THE SENTINEL

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GOING... GOING... GONE?

WE'RE STILL HERE!

1999 LAUNCH SCHEDULE

A2Z LAUNCH PICTURES

CLUB KIT REVIEW

MULTISTAGE PLANS

WHAT BARROWMAN LEFT OUT

LETTERS TO THE EDITOR

WELL DONE

Please accept this letter of appreciation on behalf of the Civil Air Patrol for the use of the CMASS model rocket launchers and equipment this past July.

Our group of cadets thoroughly enjoyed the day's events in which these young rocketeers felt firsthand the thrills of launching model rockets. Woodsom Farm Park in Amesbury offered the perfect setting and allowed for unobstructed views for small and high-powered rockets. Our squadron is deeply indebted to your organization for inviting us and providing for such a wonderful day.

The purpose of the Civil Air Patrol is to develop and motivate young adults to become dynamic leaders and responsible citizens. Civil Air Patrol is the civilian auxiliary of the United States Air Force and its members are volunteers. Our model rocketry program educates and builds awareness of aviation and space sciences through hands-on activities.

Again, thanks to you and the other CMASS members for an enjoyable day.

Joseph E. Zwirblia, 2 Lt.
Aerospace Education Officer
Worchester Cadet Squadron, Civil Air Patrol

[We're very happy to have CAP cadets attend our launches. Last year we also had two visits by the Nashua Cadet Squadron. Their Assistant Aerospace Education Officer, Bill Norcott, is now a CMASS member! —Ed]

MAY 30, 1998

Seems just a few days ago over 1000 Boy Scouts and thousands of Cub Scouts and visitors jammed the Woodsom Farm for the Scout Expo. Young kids running around having a great time learning and exploring. Sure was fun.

On behalf of the Yankee Clipper Council and all those that were there that weekend, we thank you for your help and booth display of rockets and flying. It was great. Thanks for coming and making the weekend a success.

In Scouting,
Ron Fuller,
Expo Chairman

[We enjoyed participating in the Scout Expo. It sure seemed that the scouts enjoyed our demonstration launch. We'd be happy be part of the next Expo you hold. A great thanks also goes out to all the CMASS members and their families who helped make our launch happen that day! We even did well with the launch on the "other" side of the road. —Ed]

THE SENTINEL

is published more or less whenever we get the chance by the Central Massachusetts Spacemodeling Society, NAR Section #464, of Northboro Massachusetts.

Editor Emeritus: C. D. Tavares
Editor, Layout and Production: John R. LoVerso

Membership in CMASS is open to all area NAR members. Dues are:

$4/year	for ages 14 and under;
$6/year	for ages 15-17;
$8/year	for ages 18 and up.

For others, newsletter subscriptions are $6 for four issues. Check your mailing label for your expiration. Make checks payable to *CMASS*.

All area modelers who agree to abide by the NAR Safety Codes are always welcome to sport fly at any of our launches.

ON THE COVER

Bill Spadafora took this shot of *the one that got away* using his digital camera at this year's A2Z Rocket Day on August 22 (see page 4 for more pictures). I'm sure Bill will time the shutter better next time (as well as include a description of the awesome rocket we've just missed!)

AMESBURY FOLLIES ASIDE,
OUR 1999 LAUNCH SCHEDULE ANNOUNCED

FOUR LAUNCHES SCRUBBED

After optimistically setting a schedule that included 12 launches in Amesbury at Woodsom Farm Park, four launches have already been scrubbed. Most of these were the ones in May and June, during hay growing season, so they were expected to be denied.

However, the first club launch of the season was set for April 17 and it wasn't expected to cause a problem. Still, the Amesbury Mayor's office didn't approve that date because they claimed that club use of the field would damage the hay crop. Thankfully, diligence by club secretary Doug Steinfeld paid off when he actually spoke to the farmers about use of the field in the early spring. The farmers said they had no problem with CMASS using the field during March or April, although they preferred no use in May or June. This has allowed the club to reschedule the first launch to Saturday, April 24.

It appears that the Mayor's office was still looking for some reason to prevent the launch, as they then denied the club the use of the field access road because of liability reasons. Members may recall this is the same problem that Amesbury had during the Fall of 1997. As it turned out, the club's NAR Section Insurance covers both the town and the club for any lawsuits arising from an accident on the access road. Doug is optimistic that he'll get the town to understand this in time for the launch.

Since this still unresolved as we go to press, be sure to check the status of the launch before heading out to the field. Either look for last minute announcements via email, check the club's web site (http://www.cmass.org) or call the launch answering machine.

REMINDERS

As always, please remember to **drive slowly** on the dirt road. If you see dust behind you, you are driving too fast! Please also park your cars directly along the road (do not drive onto the field)!

REMAINDER OF 1999

Following the April launch, our 1999 schedule takes a hiatus until our next launch in Amesbury on July 10. From then on, we have a launch scheduled every 3 weeks, until November. This gives us a total of seven launches planned for Amesbury, plus the A2Z Rocket Day launch in Hatsfield. This still works out to our busiest launch year yet!

A may still have a launch in May or June if we can work out an alternate field to hold it on. Don't forget the May demonstration launch we held for the Boy Scouts last year!

FRONTIER ROCKETRY

CMASS members also have an open invitation with Frontier Rocketry, now a charted NAR section (#573). They launch on a 53 acre field at Wrentham State School (MA). They have planned launches on May 22 and June 19, when we are locked out of Amesbury. I'm sure several CMASS members will attend. You can reach Frontier via our schedule web page or by calling (508) 695-0575. Note that unlike at our launches, there is a $3 launch fee.

SET UP AND TEAR DOWN

As discussed at club meetings last year, those members who help during set-up, tear down, or at the club trailer during the day (cooking hot dogs!) will be given ***special launch privileges***. Those members will be able to jump to the head of the line at the RSO desk, and their pad will get priority when there are several ready to be launched.

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AUGUST 22, 1998

A2Z LAUNCH BLOWOUT!

by
Bill Spadafora

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A GREAT DAY FOR FLYING

It was blue skies and little wind for the annual Rocket Day launch held by CMASS for the A2Z Science and Learning Store (http://www.a-two-z.com/) in Northhampton, MA. This years batch of budding rocketeers built a varied looking mix of Estes Alpha III kits, and a good turnout of CMASS volunteers kept the launch going smoothly, as usual.

The check in line and many kids with Alpha's of varying colors. C.D. at the helm, of course!

Scott Clement explaining the use of the launch pads for the fiftieth time.

Jim Cook doing safety check.

Drag racing Quest UFO's. That's mine in the air and John Buscaglia's on the pad trying to catch up.

CLUB KIT REPORT

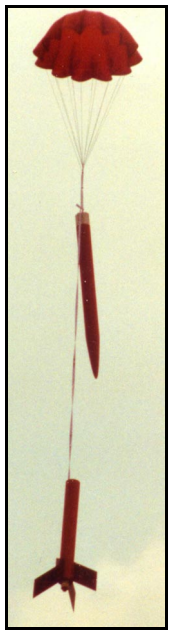
CMASS MINUTEMAN FLIES (and DIES!)

Last year, Bill Spadafora and I completed production of 21 club kits based upon the rocket held by the Minuteman in the club logo. You may have seen them fly the kit at one of last year's launches. Here are some shots of the kit in action.

There are still two kits remaining to be sold. These feature BT-70 tubes, plywood fins and centering rings, 29mm motor mount, red rip-stop nylon parachute, and a custom-made BMS nosecone and bulkhead, all for $28.

Steve Boy really enjoyed the kit. But, after looking over Bill's flight history, he put the Minuteman on steroids. He fiberglassed it (and he hates glassing), doubled the plywood thickness, and added a nice little CPR bay for the club dual deployment altimeter [see **Tony's Altimeter Project**, page 11 in the Winter 1998 issue of *The Sentinel*]. It's now worthy of a H, but of course it has lost its modroc qualities. Look for it at this year launches!

