has been worth serious consideration for publication; very few past submissions were not used while I have been the editor.

But it is a bit of a struggle at times. It is unclear to me if potential submitters are inhibited and/or not confident enough in some cases to send in material. It is also unknown how many members actually are logging onto the tripoli.org website to access this publication, and are even aware of the opportunity to have something published in our magazine. It is accurate to say that there has been only a relatively small handful of people who have in some way sent in material.

The point is that this publication still needs help, still needs content. It is highly likely that there is much potential out there that is not being tapped. But the editor and the Publications & Education Committee cannot know for certain what interesting projects our over 6,000 members may be working on that would make a fine article. We don't know who has had a local or regional launch that would be of interest to the readership. We don't know who may be working in a technical area with some linkage to rocketry which could be presented in the magazine. We need people to be proactive and get in touch with the editor to send something in for publication and/or discuss ideas for articles. No one has to be the best writer in the world, or the most accomplished photographer; a great deal can be developed with some core information and/or photos, graphics, drawings, etc.

by Ken Good

We tend to have a gap in launch coverage in particular. While Jim Wilkerson has been very supportive in providing large numbers of photos of events he attends (very soon after the event), we frequently don't have anything by way of text or narrative about the event. This is where launch report volunteers could help, with even a brief event summary. For those conducting our largest events of the year - LDRS and BALLS - please consider appointing someone on your team to be the person to submit an event report for *HPR*. This doesn't need to be a lengthy narrative - even a compilation of key statistics would suffice.

I do hope that support for this publication will increase from where it is at the moment, so that it can remain viable for years to come. With that said I should extend special thanks to Gerald Meux, who has spent much time in "priming the pump" to obtain magazine content, and has written articles himself.

As always, if you have anything to share, or even if you want to discuss possibilities, **please** get in touch with me at: **kjgood25@aol.com**

BOARD OF DIRECTORS ACTIVITIES

Board of Directors Meeting Minutes

Date: May 19, 2022, 7:00 CDT

Roll call:

Present: Steve, Chris, Dave, Bob, Gerald, Gary D, Neal, Gary R.

Absent: Pat Artis – no proxy assigned.

Approval of Minutes for April 21, 2022 (in email on May 17, 2022):

Motion: Bob Brown
Second: Steve Shannon

Vote:

Aye: Bob Brown, Gary Dickinson, Steve Shannon, Dave Rose, Gary Rosenfield, Neal Baker, Chris Short, Gerald Meux, and Pat Artis.

Nay: None

Abstain: None

Motion passed unanimously in email on May 17.

Old Business

Steve S: Safety Code - Steve explained that the following items have been questioned because they are not in the new Safety Code:

1. **Minimum Clearance Distances to Flammable Materials:** (This is included in NFPA 1127 and it wouldn't hurt to have it either in the code or in the Prefect Manual/RSO Guide or somewhere)
   a. 50 feet: 0 – J
   b. 75 feet: K
   c. 100 feet: L
   d. 125 feet: M-O
   e. For sparkies add 50%

Consensus was to include in next revision.

2. **Launch Site Dimensions:** Everyone who gets a COA (waiver) in the US agrees to abide by these but there are Prefectures outside the US who would have a different regulations to obey. The minimum Site dimensions are more restrictive than NFPA 1127.

   a. When operating Class 2-High Power Rockets or Class 3-Advanced High Power Rockets, you must comply with the General Operating Limitations of §101.23. In addition, you must not operate Class 2-High Power Rockets or Class 3-Advanced High Power Rockets —

   (a) At any altitude where clouds or obscuring phenomena of more than five-tenths coverage prevails;

   (b) At any altitude where the horizontal visibility is less than five miles;

   (c) Into any cloud;

   (d) Between sunset and sunrise without prior authorization from the FAA;

   (e) Within 9.26 kilometers (5 nautical miles) of any airport boundary without prior authorization from the FAA;

   (f) In controlled airspace without prior authorization from the FAA;

   (g) Unless you observe the greater of the following separation distances from any person or property that is not associated with the operations:

   (1) Not less than one-quarter the maximum expected altitude;

   (2) 457 meters (1,500 ft.);

   (h) Unless a person at least eighteen years old is present, is charged with ensuring the safety of the operation, and has final approval authority for initiating high-power rocket flight; and

   (i) Unless reasonable precautions are provided to report and control a fire caused by rocket activities.

Consensus was to require G (Separation Distances) or the home country's AHJ requirements, whichever are greater.

