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LUNAR'clips is also available on-line at

<http://www.starship.org/LUNAR/LUNARclips>



LUNAR Meeting November 19

7:00 p.m. - 9:00 p.m.

Andrew Pohlman is the featured speaker at LUNAR's November 19 meeting – see Andrew's talk outline later in this newsletter and the note in Jack's "Range Head" column. Andrew's presentation will follow a regular club business meeting. The meeting will start a 7:00 p.m. in the community meeting room at the Livermore Police Station, 1110 South Livermore Avenue.



New Newsletter Editor

LUNAR'clips plays an important role in communicating and building the enthusiasm, vitality and sense of shared values that are demonstrated by the membership of LUNAR. It is a primary vehicle through which we voice our passion for the sport, share ideas and experiences, and organize our activities. The newsletter editor has the primary responsibility for creating this environment. It is an important

function and it takes a lot of hard behind-the-scenes work and dedication to make it all happen.

Starting with the next issue of the newsletter, Tom Hail, LUNAR #440, has graciously agreed to serve as the new LUNAR'clips editor. For the past year, Tom has been performing a yeoman's duty, duplicating and distributing the newsletter.

The deadline for the next issue is December 28. Tom is now accepting submissions for the next issue at his personal e-mail address

THail@csi.com

Preparing and distributing the newsletter takes a lot of effort, so please contact Tom – he'll need some help.

Former editor Lynn Kissel wants to thank the membership for all the great articles and help that he's had over the last four years. It has been a rewarding experience.

Lynn Kissel, LUNAR #009, was the club's second editor; he assumed responsibility for the newsletter in 1994 with his first issue in December of that year. Our first editor, club founder Mark Weiss, LUNAR #001, established the newsletter with the first issue dated November 1992.

A comprehensive archive of all back issues of LUNAR'clips is maintained at

<http://www.starship.org/LUNAR/LUNARclips/>



Photo 1. The LUNAR tent at the EBRC Airshow. (photo by Judy Heckenbach)



The Range Head

by Jack Hagerty, LUNAR #002

NOVEMBER MEETING

Mark your calendars now for November 19. Our meeting this month will feature a talk by Andrew Pohlman on Level 1 Certification. Also, we'll have our second auction this year. There are a couple of things up for sale that the big kids might be interested in, but most of what we have is small models that the younger set would like. So bring the kids and a couple of extra bucks and you could go home with a bargain. It's lots of fun, nothing gets too expensive and the proceeds go into the general treasury to help offset the loss of Kiwanis this year.

OCTOBER, WHAT A MONTH!

The month of October was incredible for LUNAR! Here's what happened:

- We got to participate in the East Bay R/C Club's annual air show on October 4. I have the write up on that one elsewhere (which is a good trick since I wasn't even there!).
- On the 14th, we hosted a production crew for the new Discovery Channel kid's science program "Sci-Squad." Bob Fortune has an article on it elsewhere in this issue, but on a personal note I've got to say it was a very strange experience.

The weather was absolutely perfect and the small production crew (the producer, director, a sound guy, a script guy, a gaffer and the actress) was friendly and professional. The weird part is that a couple of days before the taping they sent me a copy of the script to review. When I read it I saw with some degree of anxiety that they'd given me a speaking part! It wasn't much, just five or six lines in two scenes, but that was enough to get me all nervous. I mean, it's one thing to get on the PA at a launch and talk to a couple of hundred fellow crazies, but this is national TV! I don't even like to look at myself on home videos.

Everything went smoothly and I don't think I embarrassed myself too badly. When the show is aired (sometime next Spring, they'll let us know the actual date) I'll probably watch it, but when it gets to my part, I'll probably roll my eyes to the ceiling, stick my fingers in my ears and hum loudly...

- On the 17th we had our semi-annual night launch. If you weren't there, you missed a good one. Huge crowd, clear skies and dead calm. It got pretty chilly after the sun went down which, I think, contributed to some folks leaving early. A *tule* condition formed on the field with a cold layer (about 20 ft thick) hanging over the launch field. There was absolutely no wind so the launch smoke got trapped and hung around for several minutes at a time forming big sheets and clouds. Very eerie just swirling around you like a mist, turning everyone's flashlights into light sabers. It made hard to breathe, though. Neither AP nor black powder smoke is especially healthy for you.



Photo 2. The LUNAR flight line at the EBRC Airshow. (photo by Judy Heckenbach)

While we're on the subject, I want to acknowledge a few people from that launch. First is Tom Hail who was out there at 2:30 to pull out the equipment trailer and help me set up early for the boy/cub scouts from Castro Valley. He stayed the entire time and was the very last one to leave (well, along with me) after we tucked the trailer in for the night. Jim "Ripple Fire" Horner gets the award for the most rapid-fire LCO we've ever had. It sounded like a tobacco auction there for a while! This went a long way towards relieving the long backup just prior to sunset.

Tony Cooper gets the "lateral thinking" award for reducing line



size. I flew my LOC Onyx just after sunset (my first flight at a regular club launch all year!) and wound up pranging it in the field across the street. When I left to retrieve the pieces, the line was still pretty long. When I returned a couple of minutes later, it was completely gone! "What happened to the line?" I asked. "I told them it was too dark to fly non-night equipped rockets now and dismissed them." Tony said. Well, even though the sun was down, it wasn't *that* dark yet and I said they could have flown a little longer. At that point Tony noticed he still had his sunglasses on! He got on the PA and apologized to everyone for sending them off early, but at least he was erring on the side of caution, seeing as how last year we tried to fly too late and wound up pranging a couple into the crowd who couldn't see the incoming.

Tom Hail comments "I think Tony should have gotten the 'Its Too Dark to Hear!' award also. My daughter has forgiven him, though. She was second in line when he made the call."

We didn't quite break 200, but 197 flights are nothing to sneeze at. Just think if Tony hadn't sent those people away!

- John Glenn - While an exciting and nostalgic Shuttle launch, what does it have to do with LUNAR? Simply that one of our founding members, H. W. "Bear" Neff (LUNAR #005) decided to take some vacation time to go, as he put it, "watch John Glenn get his butt kicked a couple of hundred miles up." I'm expecting a full launch report in the next 'Clips, Bear!

I watched the launch on TV with a mixture of excitement not felt in decades, and wistfulness at seeing all of the other surviving Mercury astronauts on camera again: Carpenter on NBC, Cooper on CBS and Schirra on ABC. ABC also had Gene Cernan, commander of Apollo 17 and the last man to have walked on the moon.

Two notable quotes came out of the usually banal "color" commentary. When asked about the dangers of the early space program, Wally Schirra said "Well, the four of us left [of the original Mercury 7] are all the Atlas pilots." While that didn't exactly answer the question, it's an interesting observation. Alan Shepard (who died just last July of cancer) and Gus Grissom (who was killed in the Apollo 1 fire in 1967) both flew Redstones. Deke Slayton (who died of a brain tumor in 1993) never flew in Mercury due to a heart condition, but flew on the Apollo-Soyuz Test Project in 1975.

When asked if he'd want to go back into space, Gene Cernan answered with a diplomatic "been there, done that" sort of response. But after the launch, he broke

into the commentary with "I've changed my mind! I want to go!"

And finally, after the countdown was stopped twice in the last hour for two planned holds, it got stopped twice more; once at T-9 minutes for a cabin pressure sensor, and again at T-5 for an airplane in the area. Airplane in the area? Wow, just like one of our launches! Even NASA has to wait for pilots who can't read the damn NOTAM's!

PLAN AHEAD

Since we're wallowing in nostalgia at the moment, here's another one to think about. Next summer is the 30th anniversary of the Apollo-11 moon landing. Seeing a marketing opportunity, Estes is re-releasing their big Saturn V kit, and in the current Sport Rocketry, editor Tom Beach is proposing holding a contest. Anyone who flies a Saturn V model between July 16 and July 20 (the dates of the Apollo 11 mission from liftoff to moon landing) can send him a post card and he'll put it in a drawing for a Neubauer micro-Saturn V kit. If you fly it at a public demo, which our launches qualify as, he'll do a drawing for the big Estes kit. (Note, according to Tom Hail, "A2Z Hobbies" is taking preorders on-line at www.a2zhobbies.com for anticipated December delivery.)