Left: At NARAM 40, Bill and John decided to have a drag race. That's John's on the left with an F10 in it and Bill's on the right with a G75.



by
John Buscaglia
and
Bill Spadafora

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The kit does fly and recover well on motors from an E15 through a G40, and should get between 900 and 2500 feet of altitude.

Left: The results of the drag race. When John wrote the instructions for the kit, he was sure to not mention the G75 as an appropriate motor for this rocket. The fins were set with glue rivets, but the outer layer of the tube tore off! Bill repaired the rocket, but do see below!

Right: At the October CMASS launch, John and Bill kept pushing this kit to the limit. That's John's on top proving that an F7 is not a good motor choice. That's Bill's below after being victimized by an E18 that used up half it's total impulse sputtering on the pad.

CLUB NEWS AND GALACTIC RUMORS

ON THE WIND

CLUB T-SHIRTS

We have several club T-shirts still available for sale. Most sizes are available, although some (child large) are sold out. Cost is $8 (child), $10 (adult) or $12 (2,3XL). The shirts are light blue Fruit of the Loom's *Best* 50-50, with a superb looking CMASS logo on the front. Contact the club secretary or pick one up at the next launch.

TWO-WAY RADIOS

The club recently picked up a pair of *Motorola Talk-About Family Radios*. These are intended to be used to help direct people searching the for rockets that have downed in any of the woods or the Pow-Wow River. Many times the LCO knows exactly where the rocket landed, while those searching for the rocket are looking just 100' the wrong way. Just don't forget to pick up a radio *on your way out to retrieve your rocket!* (And serious bad luck will happen to anyone who forgets to return the radio!)

LOST ROCKETS SEEK OWNERS

A friendly Woodsom traveler turned in to Steve Boy a ***Falcon*** in perfect shape. Magenta nose cone, an American flag on one fin, flown on a C6-5 at our last launch. Available at next launch to the rightful owner.

Which reminds us, the club has a ***Norad*** and a couple of other smaller models that were returned from past launches. They're all in the club trailer in the lost and found box. If you recognize something of yours you might want to claim it before the mice use it to keep warm this winter.

LAUNCH NEWS

(continued from page 3)

WOODSOM FARM COMMITTEE

The Amesbury City Council has appointed a 9 member voting board for the purpose of creating a master plan for the use of Woodsom Farm. Last year, Amesbury residents voted against golf course development on the north side of Lion's Mouth Road, against soccer fields construction on the south side of the road, but in favor of some form of field construction on the north side. The committee is now evaluating the total needs of the farm, and are designing and planning for future uses.

We're lucky that one of our members, Cornell Rosiu, is an Amesbury resident and member of this committee.

COMMITTEE MEETING REPORT

By Bill Spadafora, President

On Wednesday, February 10, Doug Steinfeld and I attended a Woodsom Farm Committee meeting to follow up on a survey concerning our use of the field. The committee's purpose is to make recommendations on the future use of Woodsom Farm. Judging what we heard, people intend to make use of the field other than just growing hay, although it is clear that hay farming will always happen on the field. For instance, there are plans to make the cow barns into a carriage museum.

The first presentation was by the Merrimac Valley Air-Istocrats (http://www.geocities.com/CapeCanaveral/Hangar/7465/), a free-flight model airplane club. It was interesting to learn that their field requirements are pretty much the same as ours. Doug did the pitch for CMASS pointing out how wonderful the field is and how wonderful we are. That was followed by informal questioning. Several of the committee members were familiar with us and one mentioned how he spent some

(continued on page 7)

WOODSOM COMMITTEE

(continued from page 6)

time in his canoe in the river near the power lines watching us fly.

In questioning the Air-Istocrats, a committee member asked why they had never held national events in Amesbury. We made a point of telling them that we had once (the 1995 National Sport Launch) but never did it again because of the inability to be guaranteed the use of the field far enough in advance. After we were done the representative of the Boy Scouts spoke. The most informative part of his talk was about his dealings with the hay farmer. As you'll remember, we've been kept off the field before June because of what the Mayor's office has described as the damage we do to the hay. It seems the Boy Scouts were told that the only concern was the possible toxicity of the fertilizer and the farmer simply didn't fertilize the areas that they used. The

(continued on page 27)

CLUB OFFICERS FOR 1999

The club officers are elected in at the first meeting in September and serve for one year. The contact information for our current officers is listed below. Feel free to contact them with any questions you have about CMASS, the NAR, or rocketry in New England. They can be reached via e-mail at officers@cmass.org.

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STEVE BOY'S
FIELD OF DREAMS

Steve explains why he could not make it to the club's fall trailer cleaning.

I could not close the year without one more launch. Paul Askins, rocketman extraordinaire, mentioned he was taking one more "casual" trip to Cherryfield, Maine, on November 22 to launch with Rich Willey and Tripoli Cherryfield. This means that I got up at 2:00 a.m. Sunday morning and drove to Union, NH (on the Maine border), loaded up with Paul and his son, and traveled in Paul's very stylish van (the radio was on the work bench) six hard hours to Cherryfield. Apparently the town was named by rocket people, because it *is* a cherry field. My best guess would be around 10,000 acres. Yes, at least 20 times Woodsom Farm. Maybe even 40; it boggles the mind and defies estimation. There are roads so you can *drive* to the rockets. And, if you perhaps grossly miscalculate and land in one of the few valleys with trees, Rich brings out his chain saw and cuts the tree down for you. These are also blueberry fields owned by Wymans, and blueberry growth is nice to land on. The weather was perfect with little wind (no wind compared to Amesbury)!

The ***Psychotic***, my kitbashed LOC Magnum 3 (fiberglassed and configured for dual deployment, empty 13½ lbs and loaded about 18½ lbs), launched on a Kosdon L630 (3", 19½ inch casing), slow burn for 5.4 seconds, apogee at 21 seconds, achieved an altitude of 7717' with Adept and Pratt deployments. Both chutes apparently (and thankfully) deployed at apogee. The rocket drifted a mile. Rich drove me out and we found it about 20 feet from one of the dirt crossroads. Paul's flight was also successful. With a Kosdon L, his 25 lb scratch built got about 4850'.

I got home at 11:00 p.m. Sunday night, having spent 14½ hours out of the previous 20 traveling. "You're crazy! Was it worth it?" my wife said to me. "Yup," I answered, and went to bed.

Sorry I wasn't there helping on Saturday, Bill, but you understand!

PLAN REVIEW

Building and Flying the MicroManche-3

by
Todd Lainhart

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The September/October 1997 issue of *Sport Rocketry* featured a construction article by Bill Dauphin entitled "Micromanche–3 —Three stage mini-engine sport model." This article describes Todd's experiences building and flying this kit plan.

Hello, I'm Todd, and I'm a Born Again Rocketeer…

26 years ago I left the rocketry hobby, my interests pranging for reasons I now can't recall. In my wake I left the evidence of years of paper route profits funneled directly to the coffers of the Estes and Centuri companies. Camrocs, Cinerocs, exotic sci-fi designs, and shoeboxes of engines filled the shelves of my home-made workbench as proud testaments to my passion. But it was the many multi-staged flyers for which I had special affection. Getting a rocket to successfully launch and stage, was not a feat for the weak or indecisive. Remember, this was in the days of pure nichrome wire, not that puny pyrogen-soaked filament that's being passed off as "igniters" these days. Let them have the "Big Bertha" – I'll take the "Black Widow" I arrogantly boasted.

The past winter I re-entered the hobby by accident, probably like so many other BARs. Cruising the aisles of the local Toys-R-Us with my son, a familiar logo caught my eye and caused me to stop dead in my tracks. Ignoring the insistence of my son that the action figures were in the next aisle over, my mind fought to focus as it rapidly processed data, both past and present hitting me like a fire hose to the chest. Here the Estes shingle announced it was still in the business of rocketry, and although there was no evidence of the ubiquitous Astron moniker, I did see a reference to the classic and familiar Alpha! Seizing the moment, I grabbed what looked to be the most challenging starter set for both my son and me (other BARs will recognize the familiar "this is for my child" ploy), and scurried off to the action figure aisles, starter set and value pack of motors locked securely under arm.

