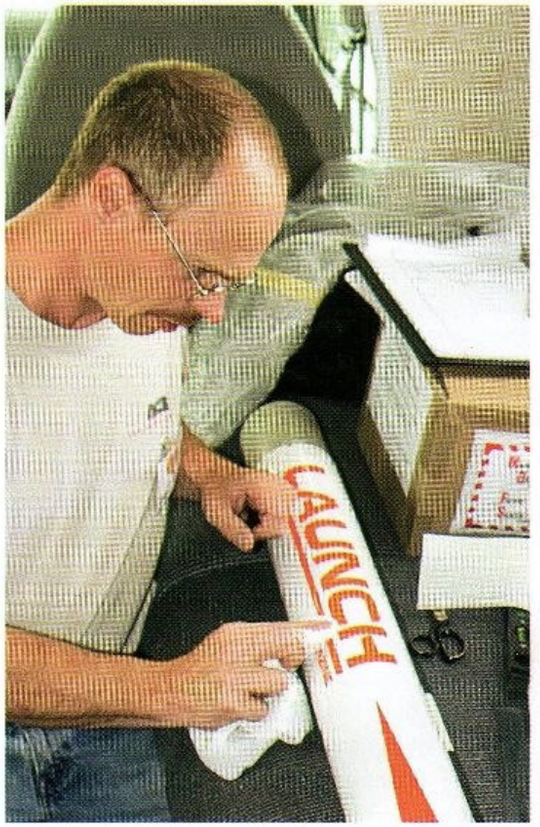
Team-SCAM member Mike Law climbs a ladder to arm the electronics on the Little 'O' Rocket. The Indiana team's project—sponsored by LAUNCH Magazine—was among the highlights at BALLS 16, an annual high power experimental launch in Nevada.



LAUNCH AT BLACK ROCK

The magazine sponsors a challenging high altitude attempt.

BY JOE ISCA PHOTOS BY KENNETH BROWN AND JOE ISCA

It was March 2007 and members of our team from Summit City Aerospace Modelers (SCAM) in Fort Wayne, Indiana, were hard at work building a six-time upscale of the wacky ACME Spitfire rocket. The goal was to have this large, crooked rocket ready for the National Association of Rocketry's annual sport launch last June. (See NSL 2007, Jul/Aug '07 LAUNCH Magazine). You'd think that a project of this size would be enough to occupy the minds of mere mortals. Somehow, Team-SCAM members Mike Law and Dennis Watkins had the time to wonder, to dream, and to kick around the idea of building an extreme rocket capable of testing the 100,000-foot waiver at the BALLS 16 launch in Nevada's Black Rock Desert in September.

So what if we hadn't finished building or launching the ACME Spitfire? They brought their ambitious idea to the SCAM high power launch in Winchester, Indiana, and before you could ask "What are they thinking?"—Charlie Humphries and I were on board for this exciting new project.

The four of us had been part of the large team of SCAM members that successfully launched a half-scale Honest John missile in 2001 and 2002, and would soon share the success of the ACME Spitfire launch. And now we were destined to build what we dubbed the "Little 'O' Rocket." For many years each of us had hoped to get to Black Rock—and now our dreams would be realized.

BALLS is one of the world's leading experimental rocketry events. The launch site is massive and well suited for the recovery of high altitude rockets. It is so large that event organizers provide a precise GPS reading so flyers can locate the site in the vast Black Rock Desert near Gerlach, Nevada.

In April, Charlie had prepared a rough outline of the steps we would need to take to complete the project, including a timeline for construction of the two-stage rocket and the logistics of bringing it—and ourselves—to the remote launch site and back. The outline made it seem so simple. How hard could this project be? That turned out to be a silly question!

An all-aluminum project was a budget buster, and was quickly ruled out. We believed the next best choice was full-sheet, wrapped fiberglass so we chose Performance Rocketry for their three-inch and four-inch diameter body tubes, nose cone, and for the couplers. We chose ⅛-inch-thick G10 for the bulkheads, and went with stronger 3/16-inch-thick G10 for the fins.