3. **Must not be under the influence of alcohol or drugs:** (This was a mistake on my part. I definitely should have included this.)

a. Here's what NFPA1127 says in the **Prohibited Activities** section:

6.1 (11) Participation by persons in prepping or launching of high power rockets, including spectators in the prepping areas, who have consumed alcohol, narcotics, medication, or drugs that could affect judgement, movement, or stability.

Consensus was to add a requirement prohibiting the presence in either the prepping area or on the range of people who are under the influence of any substance, including drugs, alcohol, or medication, which might impair their ability to respond appropriately to risky situations.

Steve will add the three items above into the next revision. Steve will create a Revisions folder for the Safety Code on SharePoint and begin accumulating revisions there. Discussed setting a revision period, possibly six months if revisions exist. We can always announce them immediately. Also, in depth descriptions of the clearance distances and range sizes to be added into Prefect and possibly TAP Manuals.

Gerald M: LDRS Update

All things are going smoothly; no problems foreseen.

Gary D: Spaceport America Cup update - Gary discussed four items:

1. The final Safety Reviews are being finished. He would like the Directors who are attending SAC to see how this is done. Also, he wants to be sure someone will be present for membership inquiries at the TRA table.

2. Gary D. was the message bearer about an inquiry from SAC about the possibility of Tripoli providing some kind of swag or bling for participants. He mentioned that some of the other organizations are having custom "poker chips" created to give away.

As far as swag/bling, Tripoli has already lowered the cost of membership to less than our cost if insurance is included, and is already providing Mentor pins to mentors who are Tripoli members. Nobody was really sold on the idea of poker chips. Bob mentioned some kind of stickers with the Tripoli logo, something that could be used on Range Boxes, or on the outside of rockets. Dave said he already has a sticker designed that's 2 inches tall by 4 inches wide. Consensus was that would be perfect. Dave will print up a bunch.

3. Who from the BoD is attending?

Bob, Gerald, Neal, and Gary D are going as representatives of Tripoli. Pat and Chris might attend in their roles as mentors/advisors to teams, but without Tripoli sponsored expenses.

4. There was a question about whether the wildfires burning in New Mexico might affect the SAC.

Gary D said probably not because of the distance to the fires. Steve asked if (even at that distance) smoke might cause visibility issues.

Neal intends to bring Eric Gates Scholarship applications to the SAC. Realistically, they may have to be for 2023, because they must be submitted by June 30.

Bob asked if we could put together a short video that explains who we are - "This is Tripoli" - which Neal could set to play continuously on a video monitor above the TRA table. Neal thought so.

Bob B: LDRS41?

Gerald: Tripoli Wisconsin is considering putting in an application for LDRS 41. They have a lot of red tape to work through with DNR, but right now they are planning to bid for LDRS 41. Gerald doesn't think Tripoli Central California will put in for 2023 but he suggested that we start talking to TCC now about putting in for LDRS 42; hopefully they would start the process now.

Also, Chris Short said that he will talk to the South Carolina guys next weekend when he's out there. Bob mentioned that maybe they would want to also consider bidding on LDRS 42 as well.

Gary R: TRATech – Lou Poccia withdrew as a presenter, leaving an opening. Neal asked about Club Express possibly giving a presentation showing how the tool that Tripoli uses could be used for individual clubs. Club Express can only participate virtually. Neal or Gary will advertise the slot, hoping to attract another in-person speaker. If they are unable to attract

another speaker and an absolute fallback is needed Bob suggested that the BoD could hold a Town Hall with the directors who are in attendance.

The AV stuff is all ready.

Gary asked Dave if he has already made the posters and banners. Dave has, and he has already packaged them up for shipping, but he said he can make a sticker to handle any revisions. Gary will get the changes to Dave as soon as they are finalized.

New Business

Dave Rose: Trifold application – Gerald had some corrections. Dave has incorporated some changes. Dave also suggested that if anyone wants to see different pictures, please get them to him.

Chris Short: TAP nomination for Steve Eves – nomination paperwork was included in the email from Chris Short.

Motion: Approve Steve Eaves as a TAP.

Made by: Chris Short
Second: Gary Dickinson

Vote

Aye: Chris S, Gary D, Gary R, Bob B, Dave R, Neal B, Steve S.

Nay: Gerald M.

Motion carries – 7-1.

Steve Shannon: Who may sign as "Guardian" for purposes of TMP test answer sheet and Launch Liability Waiver? May the leader of a youth organization sign? Example – the adult squad leader of Civil Air Patrol squadron? Gerald pointed out that the Launch Liability Waiver simply says Adult/Parent, which the BoD thought was okay.