I think commemorating the date is a great idea, with or without the drawing. By happy coincidence, our nominal launch date for next July would be the 17th. We are still applying for next year's schedule with LARPD, but we'll keep our fingers crossed. To help juice it up, we'll invite all the media we can. That includes the local papers and cable channel, and maybe even a well-known San Francisco NBC affiliate (Larry?) I think a massed launch of half a dozen Saturn V's would be quite a sight!

I suppose a Saturn 1B would qualify as well. I could drag my old original, never flown Estes kit from 1968 to put on display.



LUNAR Dust

From Roger L. Deran, LUNAR #569:

"I have written a little Java program called ROSE: Rocket Optimization and Simulation Environment. It is at <http://www.boilerbay.com/rockets/>."

From Mark Jeghers, LUNAR #129:

"I've updated my web page. Follow the links at <http://www.t4p.com/fun/fun.htm>. More stuff, including more Black Rock night photos, will be added soon. Hope you like them. Constructive feedback is always welcome.



PS: the images render better if you set your video card to more than 256 colors (if you can do so).”

From Tom Hail, LUNAR #440:

“<http://ourworld.compuserve.com/homepages/THail/Rockets.htm> has picks from the Sep launch, the RC Airshow, and the Discovery Channel videotaping. Forward any name misspellings or other errors to me.”

From Lynn Kissel, LUNAR #009:

The handouts and notes from Warren Massey’s presentation on igniters at the October 15 LUNAR meeting can be found at <http://www.starship.org/LUNAR/talks/Massey9810/>.

Back issues of LUNAR’s newsletters, dating back to the first issue of November 1992, have been scanned and are available at <http://www.starship.org/LUNAR/LUNARclips>.

I have a page with pointers to member and other sites at <http://www.starship.org/LUNAR/links/>. If you want a link to your site, send me a note at kissel@starship.org – remind me in the note that you’d like a link from my LUNAR links page.”



Days at Cape Wheeler

by John P. Adams, LUNAR # 684

It’s all my Uncle Warren’s fault. I was visiting him one summer out in Montana, and he thought I would like a model rocket. Of course, he was right. We launched it from his front yard, lighting the engine with some cannon fuse. Watching my blue and gold Estes kit streak skyward, I knew my life would never be the same. I had become a Rocket Nut. That first launch led to many more, but I had to wait until I got home for that.

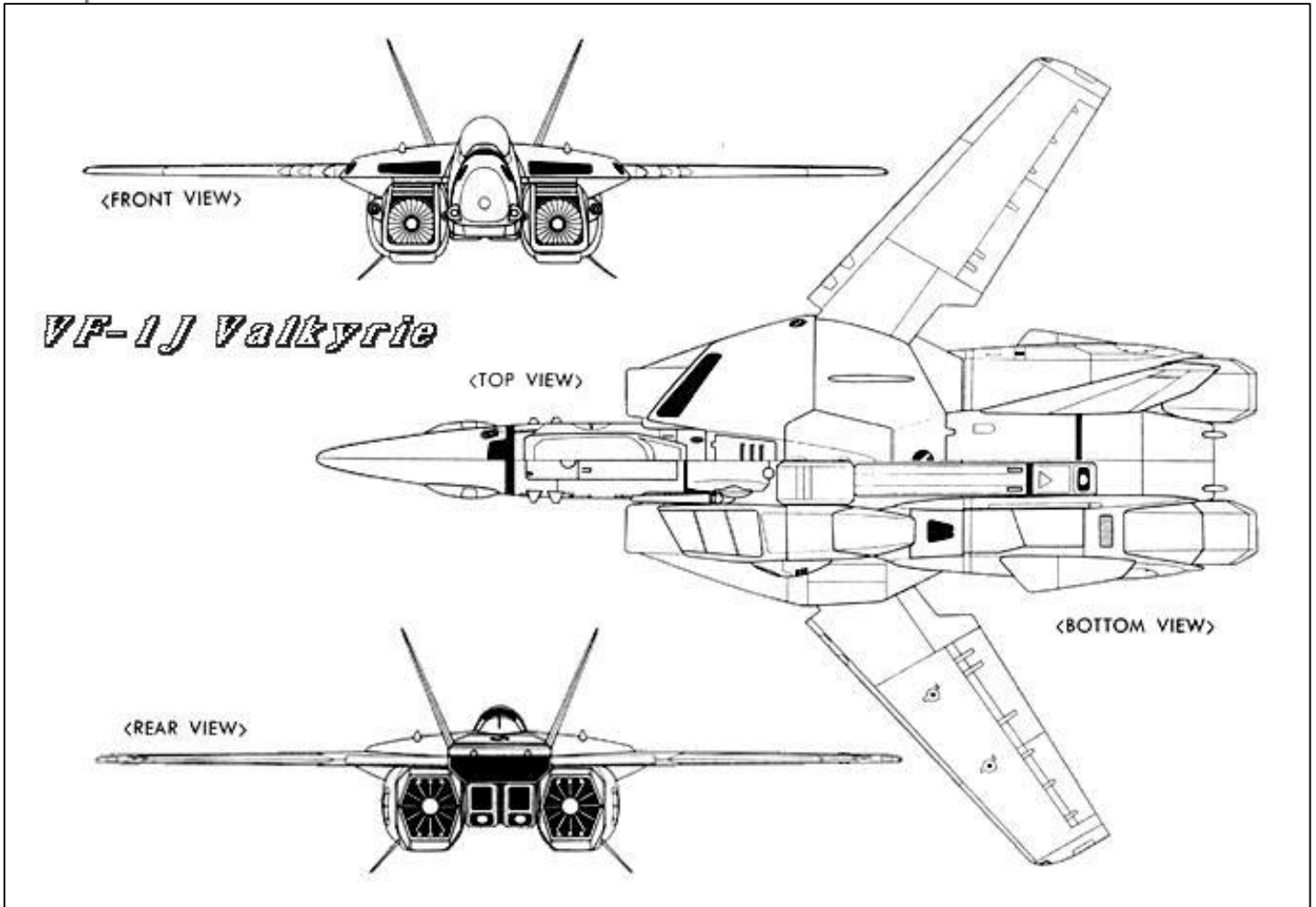
Back in Michigan, where I grew up, I found I had a new perspective on life. For a change I had begun to think about money. If I was going to buy motors, igniters, wadding, a new launcher, and maybe even a few rockets I was going to need to find a way to get money, lots of it, at least twenty dollars. The only way was mowing lawns, so off I went into the world of lawn care. After a while my fleet began to grow, what started as a lone Starblazer X-20, grew to include a Bluebird-0 and an Astron Scout. With a few more lawns under my belt, I was able to buy a launch pad (my uncle and I had used a straightened clothes hanger) and the parts for a launch controller.

I was all set! On a clear July afternoon, I collected my equipment, and plodded off to the pasture. After a few nervous moments I had my rocket on the pad, and the

igniter connected. I took a few steps back and pressed the button. WHOOSH! The rocket streaked skyward and assorted farm animals scattered in all directions. No doubt I surprised my mom, who had not yet discovered my new hobby, but as I watched the parachute deploy, and the little rocket settle gently to the ground nothing else mattered. This was the coolest thing a thirteen-year-old kid could think of in 1981. After exhausting my supply of motors, I packed up, and headed for the house. As I looked back at the launch field, something occurred to me. I was actually launching rockets. I was under staffed – there was only myself – poorly financed, and yet I was actually getting rockets a few feet off the ground. It was like I was a tiny little version of NASA, and my parent’s pasture was “the Cape”. “Cape Wheeler”, named for the road our house sat next to.