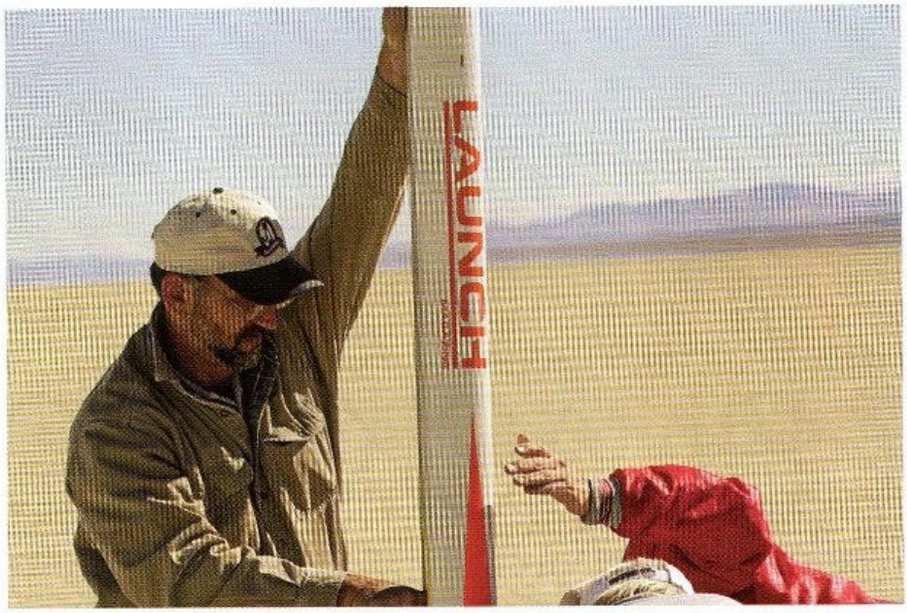
Mike designed a sleek two-stage, minimum-diameter rocket using RockSim. He and Dennis tweaked every permutation of the components: fin size and shape, fin angles, nose cone shapes, and motor combinations. The goal of every decision was to maximize the pro-

jected altitude or to improve the structural integrity of the rocket.

The design showed the 4-inch-diameter booster section at 6.75 feet tall. A transition section joined the booster to a 7.25-foot-tall 3-inch-diameter sustainer. Riding atop the sustainer was a 15-inch long conical nose cone sporting a 5:1 aspect ratio. The Little 'O' Rocket utilized two independent tracking systems: The booster housed a MaxStream/Garmin GPS unit and a BeeLine tracking beacon; the sustainer held another BeeLine beacon and a BeeLine GPS unit. Fully assembled the rocket stood 14 feet-3 inches tall and—including the 42.5 pounds of motor/propellant from the two stages—weighed 62 pounds.

The decision to go with minimum diameter tubing and minimum tube lengths made it difficult to get everything packed into the rocket. The electronics bays were an engineering nightmare or marvel depending if you were the engineer responsible for the design, or one of the awestruck team members who marveled at how Charlie could fit everything so precisely into such a small amount of space in each of the three bays. Charlie has created some amazing work over the years —but this was by far his toughest challenge (one he sometimes regretted taking on).

We were concerned with the temperature extremes the components would face: Heat from Mach speeds during boost would be quickly followed by very cold, high-altitude temperatures. Dennis conducted clever materials tests on the G10, the body tubes, and the nose cone. First he preheated his oven to 500 degrees (the temperature we might expect at Mach 3) and placed a sheet of G10 into the oven for 10 seconds (the estimated time above Mach 2). Still cool to the touch, he then put it into his freezer for about twenty seconds. No harmful effects. Next, he tested the coupler material and the nose cone and got the same results. None of the parts showed any signs of softening or other things we were concerned about.



Above: Dennis Watkins and Mike Law prep the rocket. Opposite page: The rocket lifts off, carrying essential electronics like the booster's GPS and radio tracking beacon.

Dennis repeated the oven test for 20 seconds, and the results were similar. When he conducted the test for 30 seconds, much longer than it would experience, the G10 began to get pliable. At this point we felt we had chosen the right materials for the job.

CRUCIAL DECISION TIME

Using a template, Charlie drew the fins on the G10, and hand cut them. With a belt sander and jig, Dennis produced the desired 10-degree bevels on the fins. While we relied heavily on RockSim, unfortunately, it doesn't make the crucial decisions on the kinds of materials to use, or the best methods to use to build rockets. Perhaps the most important decision we faced in this project was how to attach the fins. They would be subjected to extreme stress as the rocket reached Mach 3.

During this particular build session we sat there, almost speechless, pondering our options. Suggestions were moving as if through molasses, and no decisions were being made. It was four hours of pure angst. We knew we would cut tube slots for through-the-wall fin attachments, but with minimum diameter tubes, the fin tab is only as thick as the body tubing. How were we going to attach the fins?

Epoxy fillets were suggested, but ruled out because epoxy might not stand up to the heat. We tested using brass and then steel ¼-inch-angle iron screwed to the body and to the fins, but this just did not work out so we abandoned the idea. What about using J-B Weld to attach the fins? How about fiberglass or carbon fiber, applied fin-tip to fin-tip? I'm still not sure how we came to a final decision, but ultimately, a so-called "lock rivet" method using J-B Weld was chosen.