Bob asked Steve to get the wording added consistently to the TMP Answer Sheet to be consistent with the Launch Liability Waiver form.

Anything Else for the Good of the Association

Bob went around the virtual room and polled the directors on whether they have anything to add:

Neal offered that UROC will have their first launch at Green River, their new launch site that sort of replaces the Salt Flats. They have a 100k waiver.

Dave reported that he renewed our corporation papers in Alaska. Due in July, but Dave took care of it as soon as he received their reminder.

Also, the Tripoli 2021 taxes have been filed and accepted.

Finally, Dave asked if there was someone he could ship the posters and banners to for TRATech. Chris volunteered for them to be sent to him. They must be there by June 3, in order for Chris to take them in his trailer. Dave said he would ship them between May 23-27.

Adjourn Meeting

Motion: Steve S
Second: Bob Brown

Minutes of the Annual Members' Meeting of the Tripoli Rocketry Association

Date: June 11, 2022

President Bob Brown called the meeting to order

Roll call: In attendance were directors Bob Brown, Gary Dickinson, Gary Rosenfield, Pat Artis, Chris Short, Dave Rose, and Neal Baker.

Absent: Steve Shannon and Gerald Meux. Steve assigned his proxy to Neal Baker. Gerald assigned his proxy to Gary Rosenfield.

Bob Brown reported on the State of the Association to the members in attendance. High Points were:

1. Thank you and a plaque to ROC for hosting LDRS 40.
2. Introduction of Directors.
3. Report on the growth of Tripoli Rocketry Association – at time of meeting there were 6,116 members with 1923 Level 0 members, 1289 L1 mem-

bers, 1646 L2 members (plus 16 L2 members who will regain full L2 privileges upon retaking the L2 test), 1173 L3 members (plus 8 who must retake the test for full L3 flight privileges), 18 TMP members, and 43 TMP1 members.

4. Tripoli now has 120 worldwide Prefectures. Although most are in the USA (96), South America has experienced some growth and now has 3 Prefectures. Europe has 11 Prefectures, and Australia and Canada each have 5.
5. The financial health of the association is still very healthy with a current bank balance of $335,125. The largest single expenditures are PIP awards and Insurance costs.
6. Bob listed the standing committees.
7. Then Bob awarded the President's Award to Bill Riley for his leadership role in transferring the Tripoli website from the previous platform to Club Express.
8. Then, Bob announced the election results, which were as follows:
    a. Gerald Meux – 465 votes
    b. Steve Shannon – 374 votes
    c. Dave Rose – 264 votes
    d. Amy Howell – 251 votes
    e. Christopher Nilsen – 171 votes
    f. Bryce Chanes – 169 votes
    g. Rick Maschek – 115 votes
    h. Art Applewhite – 101 votes
    i. Mark Burton – 51 votes
9. Finally, Bob concluded the meeting by announcing the location of the next LDRS. LDRS 41 will be held at the Bong State Recreation Area, Wisconsin, on July 6-9, 2023.
10. Bob then adjourned the Annual Members' Meeting and convened the Special Meeting to Elect Officers: A quorum was in attendance and nominations and seconds were as follows:
    a. **President:** Gary Rosenfield nominated Bob Brown. Gary Dickinson seconded the nomination and the Aye vote was unanimous.
    b. **Vice President:** Pat Artis nominated Gary Dickinson. Dave Rose seconded the nomination. The Aye vote was unanimous.
    c. **Secretary:** Bob Brown nominated Steve Shannon. Chris Short seconded the nomination. The Aye vote was unanimous.
    d. **Treasurer:** Neal Baker nominated Dave Rose. Bob Brown seconded the nomination. The Aye vote was unanimous.
11. The Special Meeting to Elect Officers was adjourned and an informal Question and Answer session with the members commenced.

Minutes recreated from notes from President Brown and other directors in attendance and transcribed by Recording Secretary Steve Shannon.

Board of Directors Meeting Minutes

Date: July 21, 2022 7:00 PM CDT

Attendance

Roll call: Bob Brown, Dave Rose, Chris Short, Gary Dickinson, Gary Rosenfield, Pat Artis, Neal Baker, Gerald Meux Jr., and Steve Shannon.