The Legend of the Comanche-3

After a couple of false starts and lost rockets, I fell victim to the lure of the Comanche-3. My imagination was seized by its promises– a 3-stage rocket, capable of heights of 2600 feet and interplanetary travel (although the apparent contradiction of those last two facts was never resolved by the instructions). The blister card showed an image of a sinister, dark-orange missile, set against a background of a bleak and alien mountainous terrain. This must be one of many uncharted planets visited by the rogue Comanche during one of its clandestine missions! "The highest flyer in the Estes fleet" the card gloated, and it talked directly to me, taunting me to build and release its fury. Intoxicated and anxious, I uneasily accepted its challenge and brought it home.

Once I regained my senses, I began to build the rocket, armed with building secrets gathered from various sources on the Internet. However, it was towards the end of its construction that I began to hear of the stories and curses that I now know form its dark and secret legacy. Tales of lost stages, broken fins and twisted airframes, 2nd stages that wouldn't light, and crepe streamers that shredded upon ejection were only a few of the many confessions that I was able to record from past victims who insisted upon anonymity. Every once in a while some poor rube would tell of a sustainer that was recov-

ered within 18' of the launch pad ("I measured it!"), but all who understood the wrath of the Comanche knew it was the piteous lie of one who had fallen under its spell, and had ultimately been betrayed and destroyed.

It was then that I came to the realization that I was building a bird that was its own master, one that when put into the sky would either self-destruct, or escape the planet's pull, but never be tamed. My composure finally unraveled and I put the incomplete project on hold. I began to look for another kit to soothe my frayed nerves.

A Kinder, Gentler Comanche

It was during this period of convalescence that a therapeutic visit to The Spare Time Shop[1] brought a back issue of *Sport Rocketry* to my attention. On the back page was a plan for what appeared to be a Comanche-3, only smaller. No bleak alien terrain, no flaunts of maximum altitudes, only smooth and graceful lines, and gentle, encouraging text. The menacing taunt of the original Comanche was gone, replaced here with the quiet "mew" of a newborn child. Here was a kinder, gentler Comanche, one that wanted to be brought home and tamed. This baby Comanche, quipped the "Micromanche" had all of the attraction of its ancestor, but seemingly none of the disappointments. Was it possible that the author, this alchemist, was able to break the hold of the demons that curse the successful launch and recovery of every bird in this genealogy? Evidently here was the proof! I paid for the magazine and quickly returned to car, gloating and scheming that a Comanche launch and recovery would be mine. But I wasn't alone in my thoughts. A voice persistently interrupted my celebration, a voice I hadn't heard before, and it played this refrain from an unwanted song - "the acorn seldom falls far from the tree".

Micromanche-3 Description

The Micromanche-3 is modeled after the Estes Comanche-3, with permission from Estes. It is designed around BT-5 tubing, and so dimensions of the various parts and materials are scaled (down) accordingly. Bill Dauphin has written a plan that is complete in describing the parts and construction techniques required to successfully build his design. I only elaborate here to describe my experiences building it.

How I Built the Micromanche

I returned to "The Spare Time Shop" for the parts to build the plan. For the airframe I purchased 2 BT-5 body tubes for $.95 each, a pack of Estes BT-5 nose cones for $4.29, and a package of launch lugs for $3.19. For the fins, I purchased a sheet of 1/16" balsa at a price I'm not recalling. The sustainer requires an engine block and I was able to use one I already had lying around. Finally, a pack of mini-engine boosters and sustainer motors rounded out the purchase, adding an additional $9.00 to the total.

The design calls for kevlar line to be used as the shock cord. Finding this locally was not easy. The best I could obtain locally was 35lb test kevlar fishing line. I was unsure whether or not this would handle ejection charges, even from mini-motors. I ended up placing an order with Pratt Hobbies (http://www.pratthobbies.com) for multiple strengths of kevlar safety line. In my model, I used about 4 feet of the 100lb test kevlar tied at one end to the thrust ring. I cut a groove in the ring so that the string would not interfere with the motor, thrust ring, and body tube surfaces. I tied the other end of the kevlar to

1. The Spare Time Shop, Marlboro, MA.
CMASS members receive a 10% discount!

I had just built a 3–stage Mosquito, and I had nothing left to do but to play out the prophecy.

the nose cone, adding CA to the overhand knot.

Assembling

When building, I stuck pretty much to the directions as printed with few exceptions. The fins were finished with Elmer's Fill-n-Finish. I did use an Estes Fin Alignment Guide to place the fins for each booster (rather than using the Fin Marking Guide as suggested by Bill Dauphin), and was successful in accurately aligning the fins for all three stages. This doesn't happen often enough for me – the tool poorly aligns fins as often as not (I don't want to tell you the number of times I've ripped off glued fins, only to have to reset them by hand), and so I won this toss of the coin. Also, rather than locate the launch lugs at each stage as Bill suggests, I located them only on the sustainer in the same relative positions, as does the Comanche-3.

To finish the model, I used successive coats of Rustoleum Auto Primer, followed by a top coat of "Painter's Choice" Fluorescent Orange for the body and fins, finally using Rustoleum Metallic Silver for the nose cone. I top-coated all of this with Rustoleum Clear Enamel. In general, I really like the Rustoleum brand of enamel for finishing rockets, but it's "Painter's Choice" bargain brand (the only Rustoleum that I could find in fluorescent colors) is to be avoided.

Finishing and Transformation

It was about the time that I was considering detailing the Micromanche that I became aware of a transformation in its character – and in mine. I had regained the courage to finish the Comanche-3 by this time, but placed the rocket in seclusion so that it wouldn't negatively influence the Micromanche whose character I was taking great pains to form. Yet it was now becoming painfully clear to me that this was a bird that was designed to avoid recovery! It wouldn't self-destruct – the model was too light and strong for that possibility. But considering that the airframe is as narrow as it could be, and that the weakest engines available for the boosters are A10T-0, I was guaranteeing a flight into the abyss. I had taken the bait, and was about to be reeled in. I had just built a 3-stage Mosquito, and I had nothing left to do but to play out the prophecy.

Maiden Voyage of the Mosquit…

The first flight of this model was to be at my first CMASS launch, the first club launch of this year. However, circumstances beyond my control allowed for only a brief visit, and very little flying. The Micromanche was grounded for the day and I suspect that it somehow had a hand in the grounding, realizing its chances for escape were small at a CMASS-organized launch. But because this bird demanded to be flown, my son and I gathered up it and its larger sibling, and the next day, headed off to the local field for our appointment with destiny.

I took my time carefully prepping the rocket. The booster and sustainer motors (A10-0T / A10-0T / ½A3-4T) were joined by magic tape, with the boosters slid in place over the three-length casing. For sustainer recovery (the boosters use tumble recovery), I chose a gold metallic streamer joined by kevlar thread to a snap swivel (this is the 35lb thread that I referred to previously). After packing the wadding (a single sheet), the streamer, and the kevlar shock cord, I placed a paper tube filled with orange carpenter's chalk in the airframe, to be used as tracking powder.

We first tested the air with a Fatboy with a C6-3, successfully launching and recovering it. Seeing that the skies were safe to fly, we prepped the Micromanche on the launch pad. Five seconds after getting verbal commitments from the recovery team (my son would recover the boosters, I would track the sustainer), Micromanche-3 took to the sky.

The flight and recovery of this rocket was thrilling. It leapt off the pad, with a "Whoosh… Pop!… Whoosh… Pop!… Whoosh…," and then was lost in the sky. Time seemed to stand still. In the background, I could hear my son scurrying through the grass looking for the boosters, complaining about something. I continued to scan the sky for a trace of the rocket or its tracking powder. Nothing. More scurrying. Finally time's clutch engaged, and I saw a reflection of gold high in the sky that I immediately recognized as the Micromanche's streamer. The sustainer soon landed without incident, and we recovered all three stages. A successful launch and recovery – I had denied the prophesy and broken the curse!