Rocketry became a vehicle for all sorts of things when I was a kid: fair projects (where my Starblazer X-20 was eaten by a tree), school projects, art projects, and any other project where I could apply my new hobby. Soon I was getting mail from Centuri and Estes, and mowing lawns to pay for my expenses. Like NASA, I made mistakes. I did things like paint rockets John-Deere green (I stole a can of my Dad’s tractor paint), putting “A” engines in rockets meant for “C”s”. I launched in fog and deep snow. I forgot wadding, and once I even forgot to tighten the nut on my launcher. The rod tipped just as my Mighty Icarus thundered to life, resulting in a sub-suborbital flight. The thing nearly took my head off!!! It was GREAT!! I had flex wings that didn’t open, gliders that flew like bricks, rockets that lost their motors, and chutes that did not open. It was GREAT!!

I look back at all of my early rockets. None of them are still around, but I remember all of them. Some made corkscrews through the air, some wobbled a lot, and others flew just perfectly. Back then I made my fin alignment marks against a doorframe that was out of square. I glued the kits together with whatever was around, hot glue, Elmers, crazy glue, whatever. I painted them with whatever paint my Dad left where I could find it. Now that I have read four different editions of *The Handbook of Model Rocketry*, have no less than three different computer programs to predict stability and performance, and mark body tubes with a precision cut piece of metal angle, my rockets fly straighter and look better. But they aren’t any more fun than the ones launched at Cape Wheeler. My life was pretty simple then; mow a lawn, launch a rocket. Now things seem complicated; fix planes, pay bills, get the car fixed, buy food, and then, if I remember to check my calendar, I can get a few launches in once a month. So you will excuse me for cherishing my moments at our LUNAR launches, for one day out of every month I am no longer a thirty-year-old airplane mechanic, I’m a 13 year-old rocket scientist.



I've included a picture of my fantasy rocket, the variable geometry aero-space fighter.



[Heads Up! – a safety-related article...]

Estes X-wing™ Starfighter Launch Precautions

by William J. Orvis, LUNAR# 309

After watching several Estes Red Squadron X-wing™ Starfighters (the small ones that use 13 mm mini-engines EST 1810) fly, eject a metal bomb into the crowd, and then prang into the ground. I figured that the flight characteristics of this craft were such that we should call a heads-up launch for every Starfighter flight. However, my son and I had the fortune to build one last month for Cub Scouts and it turns out that the dangerous flight characteristics are caused by building the craft without reading the instructions.

The Estes X-wing™ Starfighter is a ready built model that

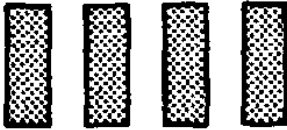
looks like an X-wing™ fighter right out of the movie (hence my son's interest in it). Assembly consists of gluing on four small fins, attaching a streamer, and applying some stickers. Most people could build it without reading the instructions on the back of the package. However, what most people miss is the small piece of paper stuck inside the package with the engine, igniter, and a small hunk of clay. That paper (reproduced here) describes how to break that clay into four small chunks and then to insert those chunks into the four afterburner bays. This clay unbalances the rocket after ejection of the engine pod so that the rocket tumbles to the ground.

It is pretty obvious now why these little rockets prang into the ground. Their builders missed the little paper addition to the instructions and left out the clay.

Heads-Up: When doing RSO duty, be sure to check for the clay in the afterburners before approving an X-wing™ Starfighter for flight. If it's missing, don't let them fly. It might not be a bad idea to mark all X-wing™ Starfighter flights as heads-up flights anyway.

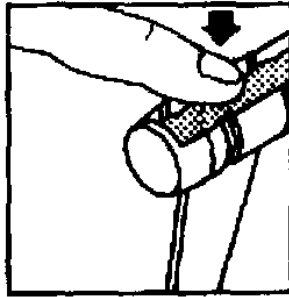


USE ALL THE CLAY WEIGHT FOR SAFE RECOVERY!

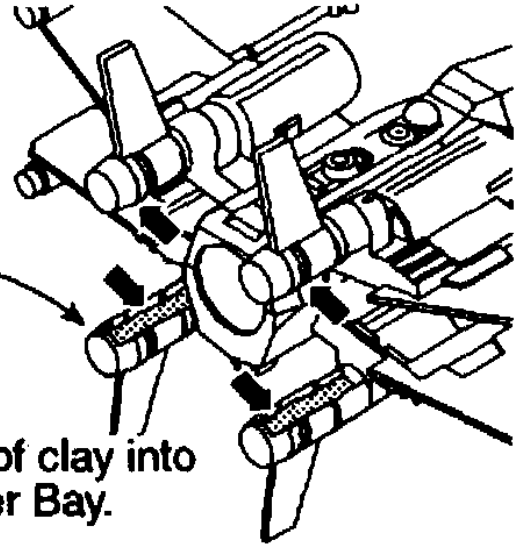


A. Cut clay into 4 EQUAL pieces.

(10-97) 84714



B. Press one piece of clay into EACH Afterburner Bay.



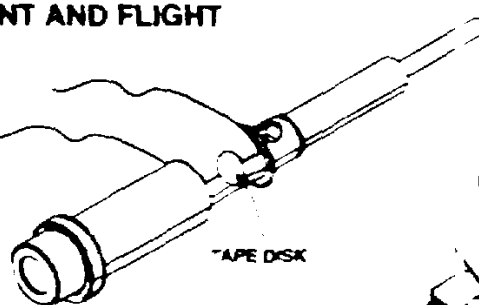
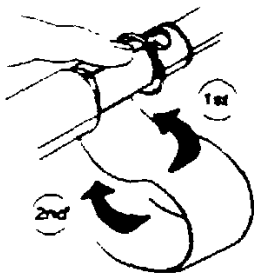
The second problem with X-wing™ Starfighter flights is the flight of the metal tipped engine pod that ejects at the top of the flight path and drops like a bomb into the crowd. Again, the problem is in not reading the instructions carefully. I had one person show me the engine pod after a flight and the streamer had not unrolled at all because it was melted slightly at one spot by the ejection charge. The instructions for attaching the streamer (reproduced here) say to roll all

but the last 12 inches of streamer onto the engine pod. The last 12 inches are to be wrapped back and forth on the engine pod instead of around it.

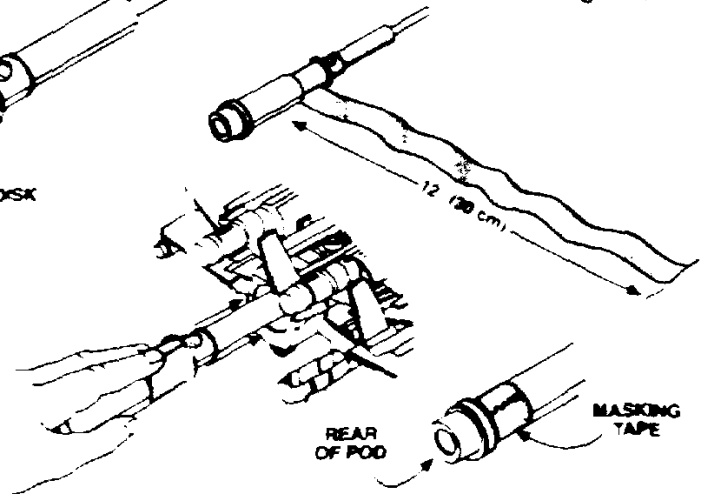
If done this way, at least a foot of streamer will deploy as soon as the engine pod is ejected from the rocket even if it gets melted a little by the ejection charge.

2. STREAMER ATTACHMENT AND FLIGHT PREPARATION

A. Remove the engine pod from rear of rocket. Use the tape disk (included) to secure one end of the streamer to the engine pod as shown.



B. Roll all but the last 12" (30 cm) of streamer around the engine pod.



C. Holding the streamer in place with finger, begin folding it back and forth around tube until all material is used

D. Holding the streamer in place carefully insert the pod into the rear of the rocket until it stops. If fit is not snug, apply masking tape where shown



HeadsUp:
When doing RSO duty on an X-wing™ Starfighter, check the wrapping of the streamer to be sure it is wrapped back and forth around the engine pod and not wrapped around the pod. Do this by pulling the engine pod out until you can see the edge of the streamer. Don't pull the engine pod all the way out because it is a real pain to get the streamer folded right and inserted back into the rocket.