Absent: None

Approval of Minutes for Meetings at LDRS:

Due to Steve's absence as recording secretary, the Board will try to reconstruct minutes from notes taken by Chris Short and Neal Baker. Steve took notes during one phone call, but misplaced them. What is known is that Steve Shannon made the motion to approve Tripoli Wisconsin's LDRS 41 bid and Bob Brown seconded it. The motion passed unanimously for all in attendance.

Future meetings at LDRS that involve off-site directors will be done as video meetings with recording turned on.

Old Business

Neal B: Website Progress/IT update

Auto-renewal – Neal visited with Bill Riley about a

week and a half ago. Bill is working on all the website items. He tried to clean up the membership types. The cleanup failed, which caused a problem so they had to go back and fix that. It will be redone with the auto-renewal piece in mind. He's being very careful so it's taking time.

Neal B: Prefecture Audit – progress report – The status on SharePoint has not been updated. So far the crew doing this has accumulated nearly 85 Prefectures but they haven't had time to put them into Sharepoint. Still working on it.

Bob asked how Dave Rose would know not to pay PIP if a Prefecture didn't return a complete submittal to the audit request. Chris Short and Neal Baker to discuss how to mark the ones that have been fully completed and passed their audits.

Bob also expressed a desire to have the audit process wrapped up by BALLS.

Steve S: More TUSC revisions – All of the corrections have been made and the revision is sitting in folder Documents>General>Safety Code Revision on Sharepoint. The changes so far include: Alcohol/drug prohibition, corrected Safe Distance Table, added flammable clearance and smoking restrictions, lightweight construction, uninvolved party distances, and Complex rocket definition. Steve tried to send out a notification but received an error message. He will work with Neal to try and learn what he did incorrectly.

Chris Short: L2 and TMP Tests and Study Guides have been circulated. Has anyone given Chris the feedback he requested? Chris has heard from Bob, Gerald, and Steve. Others asked to provide feedback within the next day or so, so Chris can wrap this up. Chris to send out cumulated revisions to the BoD so they're working from already revised document.

New Business

Dave Rose: PayPal charges? PayPal will no longer allow "Friends and Family" transfer of funds to corporations like Tripoli. This affects the ability to make reimbursements or send PIP payments. Discussion around whether to inform members/Prefectures using notices on the website and forms that amounts received via PayPal would be short by the fees charged by PayPal or whether to return to sending paper checks. Decision made that checks will be sent directly using snail mail.

Neal Baker: TRATech Committee Formation – Following the success of TRATech at two consecutive LDRSes, Bob is going to make TRATech into an official committee, which will take some of the burden off the BoD. Neal spoke about the effort needed to get the videos ready to put online and that although the work is not terrible, it would be nice to get some help and a full committee would make it easier to attract volunteers. Also, if Gary R and Neal are no longer on the BoD, this will make continuity easier. Bob asked Neal to be the BoD liaison. Bob will select a committee chair.

Motion made to form formal committee: Everyone tried, but Steve thought Neal Baker had his hand up first.

Seconded: Gary Dickinson.

Vote: 9-0 Motion passed unanimously

Steve S: TMT Manual changes to help manage relabeled certified motors. – Steve hasn't done anything on this yet. Revisit in August meeting.

Gerald M: LDRS 40 Feedback – Nothing bad about range operations. Gary Dickinson said he thought having BoD at the range to help with certifications was good. Neal said he had already sent feedback about AV equipment for TRATech. Bob commented about heat and dust, but that those are just observations – nothing that ROC can do anything about.

Gerald M: Prefects and Committee Meetings – Gerald volunteered to help organize a Prefect's Meeting and a Committee Chairs Meeting. No Committee Chairs meeting at this time, so he will work on putting together a Prefects Meeting. He's not going to work on the TAPs meeting since that's James Russell's responsibility. He'll work with Neal and the IT Committee to send out invitations for Prefects' meeting. Bob suggested that he pick a couple of dates and see how they work. Gerald asked about putting the Prefects' Manual on the agenda. Bob said there's nothing to talk about yet; it's probably a year away.

Bob B: Records Retention Period? Discussion. Some things need to be held longer than others. Also, stop accumulating some records. Test forms will no longer need to be sent in to HQ. Bob would like us to adopt some kind of Records Retention Policy regarding which records to store and which ones can be discarded and the time period before discarding. Dave mentioned that on his side the tax records need to be maintained for seven years.

Gerald asked if he could research it a little and report back next month. Bob asked that it be done earlier than that.

Steve asked if non-profits have different requirements. He mentioned that minutes probably need to go back quite a ways. He also suggested that some things shouldn't be accumulated in the first place. He mentioned L2 test forms as an example.