It then occurred to me that the Micromanche had either become so attached to me, or was too frightened by what it saw in the ether, that it decided to return home. Buoyed by its return, we celebrated with a successful launch and recovery of its larger sibling, the Comanche-3. It's reasons for returning home are less clear, but I suspect they're rooted in manipulation and deceit (but in the spirit of full disclosure, I should note that it did lose a fin on the sustainer, a classic Comanche cheat, later repaired with an epoxy rivet, and larger streamer).

Summary

Traditionally, now's the time in a review to list the pros and cons associated to a kit or plan. The pros? I think you've got a sense of them – this rocket is a lot of fun to fly, and easy to build. The cons? Can't think of one, unless you consider its tendency to get lost in the sky a negative, or you're feeling particularly unlucky. Go to the NAR web site, pick up this back issue of *Sport Rocketry* (if you don't already have it), and build yourself a Micromanche – if you dare!

Epilogue

I've flown this rocket twice more since its maiden voyage. Three successful launches and recoveries have built my confidence to the point where I've now lost my fear of finishing it. Just today I learned that I can purchase a set of Comanche-3 decals, appropriately scaled to Micromanche size. Do I apply them, or is this the moment that the Micromanche has been waiting for, to reveal its true intentions?

Author's Micromanche-3 poses with it's big cousin, the Estes Comanche-3.

CMASS ON THE INTERNET

Browsing the Web? Visit the club's home page! *http://www.cmass.org/*

Send your e-mail address to us to be added to the on-line discussion lists: *postmaster@cmass.org*

Centuri LASER-X in a Two Stage Configuration

by
Peter Luthi

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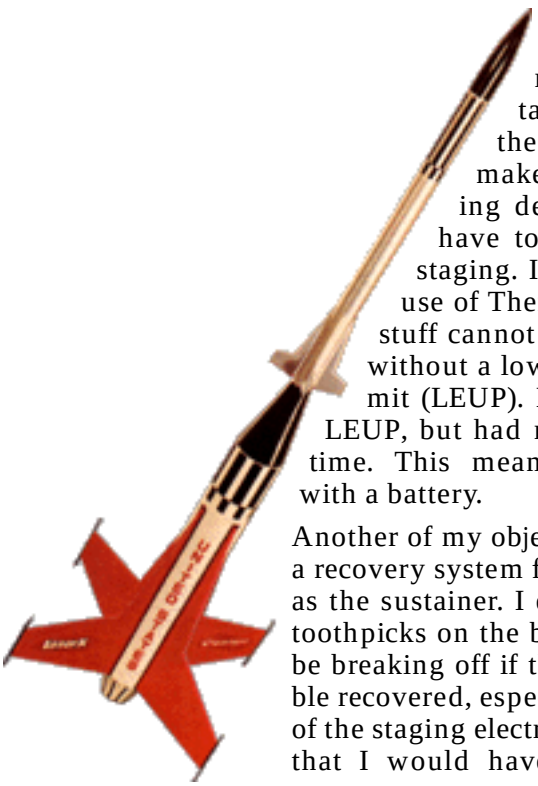
lmco.com

When I first built rockets in the late 60's and early 70's, I wasn't familiar with Centuri. I first discovered them at JimZ's Rocket Plans (http://www.provide.net/~jimz/jimz.htm). In browsing Centuri's rockets, I was impressed with the diversity and imagination of these rockets. I was particularly struck with the Laser-X. It had an exciting shape and a good set of decals.

DESIGN MODIFICATIONS

The one thing that struck me the most about this rocket is that it was dying to be a two stage rocket. The top section with the narrow body tube had the look of a boosted dart, or one of the Nike-boosted sounding rockets (such as the Nike-Deacon, Nike-Cajun, or Nike-Asp) launched in the 1950s through 1970s. I knew when I saw that picture that I was going to build the Laser-X as a two stage rocket.



The problem with making the Laser-X into a two stage rocket is that the sustainer is too far from the booster engine to make a reliable direct staging design. I was going to have to go with an indirect staging. I wanted to avoid the use of Thermalite® because this stuff cannot legally be purchased without a low explosive users permit (LEUP). I had applied for my LEUP, but had not received it at that time. This meant electronic ignition with a battery.

Another of my objectives was to provide a recovery system for the booster as well as the sustainer. I envisioned that those toothpicks on the booster would always be breaking off if the booster were tumble recovered, especially with the weight of the staging electronics. It looked to me that I would have just about enough room in the booster for the electronics and battery by having the booster separate just above the fins. This would permit a recovery system to be deployed with the engine's ejection change, and still provide a protected area for the electronics with access to the second stage.

Finally, I wanted the booster stage to use 18mm engines rather than 13mm engines. This would give me a better selection of engines for the second stage. The Laser-X plans call for a ½" tube in the upper section; to accommodate the 18mm engine I went to the ¾" tube. I wanted to increase the booster engine mount to 24mm since I knew that this would be a heavy rocket with the battery and electronics. However, that would spoil the looks of those cooling fins at the tailcone, which I feel is one of the nice features of this rocket. I stuck with an 18mm engine mount for the booster.

CHECKING STABILITY

I used Visual Center of Pressure (VCP) by Gary A. Crowell Sr. to check the stability of my preliminary design. VCP is a freeware program available on the Internet at http://www.impulseaero.com/Software/VCP/. It calculates the center of pressure of a model given the mechanical configuration. It also calculates the center of mass if you provide the weight of each component. The nicest feature if this program is that it draws out the rocket as you enter the dimensions, so it becomes obvious when you entered something wrong.

With the battery and electronics above the fins, there would be quite a bit of weight forward of the center of pressure, so I wasn't worried about the stability of the rocket in the two stage configuration. The sustainer, however, was never meant to fly on its own and the fins are quite small. To make matters worse, increasing the diameter of the sustainer from 13mm to 18mm moves the center of pressure

forward, which tends to destabilize the rocket.

The analysis by VCP showed that the sustainer would be stable with the original fin size, but not with a lot of stability margin. In addition, the center of pressure is pretty far forward of the fins. When the center of pressure is that far forward, the center of pressure prediction is quite sensitive to small physical variations in the rockets design. I decided to scale up the fins in proportion to the body tube. I used VCP to scale up the fin patterns by 138% (18mm/13mm). This provided a better stability margin for the sustainer stage and also provided a more proportioned appearance to the rocket as a whole.

IGNITION ELECTRONICS

There are two key components of the ignition system which need special attention: the battery and the burnout detection device. I had done some tests on Estes Solar igniters (see http://www.cmass.org/uploads/Peter.Luthi/igniters.txt) and found that igniters require three to five amps in order to reliably cause ignition. The smallest 12 volt battery that I've found are N-size "cigarette lighter" batteries. However, these do not have enough current capacity to set off the igniter. I selected a 9 volt NiCad (rechargeable) battery. NiCad batteries usually have a lot higher current capacity than alkaline batteries. I tried a Radio Shack 9 volt NiCad battery. It ignited Estes solar igniters several times reliably and without delay. Of equal importance, it fit within the body tube of the booster.