The original crash of the Crypt Ship.

More Tales from the Crypt

by Geoff Canham, LUNAR #493

Since my last article about the Crypt Ship (my NARTREK Gold rocket) it has completed its required six flights, and lived up to the comic-book story from which it originated. In the story it crashed at the end of its two flights, so you have some idea of how the flights went, if you didn't see them yourself.

The ship's fourth flight was at the August LUNAR launch, and the flight went fine (after two copper igniters failed), except that the parachute didn't fully open, and it came down rather hard on the bank on the far side of the road, breaking two fins.

But it was back for the September launch, which was originally going to be a Future/Fiction Scale Competition, but that got cancelled. That disappointed me, but it was handy as I had to get down south to Carlsbad for Open House at my stepson's (Matt's) school. So I arrived early to give the Crypt Ship one flight, then I would be off down the I-5. The ship was the second rocket of the day, in a slight drizzle (kind of heavy mist). It lifted off perfectly, veered away from the soccer field (where a game was going on), and started to descend. "Deploy, deploy, deploy, deploy, ..." urged the LCO as I video'd a rather rapid descent. Deployment occurred about 10' from the ground, just in time to swing the delicate fins around so they hit the ground first in the animal pens. I'm sure most people who saw it thought it would never fly again, but a lot of glue and paint enabled it to be back a month later.



I arrived at the October launch just in time to get the ship up before the sun went down. The flight went well, the parachute deployed, it descended smoothly, ... and landed right on top of the fence surrounding the pens, breaking two fins off. But it's back in one piece again, of course.

But what happened to it to cause the crash in September? On reviewing the videos of all the flights, the first thing that stands out is that it took 8.98 seconds from launch to deployment, while the other flights took from 5.08 seconds to 6.39 seconds. The normal variation was more than I would have guessed, but the one in September was about 50% more. But I also noted that the time to apogee on that flight was about a second less than the average for the other flights. Assuming that the thrust on each flight was similar, the normal drag coefficient works out about 0.80. To give the flight characteristics of the September launch, I have to use a drag coefficient of about 1.20 in the calculations (using the spreadsheet detailed in the last 'clips).

It is wrong to base a theory on one isolated event (and I have no intention of subjecting the ship deliberately to a similar flight) but it would appear that the light drizzle caused additional drag, and to take the effect into account means taking 150% of the normal drag coefficient. If anyone else has any similar flight information, I'd be interested in comparing notes.



A Trivial Shock Cord Mount

by Roger L. Deran, LUNAR #569

Why is recovery separation so common? In smaller rockets it is dangerous and embarrassing, and with high power there is no way it can be tolerated. It seems that usually the problem is the shock cord mount. Let's take a hint from H.P. and apply it to the smaller rockets; glue the shock cord or a nylon loop directly onto the inside of the airframe. This method is recommended by LOC Precision for use in rockets as large as, or larger than the EZI-65 – my own favorite. I have used it in a variety of low power rockets including kits and scratch models. It has worked flawlessly (so far!)

It may seem that gluing directly to the inside of the cardboard tube would create a weak joint, but done correctly it will be far stronger and safer than the folded paper recommended by at least one important manufacturer. The secret is to cover a wide area with epoxy and set the cord into it. The epoxy should be built up to form a solid, smoothed unit at least as wide as the folded paper type, preferably much larger. With a 98mm (4") airframe this is easy, since you can get your entire hand down into the tube

to spread the layers of epoxy. But how can you get such a joint inside a 24mm (.976") tube?

The technique I use is even easier than using folded paper. Just squeeze the epoxy into the end of the shock cord and stick it onto the end of a rolled-up 5" square piece of waxed paper. Put plenty of extra epoxy around and on the cord to form a 1" square. Now tighten up the waxed paper to fit inside the body tube and push it down inside far enough to allow the nose cone or payload section bulkhead to fit forwards of the mount. Unroll the waxed paper so that it fits snugly, pressing the cord and epoxy onto the inside of the tube. When it dries, pull the waxed paper out. Done!

The joint formed this way will be almost perfectly flat due to the pressure from the waxed paper. Flatness is very important, since any burr or blob of epoxy will tend to catch the recovery system on the way out. If you just try to use the natural viscosity of the epoxy to hold the cord during setting, the cord tends to rise up in some places and form rough spots, jagged edges, or even a genuine aft-pointing hook! These problems have to be corrected by filing, sanding, and covering with more epoxy. The waxed paper trick avoids these difficulties and requires only one mix of epoxy. I don't think it would work as well in larger tubes, but it is worth a try.

For a really perfect mount, fill the waxed paper tube with cotton balls after it is unrolled inside the body tube. This will put pressure on the waxed paper from inside and insure that there are absolutely no burrs on the edge of the epoxy. Even without the cotton ball filling, the epoxy mount is much flatter and smoother than the folded paper type. You can feel the difference by sliding a 'chute through the tube by hand. One more improvement is building the epoxy layer up even further with additional coats of glue. The additional coats will add strength and increase smoothness.

LOC Precision also recommends gluing in a loop of nylon cord instead of the shock cord. The cord is a single piece, without knots, doubled up to form the loop. The two loose ends are glued into the body tube side by side, providing a two-place connection that is even more reliable. Tie the shock cord to the loop so that if one end of the loop breaks, the cord will remain attached to the other end rather than sliding off. With this nylon loop, the cord can be removed for convenience or replaced if damaged. Use extra thick nylon cord.

One last thing: don't use the shock cord supplied with the kit! The manufacturers seem to want to save money on the cord by giving you thin, short pieces. Such cords are really insufficient, especially when the model is heavy. If there is significant weight on the forward end of the cord – perhaps a payload section – then there is going to be even more tension in the cord. If the model is moving at high speed



when the recovery system is deployed, the force of deceleration will be transferred to the model through the shock cord. If the cord stretches to its limit, the tension will suddenly go sky high.

Go to a fabric store and get some of that same elastic for almost nothing. It comes in black or white, in various widths, and in any length. Use a piece as long as you can comfortably work with. Four feet would not be extreme. There is no reason to skimp. Don't worry about weight either; safety is the number one priority.

Have fun with this waxed paper shock cord trick. Please send me any comments about it at rlderan@boilerbay.com.



The Sci-Squad Launch Report - Playing Hooky in Livermore

by Bob Fortune, LUNAR #660

There was a post on the Usenet rocketry discussion group in September from a gent named Pierre Valette who is a TV producer for Quest Productions (no relation to the model rocket company). He was looking for rocketeers to participate in a project that Quest was working on for the Discovery Channel called Sci-Squad. Sci-Squad is a show for adolescents featuring a comely 18-year old who travels around the world having scientific adventures. I passed the info along to LUNAR president Jack Hagerty and Jack pulled out all the stops to set up a bona fide launch midweek for the film crew. About 8 of us showed up to fly rockets (we played hooky from work is what actually happened) for the crew and starlet. Hopefully we'll see Jack, the starlet, and all the rockets on the small screen early next year.



Photo 3. The Sci-Squad production crew. L-to-r Producer, director, gaffer, actor, soundman. (photo by Jack Hagerty)

The LUNAR field is rated up to "H" motors, but none could be flown unless someone with a California pyrotechnic license is present. Hey, it's California, but what the heck.



Photo 4. Setting up a "take." (photo by Tom Hail)



That was taken care of when a gentleman named Tom Rouse arrived pulling a trailer with his ICANo CATS project on board. CATS is a contest to encourage development of Cheap Access To Space. The first prize is \$250,000 for the first private group to put a payload up 200 km (about 120 miles). Tom is a building contractor in San Jose, my hometown and is a member of both LUNAR and Aero-Pac. What a piece of work his ICANo CATS is, a gorgeous hunk of aluminum handmade in loving detail by Rocket Dyne Systems. It's a two stager, S to Q. Need I say more?