The slots for through-the-wall fins were cut. Tabs on the fins were only as deep as the tube wall thickness. To overcome this limitation, nine or ten "lock rivet" holes were drilled into the body tubes on either side of the fins and into the fin tabs themselves. Given the limited surface area to be "welded", J-B Weld was forced into these holes in order to increase the gripping strength of the fillets as much as possible. J-B Weld was also smoothed onto the fin tabs from the inside of the body tubes. Chopped carbon fiber was added to the fillets on the sustainer for extra strength. All fins were aligned using a custom intercoupler jig. When done, the attachments seemed quite strong. We were happy with the result and moved on.

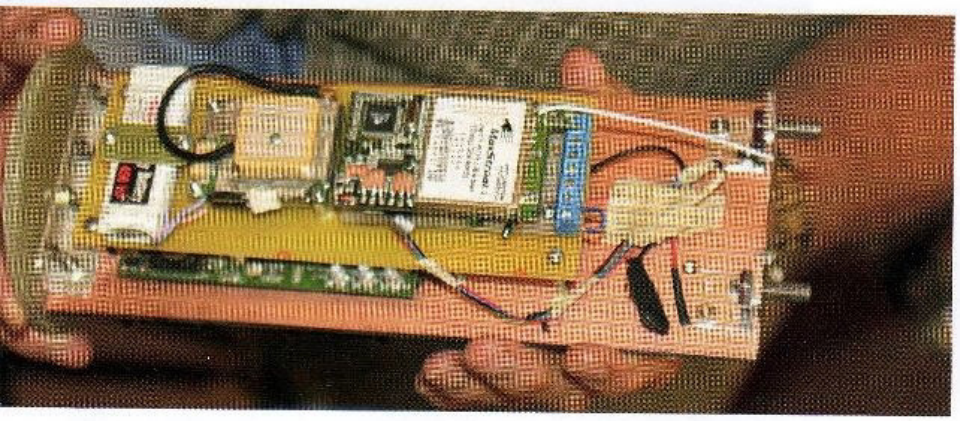
Our first choice for the booster motor was the Cesaroni N1100, but about six weeks before the launch, new shipping regulations went into effect, and production of the long one-grain motor ceased. The scramble to find a new motor began. The Cesaroni N2500 would work, which used the same motor case as the N1100.

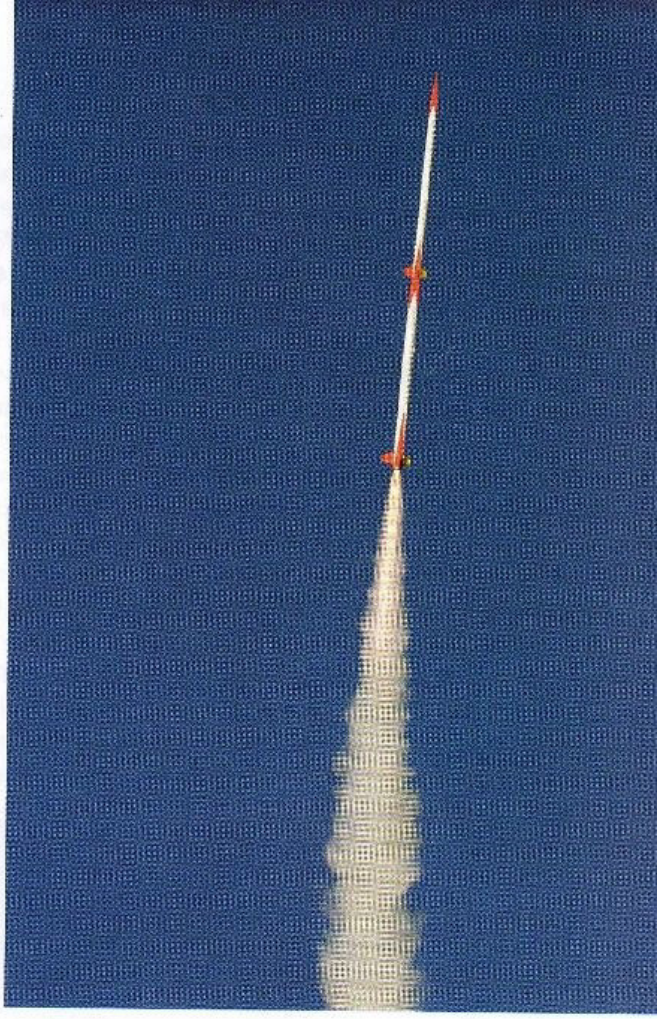
There's an interesting motor called the Aerotech M1450 by Kosdon. This is an awesome long-burn load that fits into the Animal Motor Works 75-7600 case—the same case we used to launch the ACME Spitfire. We had to use this motor for the sustainer.

The total Newton seconds of these two motors put this project into the low O-power range, and that, in turn, led to the project's name Little 'O' Rocket.