To ignite the sustainer at booster burnout, I selected a mercury switch. Because of the toxicity of metallic mercury, these are becoming hard to find. Radio Shack hasn't stocked them in years and they

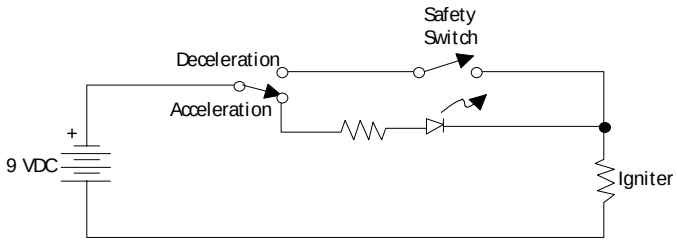


Figure 1: Sustainer ignition circuit provides continuity testing and staging.

don't have any device which is a direct replacement. Luckily, when I replaced my old thermostat with a digital one with a timer, I kept the old thermostat. These old thermostats use a bimetallic strip which tips a mercury switch with temperature. Since the thermostat also controls my air conditioning, this thermostat has a contact at either end. I removed the mercury switch and glued it into a piece of 18mm tube coupler.

Figure 1 shows the schematic of the ignition circuit I used in the booster to ignite the sustainer. It includes three key features: the deceleration detector (mercury switch), the safety switch, and the continuity detector. The mercury switch is mounted in the booster to cause ignition when the mercury lifts to the top of the tube. This happens when the rocket is under deceleration. This occurs when the booster stage burns out and the rocket is coasting. The safety switch is a 2.5mm subminiature phone jack (Radio Shack part 274-292A) which has a switch which breaks a connection when the plug is inserted. The plug is attached to a piece of streamer to make it plainly visible when the circuit is in the safe position. The continuity tester is a light emitting diode (LED) with a 1kΩ (brown-black-red color code) resister in series. I decided to attach this to the acceleration side of the mercury switch (mercury on the bottom of the tube) so the continuity tester would also check to make sure that

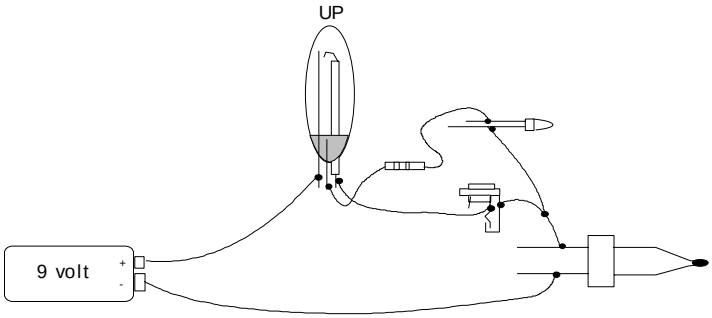


Figure 2: Ignition circuit shown as physical wiring.

the mercury switch is still attached. If your mercury switch doesn't have three wires, then just connect the resister to the positive terminal of the battery.

Figure 3: Parts of the Laser-X

Figure 2 shows the same circuit as a physical wiring diagram for those who aren't adept in schematics. The safety plug is in line with the ignition circuit, but not in line with the continuity testing circuit. The circuit is designed this way so the continuity can be tested even with the safety plug installed.

VEHICLE DESIGN AND CONSTRUCTION

The design and construction of the Laser-X rocket was basically according to the original plans. There are, however, several additional modifications that I made. Instead of using 1⁄16" balsa wood, I used 1⁄16" plywood. It's considerably heavier than balsa wood, but it's also a lot stronger. I tend to use plywood on all my rockets. A plywood fin is less likely to break, and it's easier to sand and finish that balsa. Cutting out a plywood fin is harder, but I have a Dremal hand-held electric scroll saw which makes this task very easy. I also use plywood for all my centering rings. Figure 3 shows the parts which make up the Laser-X rocket.

To attach the main fins on the booster, I went with through-the-wall-to-the-engine-mount (TTW/EM) construction. This is a standard construction technique on high power rockets, but it's probably overkill for most model rockets. I like the technique for model rockets because it makes it easier to get the fins on straight. As long as you get the slot cut straight, the vertical alignment takes case of itself. When you glue, you only have to worry about keeping the fin perpendicular to the body tube. Even this is easier with TTW/EM construction because the fin doesn't tend to move around as much. On rockets with four fins, getting the fins

perpendicular is particularly easy. I use a "C"-shaped piece of scrap plywood and mount two opposite fins at a time. By clipping the fins to the scrap plywood, good alignment can be assured.

There are three engine mount centering rings in the booster. One on top of the fin tabs, one on the bottom of the fin tabs and one at the bottom of the body tube. I usually don't use one on the bottom of the body tube, but in this case I needed a surface to mount the cooling fins against. The bottom two centering rings have a slot in them to allow the engine retaining clip to move freely.

The booster stage is designed to have it's own independent recovery system. Since we are using indirect staging, there is no need to use a booster stage engine which has a zero second ejection delay. If all goes well, the burnout of the booster will ignite the sustainer. The sustainer ignition will separate it from the booster. Using an engine such as a C6-3 in the booster will eject the booster recovery system once the sustainer is well away from the booster. If the sustainer fails to igniter, this design provides a fail-save feature. The booster and sustainer would continue to coast as an attached assembly after the booster burnout. Once the booster ejection change occurs, the booster's recovery system should bring both pieces down safely.

I used a parachute for the booster recovery and a streamer for the sustainer recovery. The booster is rather heavy, is quite fragile with those toothpicks on the fins, and is not expected to attain much altitude. All these factors lend themselves to a recovery system which provides a slow decent. The sustainer is just the opposite. It is light and rugged, and will probably reach altitudes which make drifting a concern. A silver molar streamer should provide good visibility on a sunny day.

I placed the separation of the booster section just above the fins. Obviously, this is as far aft as I could conveniently make the separation. This give me maximum room for the staging electronics. I extended the overall booster body tube about ¾" over the Centuri design to allow a little extra room. I also used a long tube coupler so the battery would actually be positioned below the top of the fins when the rocket is assembled. A plywood end

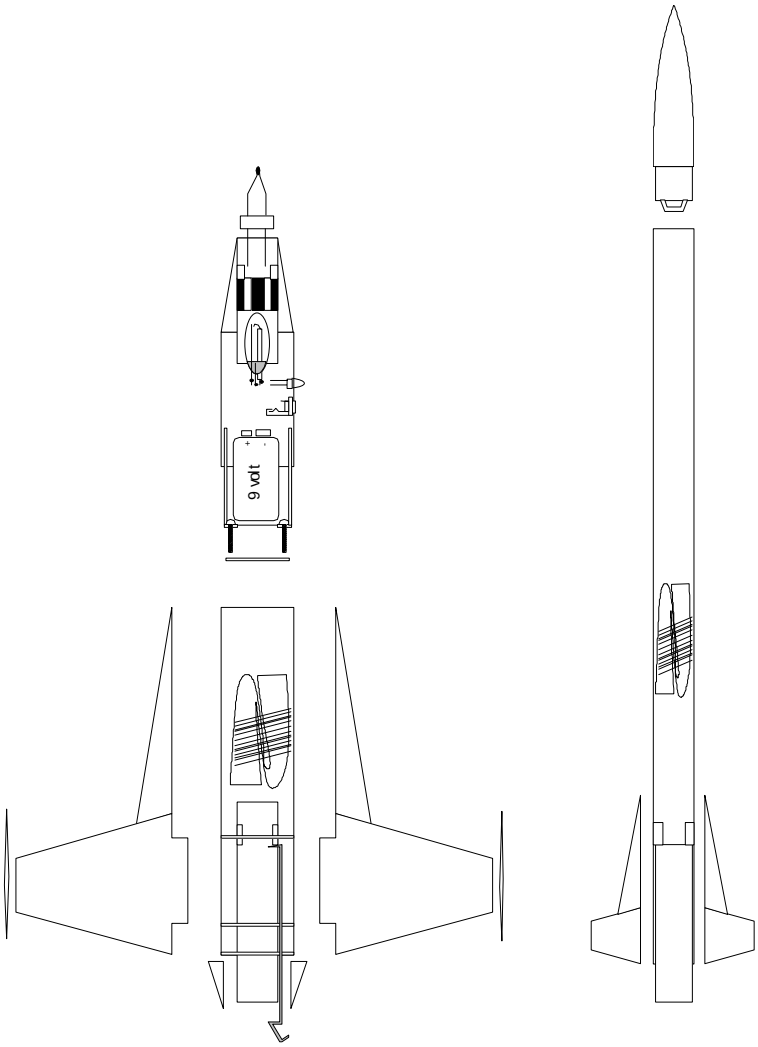


Figure 4: Interior packing

cap with a rectangular hole for the battery was glued to the bottom of the coupler tube. Two screws were epoxied in holes on either side of the cut out to allow the attaching of a second plywood end cap. This protects the electronics from the booster ejection charge and provides an access panel to the battery and electronics.