We helped Tom set up this beast, about 24' long, on the sidewalk near the range head. It will fly the CATS tracking payload and a satellite called "Barnacle" made by Santa Clara University. One cop came by, then another, then 2 more later on, then the fire captain, then a fire truck, then another fire truck, another fire captain, and one last cop....I guess word got out quick for Livermore's a smallish town.

Tom intends to fly his creation in Canada as part of the CATS contest in early 1999 so wish him the best of luck. For more info on this rocket see the ICANo web page at <http://www.icano.org/>.

Most of us got to fly a couple of rockets with Warren Massey getting off the first and most flights. The director picked three of his models to use for the first sequence, launched as a drag race. They ultimately wanted four takes of this launch: a second take because they missed the first one (the rockets "took off too fast"); a third take from a long range camera, and a fourth take "for sound" – all picture perfect launches. Warren is the equipment meister for LUNAR and is a true craftsman and creative genius.

Mine was next, a 54mm BT G10-finned creation I call the Cub Scout. It has a Glaspar probe extending through the nose cone about 2 feet long on which I skewered 2 marshmallows as "external payload", hence the "cub scout" moniker. It's really a scientific rocket to test the effects of transonic



Photo 5. "Aaaaaaand Action!" (photo by Tom Hail)

speeds on food products. Two good flights and recoveries to my delight. Next I'll try a hot dog – maybe a polish.

[Ed. See Bob's article describing his *Cub Scout* on-line at <http://www.starship.org/LUNAR/LUNARclips/v5/v5n6/CubScout.html>]

Next up was Tony Cooper's big NCR X-wing, great flight and no-breakum recovery which he followed with an AT



Photo 6. Tom Hail hooks up the Tomahawk while the Director sets up a low shot. (photo by Jack Hagerty)



Barracuda. As a finale he flew his scratch built SR-71 BlackBird on an H128. That got their attention!

Also seen was a LOC I-ROC by Ed Arminini, a beautiful Tomahawk by Tom Hail (which the cameraman doted on much to the chagrin of the owner...NOT!), and a couple of other nice rockets the names and owners of which I forget; sorry boys.

Blue skies, scudding clouds, a light breeze, and sneaking out of work all made for a fine day! The filming was pretty boring though the crew was cordial and patient. They even treated everyone for lunch after the launch.

Photos 3-11 show some of the days action. A great day and way better than working!



(Outline of LUNAR's November 19 meeting talk...)

How to get Level 1 Certified and Live to Tell About It

- Or -

Not the Right Stuff, The Big Stuff!

by Andrew Pohlman, LUNAR # 555

Certifying Level 1 can be as easy as falling off a log if you do your homework and pay attention to detail. Here is the scoop in outline form. The good news is that you will not be inside the thing you'll be sending up (not the right stuff). I'm sure those with abounding High Power wisdom will have more to say and I'm sure some will disagree with some of what I present. So be it. The point is, after achieving this right of passage you'll be able to form your opinions about what it takes to fly the Big Stuff!

1) Requirements NAR and Tripoli

- build a rocket and fly it successfully on an H or I motor provided especially for the purpose of certification.
- have the flight witnessed by an existing member at Level 1 or greater (NAR requires an additional member to witness the flight, not necessarily a certified flyer)

- fill out the forms and have them signed by the witness(es) and send them in to the appropriate organization
- the flight must be 'perfect', in that the deployment system actuated and the rocket is capable of flight without any repairs (this is a judgement call by the certification team)
- the rocket need not be recovered if it is excessively dangerous to do so, but you MUST prove the motor did not eject
- the certification team must observe you construct the motor if it is a reload
- all normal range rules apply and your certification flight will usually be announced as a 'heads up' flight (don't take it personally)
- the H128 / G75 controversy is settled: H128 is a go, G75 is a no!

2) Run Simulations (see steps 3 and 4)

- exciting cert flight should be an oxymoron and don't



Photo 7. Tom's Tomahawk takes flight on camera! (photo by Jack Hagerty)



Photo 8. Warren Massey hooks up the "experimental" finless Alpha. (photo by Jack Hagerty)

belong in the same sentence

- use ROCSIM, WRASP, Alticalc or Rockdrag (don't forget the are simulations and may not reflect reality)
- choose your desired altitude - at LUNAR Ken Finwall and I agree it should $\leq 1500'$
- Run simulations of everything and choose a rocket/motor combination that is optimized for your flight parameters
- Build a list of optimal combinations - you may not be able to acquire your first choices

Assuming you have played with your simulations until nauseated:

3)Choose a Rocket that won't fly away nor only go 300' (see steps 2 and 4)

- choose a rocket that requires a G80 minimum and has a simple design (3F&NC)
- large diameters (like 4") are best but really anything you can build well will be fine
- use lots of epoxy in construction - don't scrimp, don't get cheap

- take your time building it - don't get lazy and take shortcuts
- you MUST build a motor retention system into your rocket - Aerotech engine hooks DO NOT cut it!

4)Choose a Motor (see steps 2 and 3)

- there is no reason NOT to use a reload; if you haven't built many reloads, get some practice with mid-power models and a 29mm RMS
- if you can afford it, choose the diameter you want (29 or 38 mm) and buy the 'SYSTEM' so you'll have choices on the big day (Ken does not always have what you want)
- go for the lowest thrust that will get your machine off the pad safely
- you don't have to wimp-out and certify on an H128, just keep it sane
- if you can't get a good simulation, go to step 3 and choose a new rocket

5)Choose the Certification Team

- well in advance make an agreement with a certified flyer to be at the same launch you intend to certify at
- make sure Ken Finwall will be there to sell you a motor
- get advice from the certification team - if they don't want to give advice, choose others

6)Get the paper work well in advance and bring it

7)Choose a day when the Rocket God and Wind God are not wrestling

8)Classic Sane Combinations

- THOY Falcon on an H97-6
- LOC EZI-65 on H97-6 or H180-10
- PML Explorer on H128-10
- PML Tethys on H123-6

9)Guts-Required Combinations

- PML Cirrus on an H anything (massive altitude, tiny rocket)
- LOC Lil Nuke on an H anything (massive altitude, tiny rocket)
- THOY Phoenix on an H anything (fins exhibit many problems)
- LOC Warlock on H97-6 (under-powered nightmare - LCO should deny)
- LOC EZI-65 on an I65 (sane flight but need crack recovery crew)





Photo 9. Starlet with finless Alpha. (photo by Jack Hagerty)



Photo 10. Flew as well as we thought it would. (photo by Jack Hagerty)



Photo 11. Tom Rouse's ICANo CATS rocket, without nosecone. (photo by Jack Hagerty)



LUNAR at the EBRC Airshow

by Jack Hagerty, LUNAR #002

In mid September, I got a call from George Gissendaner of the East Bay Radio Controllers RC club. He told me that they were putting on their annual airshow for the public and wanted to know if we'd like to participate. "Sure," I said. "When is it?" "October 4th" came the reply.

That was a bit of a problem since it gave us less than three weeks to come up with a demo. Still, LUNAR hadn't been part of an airshow since the Livermore Airshow stopped flying a couple of years ago.

"I'll see what I can do," I said. I was pretty sure that I could count on some of our members to put a good demo together. A personal problem was that I couldn't be a part of it. October 4 happens to be my anniversary and when it falls on a weekend, the day gets spoken for really early.

So I put out the word on my e-mail list of members and got several responses right away. Tony Cooper, Tom Hail, Joe Heckenbach, James Spurling and Lee Techeira all jumped at the chance to show off in front of a crowd.

I did some minor coordinating up to the day of the show, and had to drive in to Castro Valley to visit the Alameda County Fire Marshall to negotiate a last minute fire permit for the show, but other than that, these guys took over the demo. The Heckenbach's, Joe and Judy, brought a canopy to

set up over the club table for the static displays and club fliers. It gave us a great place to hang the banner from as well.

Originally George had given us 20 minutes for our show, but that got cut to 15, and they tried to cut it further to 10, but we knew that was impossible. To save time in setup, our crew decided to use all 18 pads rather than try to re-rack in mid demo. The rockets were all pre-prepped and placed on their pads in the display area. The wires were run out to the edge of the runway ahead of time so that when it came time for the demo, each owner only had to carry the pad with his rocket out to the end of the wire and pound the pad in.