We decided on using Ozark ARTS2 and G-Wiz LC800 altimeters in the booster, and another Ozark ARTS2 along with the G-Wiz MC2 for the sustainer. Except for the LC800, all were recording altimeters. Giant Leap Rocketry "sliders" were installed to give each of the chutes the best chance for soft deployment. All tube lengths were adjusted to the minimum necessary to house the recovery devices.

The team faced many new challenges: first-time use of the CD3 CDC unit for apogee deployment, three (actually four) electronics bays, the





complexity of tracking a booster and a sustainer at speeds greatly exceeding Mach, rapid temperature extremes, Mach 3 stress, and sustainer ignition.

HOW WERE WE GOING TO IGNITE THE SUSTAINER?

There isn't room for a conduit in a minimum-diameter body tube. "Head-end ignition" was the first idea discussed. Using this method, the forward closure is drilled and the igniter is placed into the motor from the top, rather than through the nozzle. A number of us were quite concerned with this method. One advisor said "head-end ignition is the devil waiting to strike." It also adds considerably to the cost of the motor. Safety concerns—a poor track record among those who have tried it—plus the substantial additional cost to attempt this unproven (and scary) method led us to find an alternate way to ignite the sustainer.

Dennis came up with the alternate: Make a mini-bay using a Perfectflite timer. This 2½-inch bay would be cemented into the base of the sustainer motor at the last moment before putting the rocket on the pad. This would be considered a "single-use timer" as nothing would be left of it once the motor lit.

Dennis test fired two J-tech electric matches with the Perfectflite timer. One used a Thermite mixture of magnesium and copper oxide, while the other used aluminum and copper oxide. Both matches fired perfectly. The aluminum mixture supposedly burned hotter, so that's what we decided to use.

PANIC TIME!

Every obstacle we faced took us on an emotional roller coaster ride. We began to think this launch might not happen. About a month prior to the launch, our planned source for motors suddenly stop taking calls, and stopped shipping motors due to a fire that destroyed his rocketry supplies. That caused more than a small amount of stress for the crew. We had to find a vendor, and one who could get the motors in time for the launch!

Frantic calls were made. Ed Shihadeh of Giant Leap Rocketry stepped up to the plate. He worked overtime to guarantee we'd have both motors we needed *and* have them delivered directly to the launch site. Wow! How's that for superior customer service?

Until this point, anything and everything that could go wrong, break, or fail. . . *did*. We needed that "pick-me-up" and a few more. We had motors. The rocket looks great. The G-Wiz MC2 is talking to the laptop, (it hadn't been). Our project was approved by the Tripoli Board of Directors. Things were starting to look up, or were they?

THE MONKEY WRENCH

In July we bought four airline tickets. The rocket and everything we might need to launch our project was to be shipped via FedEx. However, as launch day drew near, it became clear we couldn't borrow a launch pad. Teams were worried a CATO would cripple the launch of their own project.

We scrapped two of the non-refundable airline tickets, and pressed Mike and Dennis into an unwelcome 31-hour cross-country drive. "Big Blue," our club's trusty high power pad and our 12-foot 1½-inch by 1½-inch rail would be loaded into Mike's truck, along with the rocket, motor cases, and the zillion other things we would need.

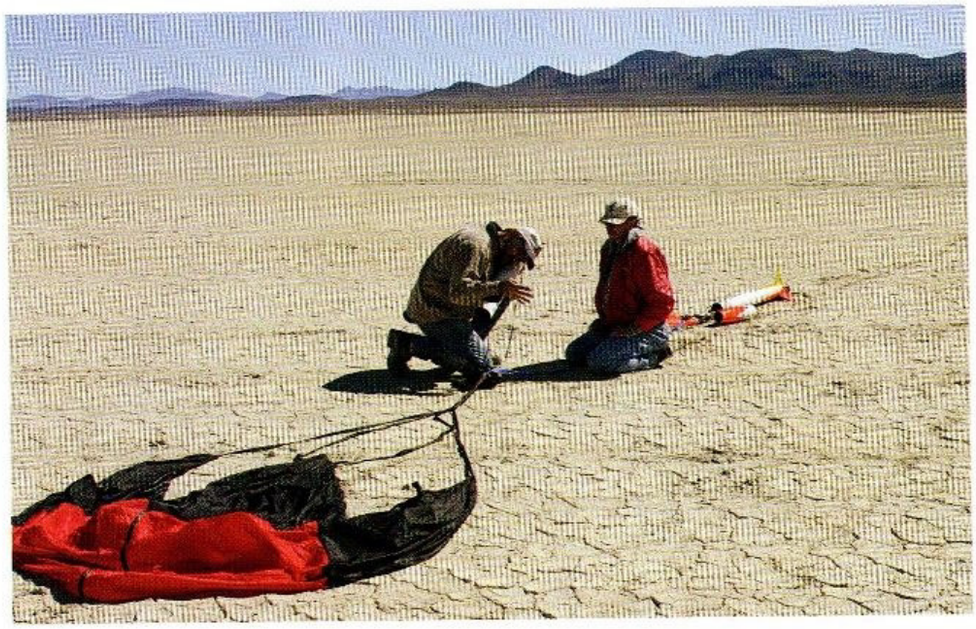
TIME IS RUNNING OUT

Three days before the drive to Black Rock, the four of us were at our club's local launch. No, we didn't get to launch a single rocket. In fact, we were running out of time to conduct the four charge tests necessary before we could safely attempt our 16-mile launch. Dennis