The coupling between stages is provided by extending the sustainer engine into an 18mm engine mount tube mounted in the transition section. This engine mount tube has a short piece of wooden dowel glued in place to prevent the sustainer's exhaust from getting into the electronics bay. There are two small holes drilled in the dowel to allow the ignition wires to pass from the electronics bay to the igniter. I also placed a small piece of engine block above the dowel to provide a place for the wires when the sustainer is attached to the booster. Since there is not enough room for ignition clips, I intend to twist the wires of the igniter to the wires from the electronics bay. This should provide a more reliable attachment than clips.

The transition section itself is make from sheet plastic. Since I changed the sustainer diameter to 18mm, the template provided with the Laser-X plans won't work. However, it is easy to design a transition section with only a compass and a ruler. You need to know three dimension of the transition section you are making: the two diameters and the length. In this case the smaller diameter (D1) is 18mm, the larger diameter (D2) is 32mm, and the height (H) is 40mm. You can calculate the three dimensions of the transition section from the following formulae:

$$L = \sqrt{h^2 + \left(\frac{(D-d)}{2}\right)^2}$$

$$M = \frac{DL}{D-d}$$

$$W = 2M\sin\left(\frac{\pi D}{2M}\right) \text{ (using radians)}$$

$$W = 2M\sin\left(\frac{90D}{M}\right) \text{ (using degrees)}$$

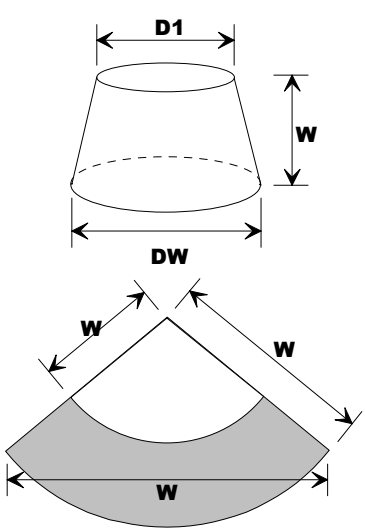


Figure 5: Transition

FINISHING

The finish selected on the Laser-X is per Centuri's package illustration. The fins were sealed with Pactra sanding sealer and sanded several times. The rocket was primed, sanded and painted white. The booster was masked and the fins painted red. The nose cone and the transition section were painted black.

For decals, I used the images at JimZ's plans site to print my own decals. Micromark (http://www.micromark.com) makes some 8½"×11" decal paper in clear and white. If you use clear, you don't have to worry about trimming exactly to the image. However, you can't print white in most printers so if your image contains any white, you have to place the decal on a white background. I used the clear decal paper. The only place where I had a problem is with the decals on the fins. The fins are painted red and the decal has white letters in a red oval. If I just print the decals and place then on the fins, the whole thing would turn out red. To correct this I painted a white oval on the fins just smaller than the decal image, this allowed the white to show through the lettering.

I used a Tektronix Phaser 350 wax transfer color printer to print the decals. I was able to fit two sets of the decals on a 8½"×11" sheet and still have room for CMASS and NAR logos for future use. The result was excellent. The colors were bright and the images were sharp. The decals applied just like any other water transfer decals and provided a very

sharp looking rocket.

The Micromark decal paper is very thin and tends to rip easily. To protect them I sprayed the rocket with a clear coat of Krylon, starting with the sustainer. Big mistake! Figure 6 shows the disaster which resulted. The clear coat caused the wax image to run badly. Instead of trying to refinish the sustainer, I simply built a new one since this is a relatively simple part of the rocket. I still haven't found anything to protect the decals, but at least I have a good looking rocket again.

PREPPING THE ROCKET

With the rocket built, I had to prepare the rocket for flight. The first task was that of selecting the engines. The rocket with the booster is quite heavy, about 5½ ounces (160 grams). This means I needed a good strong booster in an 18mm diameter. However, I didn't want to lose the rocket, so I planned to keep the motor toward to the low side. A C5-3 has the high lift-off thrust I'm looking for without going to a composite engine like a D21. With a max lift off weight of 8 ounces, the I expected C5-3 to provide good lift-off without attaining too high an altitude. I needed a relatively short delay on the booster because I didn't expect it to attain very much altitude and I wanted the 'chute to open before it fell back to earth. I didn't want to use a zero delay, because I wanted to make sure the sustainer separated from the booster before the booster recovery system deployed. The sustainer needed a long delay, but not too much engine. For this I chose a B6-6.

The night before the launch I prepped the rocket. The sustainer engine needed a little tape to keep it snug in the booster and keep the whole thing straight. I recharged the battery, packed the streamer and 'chute, and inserted the safety plug. Of course I didn't put the igniter in the sustainer engine until just before launch.

THE LAUNCH

The launch day was July 11, the first launch of the year at Amesbury. It was a very windy day, but I was anxious to try out my new rocket. I attached the wires to the igniter by twisting them together. The continuity LED was lit, but very dimly. I should have used a smaller resister than a 1kΩ. Perhaps a 330Ω would have provided a brighter indication.

Figure 6: Clear coating caused the running of the wax transfer decals.

I took the rocket through safety check and set it on the pad. Since it was so windy, I angled the rocket into the wind so I had a chance of recovering the booster. I waited until just before launch to removed the safety plug because I was afraid that the strong wind might bounce the mercury switch around so much that it could prematurely igniter the booster.

With the safety plug removed and the countdown complete, the rocket was launched. The lift-off was much slower than I had anticipated. The rocket lifted slowly off the pad and angled into the wind. At booster burnout, the rocket was about 100 feet up and flying horizontally. The staging electronics worked perfectly. The sustainer ignited and took off like a missile … horizontally. The light sustainer was very fast compared to the heavy booster. The booster recovered on it's parachute while the sustainer headed

toward the brook. The ejection charge deployed the large streamer just on the far side of the brook under the power lines; not a fun recovery, but I did get it back.

A POST MORTUM

In retrospect, I made three key mistakes when launching this rocket. First, I should not launched this experimental rocket on such a windy day. I was overly anxious to try it out and I could not bring myself to postpone it's maiden voyage. Next, I should have remembered not to angle a multistage rocket into the wind the way I did. Multistage rockets tend to have a lot of fin area and thus be over stable. This causes them to weather cock in high wind. The second stage always tends to exaggerate any angle and that's partly why I got a booster flight which looked more like a cruise missile than a sounding rocket.

Finally, I should have gone with a stronger booster engine. An Aerotech D21 would have provided a quicker lift off and thus less weather cocking. The predicted altitude for a C5/B6 combination is about 1300 feet while a D21/B6 combination would only increase that to about 1500 feet. A D21/½A3 combination would have provided an easily recoverable 900 feet.

When I got the rocket back home I discovered that the mercury switch had broken. I don't know if this happened on recovery or on the trip back home. This rocket won't fly again until I can find a replacement for a mercury switch.

Despite all the problems I encountered, or perhaps because of them, I really like my two stage Laser-X. I looking forward to correcting my mistakes, fixing the electronics, and launching this one again.

Two stage Laser-X launching into the wind.