Lee Techeira did all the announcing for our part of the show and got everything launched within the window, except for a few misfires. The demos ranged from an Estes Mosquito on an "A" (which accelerates at over 100 g's) up the scale to several "G" powered flights. Since there was no waiver, we had to stay under 1,500 grams, but the crowd didn't seem to care. They all gasped and applauded at the appropriate times and we handed out a lot of club fliers.

The ultimate sign of approval is that we've been invited back for next year!

See Photos 1, 2 and 12 for scenes of the EBRC Airshow action.



Photo 12. Under the LUNAR pavilion at the EBRC Airshow. (photo by Judy Heckenbach)



The Cub Scout

by Bob Fortune, LUNAR #660

A while back I realized I had a bunch of odd sized 54-mm motor-mount tubes kicking around. The inside diameter was off a bit and would not fit LOC adapters so they sat in my tube box. Also taking up space was a sheet of copper-foil-clad G10 that electronics folks use to make printed circuit boards. You can find the type of copper-clad G10 I used at Radio Shack, Fry's or a well stocked electronics supply place. The foil is only a couple of mils thick; intended to be etched away in the circuit making process. The only thing I was lacking was a nose cone that I picked up at the hobby shop that fit 54-mm motor-mount tube.

I was set, all I had to was figure out a design. I wanted to cut the fins from the G10 with the minimum of fuss, which explains their triangular shape; just draw diagonals and cut. I had one piece of 32" 54-mm motor-mount tube and one piece of 17" 54-mm motor-mount tube that I wanted to get rid of hence the length of the rocket. Plugging these parameters into RockSim (www.apogeerockets.com) made for a surprisingly stable rocket, able to fly on all the motors from "E" to "H" in 29 mm without adding nose weight.

So I had an odd rocket that was a bit boring except for the interesting brushed copper fins. Then I found a long fiberglass rod in the garage that would make a nifty "probe". This was originally made to hold a flag on a long pole you would attach to a bicycle for visibility. I modeled this in RockSim and it still flew well but the rod was a bit splintery so I looked around the garage and came up with something a bit more robust, GlasSpar. GlasSpar is a fiberglass tube, black in color that comes in 3-foot lengths. It can be found at hobby shops and is used as a central spar in model airplane wings.

The nose cone is hacked off at the tip until the hole that is exposed matches the O.D. of the GlasSpar. I used a bench grinder to accomplish this task. Allow about an inch to protrude out the aft end of the nose cone that is also cut to the same GlasSpar O.D. These holes will act as centering rings for the probe. Wrap masking tape around the protruding aft end of the GlasSpar to keep it from moving forward. Glue consecutive loops of string where the GlasSpar exits the nose cone forward building up the string till it matches the ogive of the nose cone using thin CA to keep the string in place. Epoxy this mess smooth to match the nose cone. Make sure that this probe is removable (just in case) by putting a piece of wax paper or plastic wrap between the nose cone and string. The masking tape alone will keep the probe from exiting the nose cone on deployment but just in case I epoxied a knife insert into the GlasSpar to hold a screw. I had to grind most of the threads off the outside of the insert to get it to fit properly. A knife

insert is like a metal coupler that has knife-like wood screw threads on the outside and machine screw threads on the inside and is usually made of brass. Two holes are drilled in the nose cone shoulder through which 1/16" cable is passed to make a loop secured by crimps. A piece of metal drilled with two holes or a master link keeper off a bike chain is screwed to the knife insert. The forward bridle quicklink connects the master link keeper and nose cone cable together to make a redundant nose cone retention system. A couple of screws through the airframe into the nose cone makes for a real belt and suspenders approach to bridle retention. This rocket has deployed at over 100 mph with no ill affects.

Now I've got this long rocket with an equally long proboscis and what am I going to call it. The probe made me think of the sticks we used roasting marshmallows over the campfire at the last scout campout and I dashed into the house to find a couple of the tasty treats. Installing them onto the GlasSpar I knew what to call this thing ... the "Cub Scout".

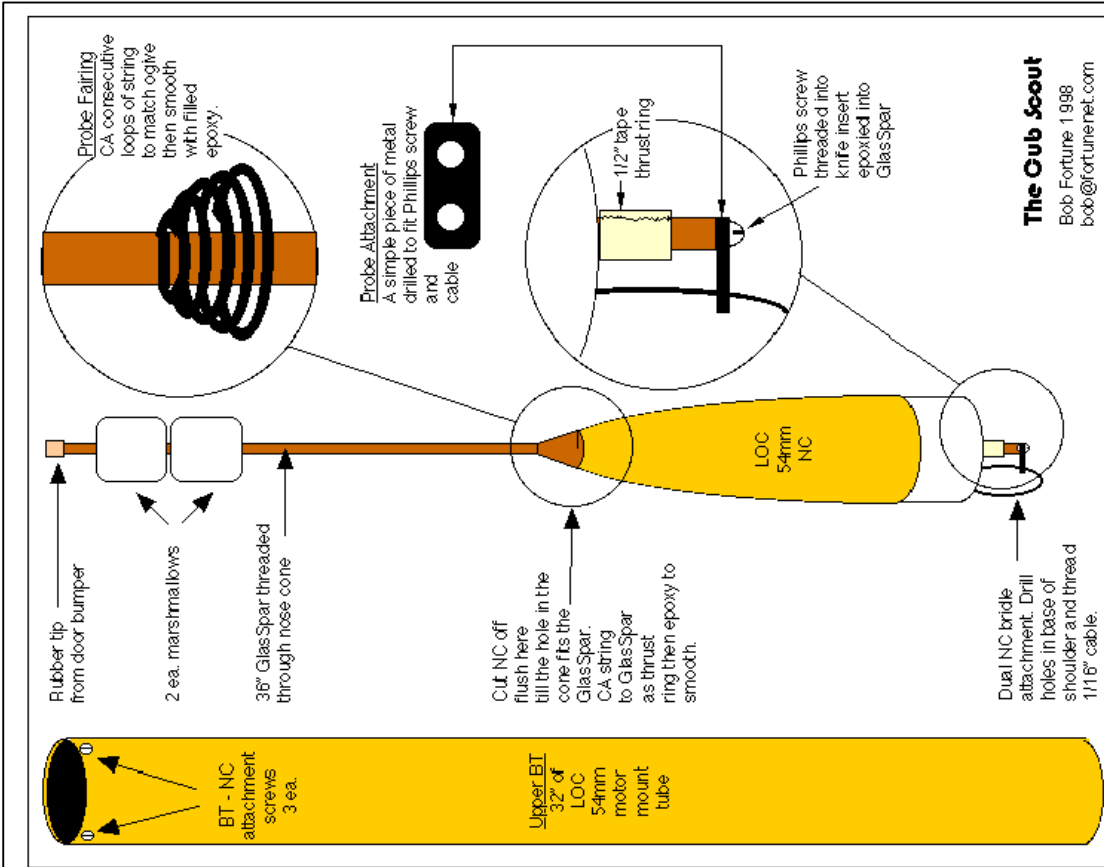
The fins are mounted about 3/4" from the aft end. I used a Dremel with a fiberglass-covered cutoff blade to cut slots in the body tube (BT) once I had epoxied the LOC adapter in place. If you use plywood you can stack blades together to make a "stacked dado cutter". Two larger blades on the outside and 3 or 4 blades sandwiched in between make a nice slot for 1/8" plywood for your future rocket projects. I made sure that the centering rings were located in the LOC 54mm-29mm adapter so that slots could be cut to receive the fins, actually locking them in place.

Since the fins are copper-clad and tarnish rapidly I took some 100 grit sandpaper and made a nice "brushed" finish in one direction both sides and sealed them with clear shellac. Spray varnish, lacquer, or acrylic will work as well. Once dry they were epoxied into place taking care to make the fillets as smooth and straight as possible since they would be exposed and left unpainted. Microballoons and epoxy blended together make for nice fillets which can be smoothed with a gloved fingertip dipped in denatured alcohol. Let the epoxy set until it is not goopy but will still move easily under finger pressure. Take care to wipe the epoxy off in a straight line where the fillet remains exposed at the fin.