measured 8/10ths of a gram of black powder, and wrapped it and the J-tech E-match in a baggie. This first test had to blow the nose and the main chute from the sustainer. Three 2-56 shear pins were holding the nose to prevent drag separation. The nose cone was carefully covered to protect against scratches or damage. After a 5 count, Charlie held a 9-volt battery to the E-match. We heard a small pop. Dennis felt the charge go off, but the nose cone did not separate. That's why charge tests are so important. The main chute would never have come out at 5,000 feet, and the rocket would surely have been damaged.

Attempt number two of our first test was conducted in the same manner, except this time, the black powder charge was upped to 1.8 grams. This time it was a complete success, and we could log the 1.8 grams into our preflight checklist as the correct amount to use for the sustainer's main chute deployment charge.

The second charge test was for the sustainer's apogee drogue chute deployment at 85,000 feet. At that altitude there simply isn't enough oxygen for black powder to pressurize the space, so our second charge test involved the Rouse-Tech CD3 12-gram CO2 recovery system. The cool thing about this system is that, unlike black powder, the unit pressurizes at 1,000 feet equally as well as at 85,000 feet. None of us had ever used this device, so we were anxious to try it out. The deployment test worked perfectly.



Next in line were our tests of the booster's deployment system. The apogee charge of 1.8 grams of black powder worked well, as did the 2.2-gram charge for the booster's main chute deployment.

THE ADVENTURE BEGINS

On Tuesday, September 25, Mike and Dennis began their 31-hour drive. Except for the long hours and some nerve-racking moments in the mountains of Wyoming, their trip went relatively well. Very early on Wednesday, Charlie and I drove from Fort Wayne to the Indianapolis airport. We caught our flights to Dallas, and then to Reno. All went well, except that our luggage didn't arrive with the flight. Were they going to deliver our luggage to the Black Rock Desert? Luckily, we had planned to spend that night in Reno, and sometime between 2 a.m. and 4 a.m., our luggage made it to our hotel. Whew!

With luggage in hand, we took a cab to pick up a motor home rental. Don't ask us about the route we took to get to the wrong rental site. And don't ask about the guys from the University of Michigan, who didn't get 500 feet out of that rental site before ripping off the side of their rental motor home. From what we heard, they had to have the fire department free the unit from some posts upon which they had become impaled. Eventually, we got to the correct rental site, got our unit, went grocery shopping, and made the drive to Gerlach where we met our teammates at Bruno's Country Club.

During one of our advice-seeking forays, one of the experienced BALLS flyers sent us an E-mail that said, "Be sure to make the other guy drive his car, you will *never* get the dust out." After sending it, he noticed he had sent the message to *all* of us. Doh! But how prophetic. Sorry, Mike.

OUR ARRIVAL AT BLACK ROCK

Black Rock is an amazing launch site. We were first-timers, and we were in complete awe of the site. The dimensions are too incredible to imagine. Twenty miles of unobstructed recovery to the east and another twenty miles to the west. Ten miles to the north and about ten more miles to south. How could anyone ever lose a rocket here?