3-ENGINE, CLUSTERED PROWLER

RECIPE FOR A GROWLER

by
Todd Lainhart

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The Estes Prowler is a "Beta Series" kit introduced in 1998. Its relatively inexpensive price, size, and choice of body tubes has inspired many rocketeers to "bash" or modify the kit to allow for more than its single 18mm motor for propulsion. Some Prowlers are modified with D-F motors, requiring structural enhancements to the rocket to accommodate the increased thrust. The propulsion modifications described here, a cluster of three 18mm engines, require no structural enhancements other than the creation of a new motor mount assembly. Credit is given to Peter Away for bringing this modification to my attention in the USENET group rec.models.rockets.

PARTS LIST

- 1 Prowler Kit (Estes)
- BT-20 body tube (for motor mounts)
- 3 used 18mm engines (for thrust rings)
- 4 foot length of 1000' lb. kevlar shock line
- 6-8 feet of 3⁄16" elastic shock cord
- 3⁄16" launch lugs
- 2 8x32 bolts

MOTOR MOUNTS

Open the Prowler kit, and remove all the parts, setting aside one of the motor mount tube centering rings and the motor mount tube. Using the supplied motor mount tube as a guide, observe its length, and cut three equal lengths of tubing from the BT-20. These will be the motor mount tubes (MMT) for the clustered engines. Estes Rocket Builder's Marking Guide comes in handy here for measuring the tube, allowing a concentric mark to be drawn around the tube, and supporting the tube while cutting. To make a clean cut, rotate the BT-20 several times while engraving lightly with a hobby knife, scoring the tube deeper on each revolution until completely severed.

On each spent engine casing, place a mark 1⁄8–3⁄16" from the delay end of the engine, and mark it along its circumference with the marking guide. These will be the thrust rings or engine blocks. Using a hacksaw or razor saw, cut these rings off the ends of the casings. Smooth and finish the insides of the rings with yellow glue to prevent them from unraveling.

Using an unmodified engine as a guide, mark it a scrap piece of balsa or chopstick, apply yellow glue up 60mm from one end of each BT-20 motor mount tube, and slide the thrust rings into place using the marked engine as a guide, sliding it until the T. Remove the engine immediately and repeat the process for the remaining two MMT.

MOTOR MOUNT ASSEMBLY

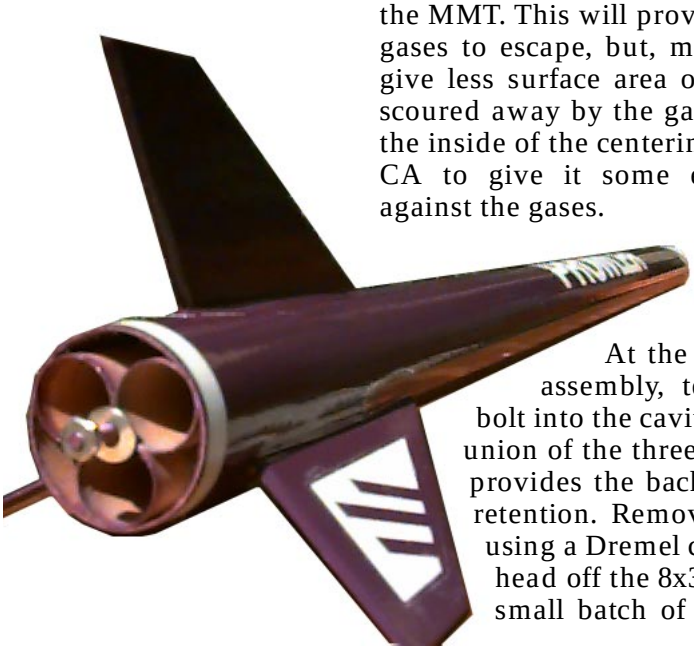
With the marking guide, place a straight line up each length of MMT. Draw a bead of yellow glue along one of these lines, and join two of the tubes lengthwise along this line using a flat surface for support. Before doing this, note which end of each MMT is the motor end and mark appropriately. You want to be sure that you don't glue a non-motor end of a tube alongside the motor end of another!

For extra strength, touch the MMT tubes lightly together so each are marked with a glue bead, and then separate the tubes smoothing the glue beads and let each dry separately. Then repeat the previous process – you'll be gluing the glue seams together, providing a much stronger bond between the tubes.

In the valley created by the two glued MMTs, you'll glue the third MMT, using a similar process as before. For another description of this process, refer to the instructions for the Estes Astron Ranger; these are available for download from JimZ's Rocket Plans web site (http://www.provide.net/~jimz/jimz.htm). The Estes Astron Ranger was one of the first production clustered rockets, and the design described here is very similar.

After the MMT tubes have dried, test fit the tubes in the lower airframe of the Prowler. The fit should be snug with the valleys of the tubes aligning exactly with the fin slots in that airframe. Remove the mount and find the forward centering ring from the Prowler Kit. Using yellow glue, attach this centering ring to the forward end of the motor tubes, centering the motor tubes on the ring. This ring will prevent ejection gases from escaping to the rear of the rocket, directing them to the recovery device. After the glue has dried on the centering ring joints, use a grinding bit on your Dremel tool or hobby knife to remove the portion of the centering ring where it covers the ends of the MMT. This will provide room for the gases to escape, but, more importantly, give less surface area of the ring to be scoured away by the gases. Finally, coat the inside of the centering ring with thin CA to give it some extra protection against the gases.

Detail of the motor retention bolt.



MOTOR RETENTION

At the back end of the assembly, test fit the 8x32 bolt into the cavity created by the union of the three tubes. This bolt provides the backbone for motor retention. Remove the bolt, and using a Dremel cutoff bit, cut the head off the 8x32 bolt. Mix up a small batch of 5-minute epoxy and drip it down the tube cavity, using a toothpick to feed it in. Slide the bolt into the cavity, leaving about ½" exposed. Put the completed motor mount assembly (MMA) aside to dry.

ATTACHING THE SHOCK CORD

After the motor mount assembly has dried, cut a length of Kevlar shock cord that when extended is the length of the Prowler airframe, minus the motor mount length. Drill a hole at the joint of the centering ring and MMT, feed in one end of the Kevlar, and tie a knot to secure the end. Glue the knot to the MMT with CA or yellow glue. At the free end of the Kevlar, tie a loop and CA that knot. That loop provides the anchor for the elastic shock cord, and should end just inside the airframe when fully extended. Tie one end of a 6' long 3⁄16" elastic shock cord to the Kevlar loop, and tie the shock cord into a bundle to keep it out of the way.

INSTALLING THE MMA

Test fit the motor mount assembly into the end of the body that contains the fin slots. The ends of the assembly should be flush with the end of the tube, and the valleys of the assembly should align with the fin slots. Turn the assembly ¼" turn so that a motor mount tube is now located directly under each fin slot. With a scrap piece of balsa, spread a bead of yellow glue along the inside of the body tube where the assembly will touch when placed back in position. Immediately turn undo the ¼" turn, so that the assembly seats in the glue.

COMPLETING THE ROCKET

Finish the rest of the model as described in the instructions, joining the remaining body tubes and couplers. Sand and finish the fins prior to installation. I prefer to seal the fins using Elmer's Fill-n-Finish

diluted with water, as described in a previous issue of *The Sentinel*. Test fit the fins into the slots to make sure the fin tabs fit snugly in the grooves of the MMA. If the tabs are too long, sand them back. If the tabs are too short, you can compensate by filling the MMA valleys with thick CA or fast setting epoxy. On my model, I used both thick CA and yellow glue, as I was not careful enough when sanding and fitting the tabs. Glue each fin to the tube, first by laying down a bead of cement into the MMA valleys (dripping the glue through the fin slots), and then inserting the fin, holding it in place with the Rocket Builder's Marking Guide. Glue on the launch lugs. Fillet both the fins and the launch lugs.

FINISHING

Fill the body tube joints and spirals with spackle or wood filler. Successively sand the body with 320, 400, and 600 grit sandpaper until smooth. Wash the mold release and oils from the nose cone with dish washing detergent and a toothbrush. Cover with multiple coats of gray auto primer, sanding between coats, and finish with coats of Rustoleum Gloss Purple. After waiting at least a couple of days (preferably a week), apply the decals and coat with Clear Enamel. To easily handle the rocket during painting, glue a spent 18mm engine casing onto a dowel, and friction fit that into the one of the motor mount tubes.