Bob expounded on the L2 test forms and said that we could simply sign the certification form and give it to the applicant with the signed test scores recorded upon it. They would be responsible for keeping track of it until they took their flight. The test forms would not be submitted to HQ, but would be ripped up or shredded by the test proctor. Bob asked if anyone would be concerned that we didn't keep the tests. There was unanimous agreement that keeping the tests was unnecessary. Bob asked Gerald to add that to the agenda for the Prefects' meeting.

Bob B: Downloadable Membership Cards – Bob had Neal talk about how we could do downloadable membership cards for our Student and Junior members. Club Express will allow us to do virtual cards – on-screen images that can be saved or even printed by the member. Trial run to see if this will work for Student and Junior members. Bob displayed his daughter's envelope with her new card from HQ. He talked about how the plastic card that costs us about three bucks to make and then we're sending the cards in 33 cent padded envelopes that cost nearly $4.60 to mail, so the cost for each card is about $7.93 plus labor. For a student member price it would appear that we're squandering money.

The board was in agreement. Neal will look into this more. It's a $400 feature. We will start it as a test run. HQ expressed a need to verify student status before allowing student members to print their cards. HQ makes students send in copies of student IDs. Neal thought that something could be done to indicate an unverified status and HQ would be able to do something to change that status once they received a student ID. **(Secretary's comment – after discussing this with Bob, we both expect that this will apply to Juniors as well. It provides the same benefit, but without the complication of student id verification.)**

Anything Else for the Good of the Association?

Gary Dickinson: A university team asked if they do motor tests inside a shipping container, do they still need to follow safe distance rules. After the laughter died down the answer was yes.

What about Club Express to help individual prefectures. David Boyd asked about software to help manage club memberships. Steve brought the subject up in the meeting. Neal explained that since we are a partner, our Prefectures would be able to use Club Express at a price that's one step discounted below normal pricing. Steve to give Neal Baker's name to David Boyd to discuss whether Club Express would be helpful. Also, Neal will send an email to the Prefects letting them know about Club Express if they're interested.

Gerald wanted to congratulate the directors for being re-elected and tell the BoD thanks for the past 1, 2, or 3 years and cheers to the next 3, 2, or 1 years. He appreciates all the growth and leadership and support. He feels that we have a strong directorship going forward.

Adjourn Meeting

Motion: Chris Short
Second: Pat Artis

Board of Directors Meeting Minutes

Date: August 18, 2022 7:00 PM CDT

Attendance

Roll call: Bob Brown, Gary Dickinson, Dave Rose,

Gerald Meux, Gary Rosenfield, Chris Short, Neal Baker, Pat Artis (unavoidably delayed until the New Business section), and Steve Shannon.

Absent: None

Approval of Minutes for Meetings at LDRS:

Motion made: Gary Dickinson

Seconded: Gary Rosenfield

Vote: 8-0 in favor: Bob Brown, Gary Dickinson, Dave Rose, Gerald Meux, Gary Rosenfield, Chris Short, Neal Baker, and Steve Shannon.

Approval of Minutes for July 21 monthly meeting:

Motion made: Gary Dickinson

Seconded: Bob Brown

Vote: 8-0 in favor: Bob Brown, Gary Dickinson, Dave Rose, Gerald Meux, Gary Rosenfield, Chris Short, Neal Baker, and Steve Shannon.

Old Business

Neal B: Website Progress/IT update

Auto-renewal? There's an issue with the way Club Express software processes payments that's delaying the IT committee from activating Auto-renewal. They're working on it. As part of having Club Express handle CC payments we had to set up a Stripe account, which saves a little compared to PayPal. Stripe works internationally. For instance, PayPal didn't work for international students at Spaceport America; Stripe did. Dave said he has seen the same at BALLS, where some international attendees couldn't use PayPal.

The process has been completed to print virtual membership cards. As a cost saving measure, this is how Students will receive their cards going forward. When a student joins they receive an email that explains the process for proving they are eligible for reduced student rates. After completing that step they receive another (automated) email explaining how to download/print their virtual card.

Bob suggested that we should put an announcement on the front page of our website letting people know about this feature and explaining how to access it. Neal took that on.

Also Neal reported that he and Bill Riley have been steadily working on improving the website, making it more attractive and functional.