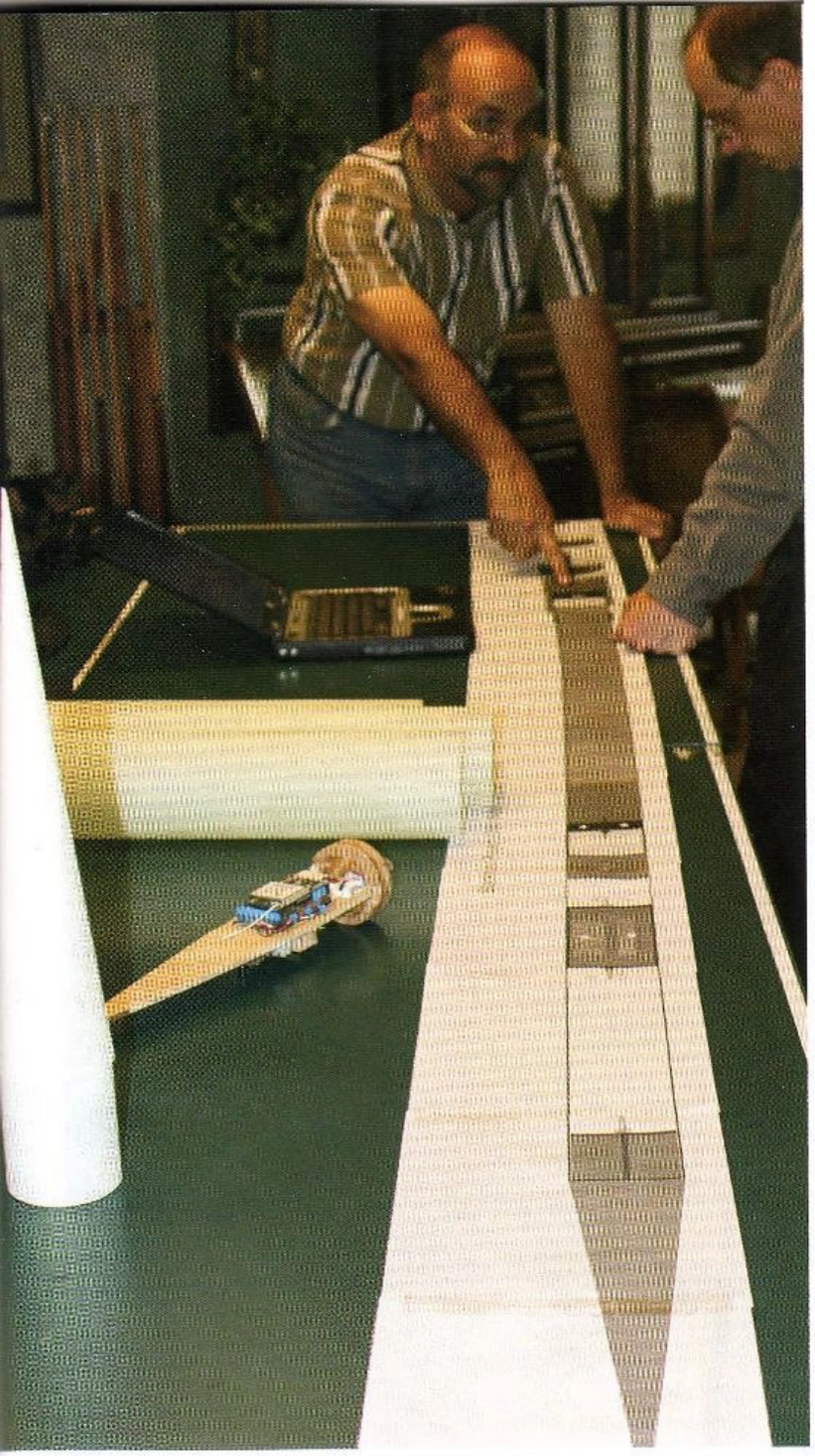
I suspect that even veteran flyers continue to take in the wonder and sheer beauty of the site. Using one's imagination it would be easy to think we had been transported to the surface of the moon, treading on regolith, and taking in the truly beautiful panoramic views of distant mountain ranges.

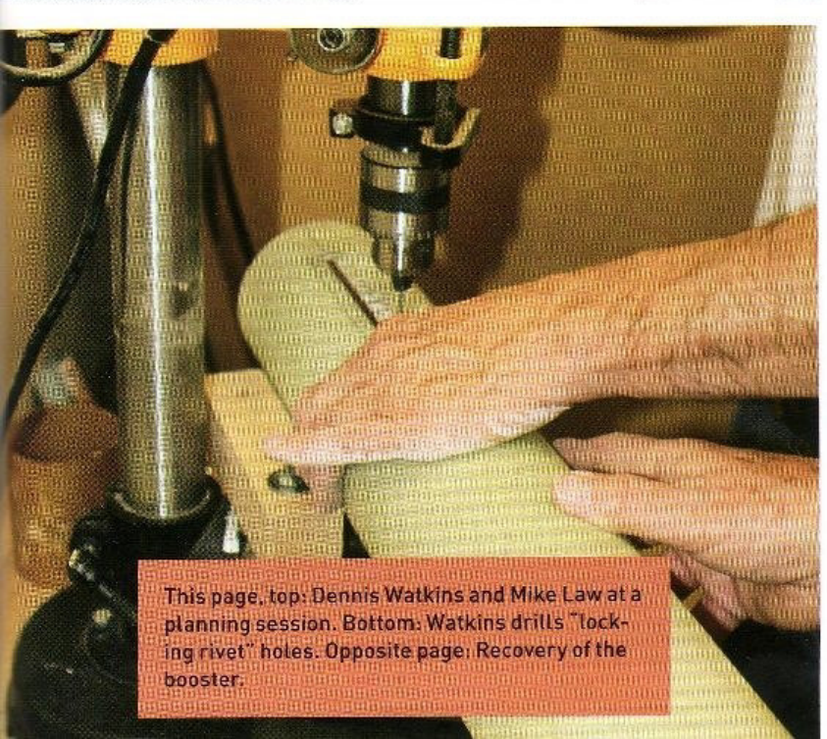
Friday, September 28 was to be the first day of the BALLS 16 launch. However, there was a waiver snafu, and no flights were to take place before 4 p.m. That meant there would only be a two hour window for flights that day. As it turned out, the weather Friday morning could best be described as a sustained wind storm. By the afternoon, the winds picked up and created a white-out dust-storm situation. The winds were so high—waiver or not—there were not going to be any flights that day. The upside of the waiver snafu, the 100,000-foot waiver would be in effect all day Saturday and Sunday. The forecast for Saturday called for sunny skies, temps in the 70s, and the winds were expected to be calm. Calm at ground level that is. Winds in the jet stream, above 25,000 feet or so, were projected to be above 100 mph. We hadn't faced those before, and at Black Rock, we weren't sure if they should be a cause of concern for recovery of the sustainer.