The retention system is Stu Barrett's Anti-Zipper method. You can see the details of this construction at

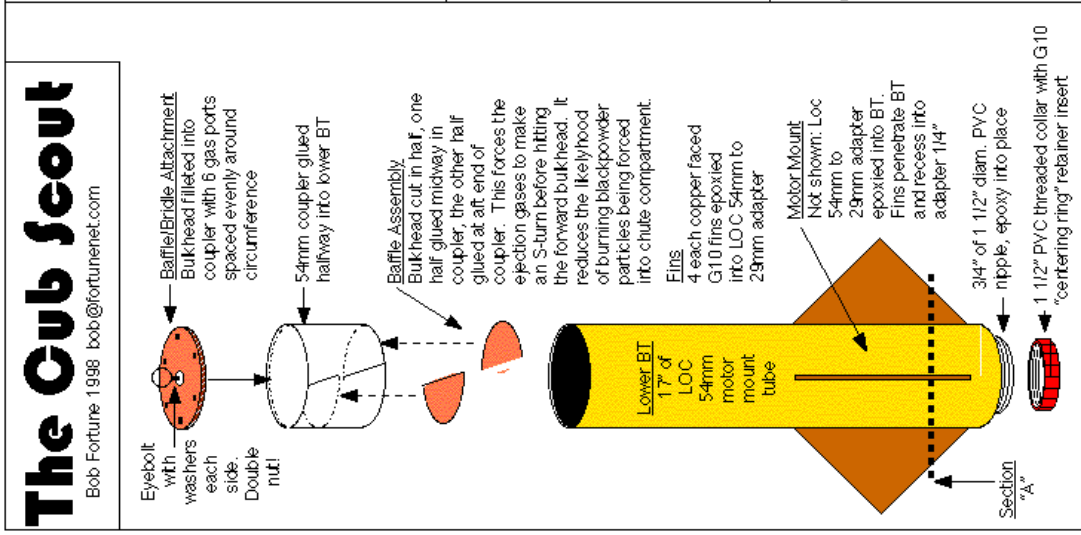
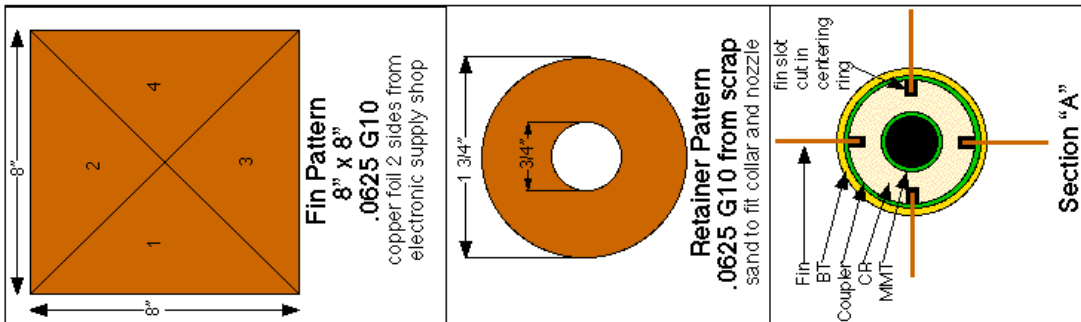
http://www.rocketryonline.com/infocentral/index_const_ruction.html

click on the anti-zipper design. This is a great system and I heartily recommend it. It even works well for smaller rockets! The baffle assembly is a LOC bulkhead assembly with an extra bulkhead cut in half and inserted in coupler as shown. You might also use a second bulkhead and drill



holes that do not line up with the forward bulkhead as the aft baffle in lieu of the system I described. Discard the LOC supplied eye screw and substitute an eyebolt which is double nuted behind the bulkhead to prevent unscrewing under the parachute. This eyebolt can spin freely on the washers to allow the booster to rotate as it descends without taking a chance on having it unscrew the bolt.

The spiffiest part, I think, is the motor retention system. It is a variation (read: blatant rip-off) of Don Qualls UMRS though it does not use the PVC cap Don originally included in his design. You can find the UMRS in an earlier issue of Sport Rocketry. In 1 1/2" PVC, the cap was too heavy for this application. This whole assembly is serendipitous for I forgot to add T-nuts before assembling the adapter. Then the knife inserts, which I had intended to retrofit after the fact, broke in the hard epoxy. Egads, what to do. Scrounging through my plumbing parts I came up with an ordinary 1 1/2" PVC nipple and a 1 1/2" PVC collar that is used to hold a nylon gasket and P-trap assembly into the wall for your sink drain. These items are available at the hardware store. I cut the nipple off





at a length that allowed the thrust ring on 29mm AeroTech RMS to be retained by a centering ring (CR), so to speak, of G10 and the PVC collar. It's actually a retention ring in this usage. Sand and test to fit before epoxying this into place. Make sure you have at least 3 or four threads of the collar on the nipple for positive retention. Test fit the nipple for length before epoxying in place to make sure it fits all the 29mm SU and RMS cases possible.

The G10 retention ring is made of a scrap of the same material as the fins. Old circuit board will work just as well here though you may want to pick up some additional boards while at the electronic shop. Make a square on the material you intend to cut just a bit larger than the collar I.D. Draw diagonals to give a center reference point. Determine the I.D. of the coupler and divide by two to give the radius and mark this on the G10. Do the same thing with the motor nozzle and mark the radius as well. Using a compass draw a complete circle and then cut out best way possible. I have circle cutters and hole cutters which makes the job easy on a drill press but sawing, sanding and judicious use of a Dremel will work just as quickly.

The bridle is 15 feet long with quick links on either end and a welded ring as the parachute attachment point. I threaded 15 feet of 1/4" nylon "shoelace" through 4 feet of 1/2" "tooobular nylon". The 1/2" toooobular stuff acts as an ejection gas protector for the smaller diameter nylon bridle and is covered with tape at the booster attachment point quicklink to protect the smaller nylon knot. This material can be found at R.E.I or any other mountaineering store or on the net. I used a 42" parachute with a reefing line though a 36" round nylon chute should work just fine. It has recovered twice from 1,500 feet with no damage with only the deployed bridle slowing its descent, the parachute chose to remain asleep in the airframe. :) Attach the parachute to the bridle so that the booster hits the ground first but also take care that the bridle is long enough to pull the chute free of the upper BT since the suspension lines on the chute can often be quite long.

Parts List:

| | | |
|---|---|--------|
| 1 | 32" 54 mm (2.14") motor mount tube | \$5.65 |
| 1 | 17" 54 mm (2.14") motor mount tube | \$2.83 |
| 1 | ea. LOC Bulkhead Assembly BA-2.14 (includes coupler and eye screw) | \$3.00 |
| 1 | ea. Bulkhead to fit coupler (make this) | |
| 1 | ea. LOC Nose Cone PNC 2.14 | \$8.50 |
| 1 | ea. LOC 54mm-29mm adapter MMA-3 | \$4.75 |
| 1 | 36" GlasSpar fiberglass tube x 3/8" diam | \$3.25 |
| 1 | ea. G10 sheet 8" x 8" copper clad 2 sides | \$7.35 |

| | | |
|---|--|-------------------|
| 1 | ea. eyebolt | |
| 2 | ea. washers | |
| 1 | ea. piece o' metal (master link clip) | \$0.65 |
| 2 | ea. nuts | |
| 1 | 15' 1/4" nylon "shoelace" as bridle | \$0.13/ft. |
| 1 | 4' 1/2" toooobular nylon as sheath | \$0.24/ft. |
| 2 | ea. QuickLinks | \$2.25 ea. |
| 1 | ea. 3/4" Welded Ring | \$0.49 |
| 1 | ea. welded ring - chute attachment point | \$0.45 |
| 1 | 3/4" 1 1/2" schedule 40 PVC nipple (cut off) | \$0.14 |
| 1 | ea. 1 1/2" PVC collar | \$0.65 |
| 1 | ea. G10 collar centering ring/retainer | (priceless) |
| 1 | ea. door stop bumper | (steal from home) |
| 2 | ea. Marshmallows (Stay Puft) | (pantry item) |

Going over this I realized there are over \$40 worth of parts here which may be too much for some folks. You may be able to substitute 3/32" plywood for the G10 and save 5 bucks. You can also eliminate the use of the LOC MMA-3 using only centering rings and a motor mount tube and knock off another couple of bucks as well but for strength I would then choose to go to the motor mount tube with the fins. Changing the retention system to something a little more conventional might also save a dollar and trip to the hardware store.