Neal B: Prefecture Audit – progress report

Neal and Chris have received 82 submissions so far with no response from 38 Prefectures. Neal has finished contacting those Prefectures that had responded before we started asking for COAs. Almost all of them have submitted COAs. Neal and Chris are reviewing them for completeness and distance requirements. Chris has found a few that have altitudes that exceed what FAR 101 calculations allow. They will probably have to reduce their altitude. Chris has only found one that doesn't' have enough distance to fly at all.

Bob asked what is being done with the information. Chris suggested that he get a few more done and then send out a listing so we can discuss what our next step should be. Bob said he thought we ought to be contacting Prefectures as we find problems rather than allowing Prefectures to continue flying non-compliantly.

The discussion then turned to who would contact these Prefectures, which also links to the first topic in New Business, which is non-payment of Prefecture Dues. After some discussion the consensus was that it would be better if HQ contacts the Prefectures that have problems, whether the problems are related to FAA compliance or annual Prefecture Dues.

Chris Short: L2 and TMP Tests and Study Guides – Chris completed the L2 Study Guide and Test Questions and sent them to the BoD email list in late July asking if Dave Rose would forward them to the Publications and Education Committee. Dave is the liaison for that committee. Unfortunately, that email wasn't received by Dave. Chris will send a copy directly to Dave. Chris's part is complete. The Pub & Ed committee will format the Study Guide and get it printed as well as generate the tests.

Chris expects to finish the TMP this year.

New Business

Pat Artis joined the call after being delayed by circumstances beyond his control.

Bob Brown: Prefecture Renewals. Even though it's two thirds of the way through the calendar year, 46 Prefectures (roughly 39%) have not paid the $10 to renew their Prefecture for 2022. Dave put together a list of Prefectures which shows which ones have paid and which have not. 74 have paid (one paid this week).

Bob called HQ to see what their procedure is. They replied that they don't do anything now that Prefectures renew through Club Express. Neal agreed that was probably accurate.

- Bob explained that we're going to task HQ with following up on these missing payments. Contact will be made to both the Prefect and the Secretary (the two known contacts we have).
- Bob proposed that we give those Prefecture who are in arrears 30 days to get current with their 2022 dues or we cancel their Prefecture.
- Going forward, HQ will send out the renewal notice on November 1.
- First reminder will go out December 15, saying the payment is due by December 31st.
- Final reminder will go out January 15 saying they will lose their Prefecture status is not paid before February 1.
- February 1 – a notification of loss of Prefecture Status is sent to both the Prefect and the Secretary of the Prefecture.
- If they missed the February 1 deadline, they are no longer eligible for PIP money that year.
- If they don't pay by April 1, they must reapply, just as if they were applying to become a new Prefecture. Their history of non-payment will be considered when evaluating their application.

Gerald asked if we should require a third contact person for each Prefecture so if a Prefect and Secretary drop off the face of the earth we have someone to contact. Discussion about that idea and whether it would actually solve anything. In the end it was thought that if a Prefecture receives a 60 day notice and a reminder, they should be able to pay it on time. The importance of an official "due date" was emphasized. The need to receive current information regarding the results of the Prefect and Secretary Election were also mention as well as the launch organization for insurance purposes commitment. Bob said we could put together a package to cover all of these needs.

Bob will write up a policy proposal to be voted on by the Board this coming week. Once it has been approved it will be turned over to HQ to manage.

At this point Pat gave Gerald his proxy because he had to leave.

Anything Else for the Good of the Association?

LDRS 41: Gerald and Neal discussed a concern that Tripoli Wisconsin had about site dimensions. They could support M and N motors if they add another set of pads about half a mile to the east along the runway. This would also allow them to increase their COA from 10,000 AGL to 14,000 feet. Neal attended a meeting with them on Monday to discuss but he felt that this would add a lot of confusion. His recommendation would be to just stick with the 10,000 foot COA. After some discussion the rest of the BoD agreed.

Prefects' Meeting: Gerald also spoke about the recent Prefects' Zoom meeting. 31 Prefects attended. Neal commented that it was helpful from the standpoint that Prefects help each other solve common problems. Gary Dickinson commented that 31 is only 25% of the Prefects and that somehow we need to get more of them. Dave cautioned that our Zoom license only supports up to 100 Prefects, not to mention the challenges that accompany having 100 people who would like to talk.

Bob thought that having the meeting more frequently would encourage more Prefects to attend. He asked if we should have an in-person Prefects' meeting at either BALLS or LDRS. Consensus was that LDRS would make sense and we can see how many actually show up.

Adjourn Meeting

Motion: Gary Dickinson
Second: Gary Rosenfield