The guys set up "Big Blue," our club's high power pad with a 12-foot 1½-inch by 1½-inch 80/20 rail. Since we were flying a complex motor in the O-class range, the set up of the pad had to be done at the away-cell, 2,500 feet from the range head.

We took delivery of the motors from Giant Leap Rocketry, and since we had planned for Friday to be our day for preparation, we settled into the motor home and began to build motors, assemble bays, check continuity of all circuits and E-matches, and review every item on the pre-launch checklist.

It's hard to imagine just how many batteries it takes to fully "arm" a rocket of this complexity. Twelve batteries were in the rocket and another dozen assorted batteries were used to run the ground support devices for tracking the booster and sustainer. We tested the voltage on every one of these.





This page, top: Dennis Watkins and Mike Law at a planning session. Bottom: Watkins drills "locking rivet" holes. Opposite page: Recovery of the booster.

Building motors should be relatively straight forward, however, we've had a problem with using this Cesaroni N-motor case. Not sure if it is the case or the liners, but every liner requires major sanding in order to fit. It took Dennis, Mike, and me over three hours of steady sanding to get that liner to fit. Then there was a bit of trouble installing the nozzle. But finally, it came together.

The motor was bolted into the booster, but difficulties arose there as well. We had a ⅜ inch double nut, but needed a single. Dennis jury-rigged a screwdriver and adjustable wrench and was able to lock the motor securely into the booster. Building the Aerotech M1450 went smoothly.

Saturday morning, Mark Clark held a brief flyers meeting. He described the ground rules for launching at BALLS. The meeting was short, and soon thereafter, we packed everything up and took the Little 'O' Rocket to the away cell.

Before the rocket could be put onto the rail, the Perfectflite timer had to be connected to the E-matches in the sustainer motor. Then the 2½ inch bay holding this so-called "throw-away" Perfectflite timer, was cemented into the base of the sustainer motor. When the motor comes to life, this bay is toast!

Since most of the preparations had been made the day (and many months) before, set up and arming of the rocket went quickly. So quickly, we hardly had time to get nervous (don't believe it). Calls were made to the LCO. He announced the project to the crowd, and before long, we were given the okay to launch.

5-4-3-2-1-Launch. The Cesaroni N2500 lit immediately. The rocket sped away at up to 992 miles per hour. The booster had performed flawlessly to apogee at 16,500 feet. After the planned 10.5 seconds of coasting, which dropped the sustainer's speed to below mach, the Perfectflite timer lit the Aerotech M1450 motor, and the sustainer raced away.

Suddenly, as the rocket again zoomed through Mach-1, Mach-2, and approached Mach-3, something terrible happened. We weren't sure exactly what, but we knew the project was in trouble. We were all a little stunned, but the guys stuck to their assigned tasks and tried to track the booster and sustainer throughout the remainder of their flights.

Dennis had a solid lock on what he thought was the sustainer, and tracked it until it landed. It turned out, however, to be the booster section that returned to earth in perfect condition. Charlie had been tracking the sustainer, but at the moment of "the event" he lost all tracking signals from the BeeLine Beacon and the BeeLine GPS unit. We did not know what happened, and would not until we recovered the sustainer, and downloaded the data from the G-Wiz MC2 and the ARTS2 recording altimeters.

Since we lost sight of the sustainer at an unknown altitude, we didn't have a clue as to where the sustainer was headed. The only indication we had was where the booster landed, and where other rockets were landing. With that bit of information, the team set out to search for the rocket. We split up and searched the desert floor. We searched the brush areas at the edge of the desert floor, and we searched the mountainous areas beyond the brush.