I would recommend the first flight to be done on an F motor without the probe in place just to make sure everything is working okay. Put a piece of tape over the nose cone hole if you fly it without the proboscis. AT Econojet G35's fly this quite nice though I recommend a 4 second delay if marshmallows are installed, the 7 is a bit dicey. I have also flown it successfully on AT RMS G64 with a 7 second delay.

If you have any questions or comments please email me!

bob@fortunenet.com

Thanks for taking a look at my design.

[Ed. The *Cub Scout* has been entered into the rec.models.rockets Design Contest. Find Bob's and the other submissions to this contest on-line at <http://www.users.zetnet.co.uk/davelee/rmr/descon.htm>.]





Photo 13. Tour gathering outside the main gate to the Naval Air Weapons Station at China Lake. Back row, l-r: Nevin Loop, Anthony Colette, Larry Lynch-Fresner, Tom Rouse, Mike Gillette. Front row, l-r: David Booth, Lynn Kissel, Greg Hendrick, Pius Morozumi, Steve Preston. David Booth was in charge of the tour and he is a principal propellant chemist with 32 years of experience. He is the premier propellant chemist in the US and probably the world! (photo by Rocky Harris)

China Lake, Sep. 25, 1998

by Lynn Kissel, LUNAR #009

It was brought to my attention by an e-mail message. A tour was being organized of rocket propellant and production facilities at the [Naval Air Weapons Station](#) at [China Lake](#). It was a long car trip, but the Kissel's had just bought a new minivan and I was feeling like a road trip. Besides I might never have another opportunity to visit a place like China Lake, a restricted government test range founded in 1943 for test and evaluation of rockets being developed for the Navy by CalTech. The place is COLOSSAL, covering about 1700 square miles of the upper Mojave Desert, about 150 miles north of Los Angeles.

We saw some pretty incredible facilities on our tour; gigantic propellant casting pits capable of preparing 5-foot

diameter, 30-foot long rocket motors; a large variety of propellant mixing facilities wherein explosive propellant components are mixed while being monitored from a remote control room. The largest of these facilities could prepare one ton of propellant at a time! We were not allowed to bring cameras into the facility so I got no photos, only some snaps by the main gate to the base.

I'm left with a strong and melancholy feeling from this tour, and I've seen it at facilities all across this country and around the world. Right now a generation of Cold-War scientists, engineers and technicians are quietly retiring, taking with them a wealth of information and experience. As the work was done behind closed doors, most people are unaware of what's being lost. I don't want a return to the Cold War, but I wish we could save the knowledge.





Who you gonna call?

| | |
|---|----------------|
| LUNAR HOTLINE | (925) 443-8705 |
| PRESIDENT | |
| Jack Hagerty, jhagerty@juno.com | (925) 455-1746 |
| VICE PRESIDENT/EDUCATION | |
| Ron Baskett, rbaskett@hotcoco.infi.net | (925) 462-2197 |
| SECRETARY/TREASURER | |
| Mark Weiss, bjweiss@earthlink.com | (925) 447-9025 |
| MEMBERS AT LARGE | |
| Robert Taylor, 74551.1701@compuserve.com | (925) 447-2291 |
| Warren Massey, masseys@pacbell.net | (925) 443-4933 |
| EDUCATION | |
| Andrew Pohlman, apoh@sinewave.com | |
| MEMBERSHIP/EQUIPMENT | |
| Warren Massey, masseys@pacbell.net | (925) 443-4933 |
| NEWSLETTER | |
| Lynn Kissel, lkissel@starship.org | (925) 294-8047 |

Who We Are...

LUNAR is the Livermore Unit of the National Association of Rocketry, Section #534

LUNAR is located in Livermore, California, about fifty miles southeast of San Francisco. We are organized to supply a safe, educational and legal means of furthering the hobby of model and high-powered rocketry in northern California, to aid and encourage the development of all club members' knowledge and expertise in the area of rocketry, to promote youth education and community involvement, and to engage in scientific, educational and related activities. LUNAR is open to rocketry hobbyists of all ages to further the sport and science of hobby rocketry within the NAR (National Association of Rocketry) and Tripoli safety codes. These codes have allowed hundreds of millions of model rocket launches by hobbyists since the late 1950's without serious injuries.

LUNAR also supports assorted rocketry activities of community youth groups. We have hosted launches (and in some case building sessions) for the Boy Scouts, 4H, Indian Guides, the GATE program, and LARPD Science Camp.

Launches

Section launches are usually held from 8:30 a.m. to 12:30 p.m. on the **third Saturday of the month**, unless preempted by other civic events. Our launch site is in Livermore at the soccer practice field of Robertson Park, adjacent to the rodeo grounds, in the southeast corner of town. Generally these are

sport launches, although we occasionally hold sanctioned *contest launches* for points in the NAR national contest standings, *theme launches* where we focus on a particular class of rocket, and *night launches*.

LUNAR's launch site has been certified by the Fire Marshall up through "H" power, and is the only place in northern California where this level of power can be legally flown.

The LUNAR Hotline - (925) 443-8705

The Hotline is available to provide up-to-date event information. It's a good idea to call our Hotline to verify the date of the next launch or meeting.

On launch days, the Hotline recording is updated by 7:00 a.m. to reflect the Go/No-Go status of the launch. On launch days with questionable weather, it is especially important to call the Hotline to get the latest information. You can also leave messages on the Hotline.

Meetings

The LUNAR annual meeting is held during the first quarter of the calendar year at a time and place announced to the membership. At this meeting, officers are elected and other club business is conducted.

Other section meetings are currently held on a bi-monthly bases. These meetings cover section business, and typically include presentations by club members or other experts on some aspect of the hobby, ranging from simple building tips to advanced science and engineering principles.

WWW site!

LUNAR maintains a World-Wide-Web site on the Internet. It is accessible via the URL (uniform resource locator)

<http://www.lunar.org>

There's a lot of stuff to see there, and it always contains the latest information about LUNAR and our activities. For example, you'll find our latest launch and meeting calendar, directions to our launch site, a gallery of photos from past launches, the on-line issues of the LUNAR'clips (the section newsletter), our section bylaws, pointers to member rocket pages, pointers to other rocket and space related information on the Internet, and lots more!

The on-line version of the LUNAR'clips is in some ways better than the hard copy version that we mail to the membership. For example, the on-line version often has color images or additional visual material that doesn't appear in the hard copy version.



LUNAR Calendar

Launches at LARPD Soccer Fields, Robertson Park (N 37° 40.10', W 121° 45.36')

Meetings at community meeting room, Livermore Police Station, 1110 S. Livermore Ave.

WARNING! Times and dates are subject to change with little or no notice. For launch confirmation call the LUNAR Hotline (925) 443-8705 after 7 am on launch day. Otherwise, visit the LUNAR web site at www.lunar.org for the latest information.

November 19, 1998, MEETING ♦

Thursday, 7:00 p.m. - 9:00 p.m.
Andrew Pohlman, Level 1 Cert.

November 21, 1998, LAUNCH ↗

Saturday, 8:30 a.m. - 12:30 p.m.

December 19, 1998, LAUNCH ↗

Saturday, 8:30 a.m. - 12:30 p.m.



LUNAR
912 Loyola Way
Livermore, CA 94550-7286