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We drove across the desert and scanned for the rocket using the tracking software and mobile antennas. We trained multiple sets of binoculars on the horizon, searching for the wayward rocket. We searched, and hiked. Then hiked and searched; covering many square miles. We searched. We hiked. We trod through the sandy brush. We checked out every inch of the terrain with binoculars. Then after many hours of searching, and, like finding the proverbial needle in a haystack, I spotted the unmistakable fluorescent orange nose cone lying in the brush, some distance away. I was overjoyed, and yelled that I had found it. I ran to recover the nose cone, only to discover that it was only the nose cone. The cone had housed and had been securely screwed to a board holding the GPS unit and the BeeLine tracking beacon. But they were nowhere to be found. Night was fast approaching, and it was getting cold. So after more than seven hours of searching, we headed back to the motor home quite discouraged.

We were so tired when we got back, that we didn't notice that the sustainer was sitting on the couch in the motor home. It wasn't the complete unit. But it was the sustainer body and the undamaged motor case. We weren't sure how it got there, or where it came from—but we were grateful that at least this portion of the sustainer was not lost.

Later that night, we learned that event organizers Mark Clark and Robin Merideth had found the sustainer lying on the desert floor. Mark had performed pre-flight RSO duties on the rocket, so he knew exactly where the rocket belonged. We appreciated their finding it, and delivering it to our motor home.

Team-SCAM members, from left, Mike Law, Charlie Humphries, Dennis Watkins, and Joe Isca.

A quick examination of the rocket showed that the front end had sheared off and one of the fins had been cleanly ripped from the body. But, did this cause the "event"? Or, was this the result of some other catastrophe—perhaps the altimeter bay breaking away from the body and taking out the fin when the rocket approached Mach 3?

We did not know the answer, and we did not have the all-important altimeter bay—which might better help us decipher the sequence of events that led to the breakup of the rocket. It was late, and we were all exhausted from the daylong search.

Early Sunday morning, we were back in search mode. We found out where Mark and Robin had discovered the sustainer. We used our last GPS readings, and set line of bearing coordinates. We continued searching every conceivable area where we thought we might find the bay. The search yielded nothing but the hope that someday it might turn up.

DOES IT EVER END?

The launch had ended, but our adventure was not yet over. That night was an eerie one. We watched as all of the campers and motor homes left, as one might expect at the end of a launch. As evening approached we noticed we were completely alone in this massive desert, except for a single motor home at the far end of what had been the flight line. We were enjoying the solitude, taking in the beautiful view, watching the sun set, and cooking some burgers on a disposable grill. While they were cooking, the wind started to pick up. Before the burgers were done, we found ourselves in the midst of another full-blown dust storm. Can you taste those burgers? Hmmm!

Our plan was to return the motor home the next day, when the rental office opened. We ate the burgers, packed the truck, discussed the flight, and made our best guess as to what happened and what went wrong. It would be neat and tidy if we could have come up with the answer, but we did not. We were very tired from our two days of searching, so even though the motor home was rocking and rolling in the wind, we called it a night and turned in.

WHAT'S THAT?

At 4:30 in the morning, we were all groggy from a lack of sleep—but there it was—the unmistakable sound of rain lightly hitting the roof. We all jumped up and quickly dressed. While we were getting ready we noticed the other motor home making their rapid escape. Mike and Dennis got into the truck and led the way, while Charlie and I followed in the motor home. It was still dark out. It was still raining but we *had* to get out of there before we got stuck. The material of the desert floor gets very slick when wet. Mud was quickly appearing where the firm desert floor had been. It wasn't quite like winter driving yet, but it was getting slippery. We headed toward the lights of Gerlach at a slow pace (too slow for my comfort). We did reach the highway, and managed to make our way to Bruno's, where we had agreed to have breakfast.

Mike and Dennis got out of their mud-covered truck. We attempted to do the same. We couldn't open the doors. Mud completely covered the motor home and was seemingly turning into concrete. Gratefully, Mike had a long board in his truck which he and Dennis used (for quite some time) to chisel away the mud from the doors. We were free at last. The breakfast at Bruno's was far more memorable than the gritty burgers and eggs we had planned on having, had we peacefully spent the night at Black Rock. The only adventure left was a 2,100-mile rain-filled trip back to Indiana for Mike and Dennis. Charlie and I, on the other hand, had the opportunity to return the motor home back to the rental company. You can't imagine how much they're going to charge us to clean it!

That is the story of our Black Rock adventure. While the flight wasn't the success we had dreamed, we did successfully apply many new techniques and learned much more. We are especially grateful to Mark Mayfield and LAUNCH magazine for their exclusive sponsorship of our project.

The four of us have not yet been together since our safe return. Will we decide to conquer Black Rock at some other time in the future? Keep reading LAUNCH Magazine. We'll keep you posted. ✦