PREPPING AND FLYING

Mounting the motors is as simple as placing each motor in a tube of the MMA, and then placing a washer and hexnut over the 8x32 MMA bolt and tightening. The washer should just cover the lips of each motor, and not interfere with their clay nozzles. After tightening, install an igniter in each motor and finish prepping the rocket as usual.

You'll need a 12 volt launch system capable of throwing enough amps at the igniters so that they'll ignite all three motors simultaneously. You'll also need some clip whips for your ignition leads to distribute the current across all of the igniters. You can either have whips of three and three, or twist some of the igniter ends together so as to minimize the number of clips required (of course, respecting the laws of polarity). Don't worry if you don't have this level of ground support. CMASS launches have all of the hardware available to help you make the launch of the Growler a successful one. It's where I plan on testing mine!

[Thanks to John Buscaglia, Bill Spadafora, and Doug Steinfeld for their ideas on motor retention and inhibiting exhaust gases.]

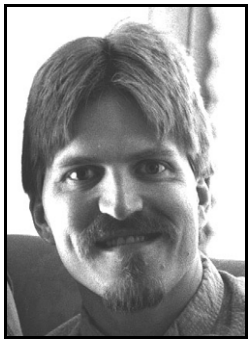
CMASS COMPETITION FLYING AT NARAM 40

This is CMASS Competition Team *The Good, the Bad and the Ugly*, consisting of members John Buscaglia, Gary Miller, and Fran Miller. I'll let you decide who's who. The rocket is John's *Asp*. It was a fine looking model but he didn't win. The rockets he was competing against were unbelievable. The team took the 4th place National Team Championship trophy.

Photo and text by Bill Spadafora.

WIND INSTABILITY

WHAT BARROWMAN LEFT OUT



by
Robert Galejs

galejs@ll.mit.edu

In Centuri TIR-33 (reprinted in the March '98 issue of *High Power Rocketry*), Jim Barrowman outlined a method for the determination of the center of pressure (CP) of a model rocket, now known as the Barrowman Equations (BEq). He recognized that the CP moves forward as the angle of attack (AOA) increases from zero. The largest AOA experienced by a model rocket is when it leaves the launch rod in windy conditions. The larger the wind, the larger the apparent AOA of the rocket. It is usually assumed that a 1 caliber (rocket diameter) margin between the CP and the center of gravity (CG) provides sufficient margin for this forward motion of the CP to allow for a stable flight of a model rocket.

In the article "Wind-Caused Instability" in the same HPR issue, Bob Dahlquist presents experimental results on this CP variation for four model rockets. This data shows a linear variation of CP vs. AOA. This deviation is significant even at angles less than, 10°, the region that Barrowman considered small. The Alpha, a shorter/squat, rocket shows a smaller CP variation (in terms of calibers) than the longer/skinnier rockets (Nikesmoke and Delta Clipper).

An extension to the Barrowman Equations that models this CP variation with AOA is presented here. This extension well models the CP variation for three of the rockets measured by Dahlquist (The fourth rocket had canted fins and did not fit the assumptions of the BEq). Also presented are some predictions for two extreme cases. One is a long-skinny rocket that went unstable at a CMASS launch this spring. This example shows dramatically that the one caliber rule of thumb is not sufficient for stable flight in all cases. The other is the Estes Fatboy which indicates that short/fat rockets may be more stable than typically thought.

What Barrowman Left Out

In Centuri TIR-33, a plot of body lift vs. AOA shows that this force is quite small at angles less than 10°. This plot is used to justify the neglect of body lift in the BEq. However, at these small angles, the wing and nose lift varies linearly with AOA, which also falls to zero at small angles so that it is not clear at what point the body lift can be neglected. The body lift force [references 1,2,3,4] may be expressed, for small angles, as:

$$N = \frac{1}{2}\rho V^2 K A_p \alpha^2$$

where K is a constant between 1.1 and 1.5, $\frac{1}{2}\rho V^2$ is the dynamic pressure, A_p is the body planform area (including the nose, body and all transitions and boattails but not the fins) and α is the angle of attack, measured in radians. This lift acts at the center of the planform area. When this force is put into the BEq format, one factor of α is factored out, leaving a linear variation with angle. This is just what is required to give the linear variation of CP vs. AOA found experimentally. Put into the Barrowman format, the coefficient of body lift is:

$$C_{N\alpha^2} = 4\frac{K}{\pi}\frac{A_p}{D^2}\alpha$$

Where D is the diameter of the rocket at the base of the nose cone. This force acts at the center of planform area:

$$\overline{X_B} = X_{\text{plan}}$$

The contribution of each body component (nose, body tube, transitions) can be calculated separately or the entire body lift contribution can be done at once

using the total planform area. Table 1 shows the planform area and moment arm for typical model rocket components shown in Figure 1.

	A_{plan}	X_{plan}
Conical Nose	½ $L_N D$	⅔ L_N
Parabolic Nose	⅔ $L_N D$	⅗ L_N
Ogive Nose	⅔ $L_N D$	⅝ L_N
Cylindrical Body	$L_B D_B$	X_{BN} + ½ L_B
Conical Transition	½ (D_1+D_2) L_T	X_{TN} + ⅓$L_T(D_1+2D_2)/(D_1+D_2)$

Table 1: Area and Moment Arm for Rocket Components

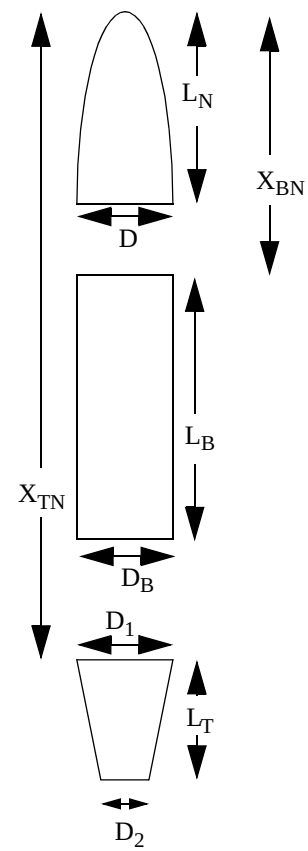


Figure 1: Rocket Components

The force from transitions is positive, regardless of whether it is an expanding or reducing transition, since it only depends on area.

To apply these equations, simply add $C_{N\alpha^2}\overline{X_B}$ to the numerator and $C_{N\alpha^2}$ to the denominator of the usual BEq for each rocket component.

Comparison of Model with Data

I received the dimensions for three of the four rockets measured in the HPR stability article from Konrad Hambrick, an Alpha II, Nike-Smoke and Delta Clipper (Figure 2).

I applied the BEq and my body lift extension to these rockets. The constant K was varied to fit the three data sets. A value of 1.0 gave good agreement between the data and the model. Table 2 presents the resultant CP equations in terms of calibers. The model predictions and experimental data are presented in Figure 3. The data is show by dashed lines and the model by solid lines.The agreement between the model and experiment is near perfect up to about 10° and quite good up to 15°. Above 15°, the actual CP moves forward more quickly than predicted by this model. This behavior is prob-

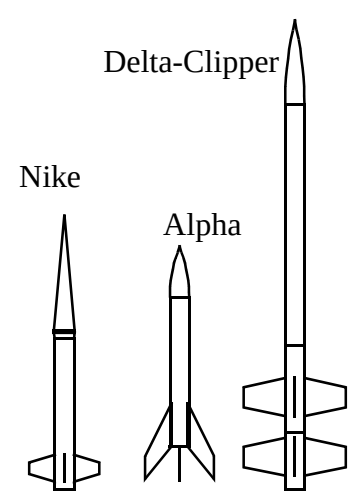


Figure 2: Test Rocket Planforms

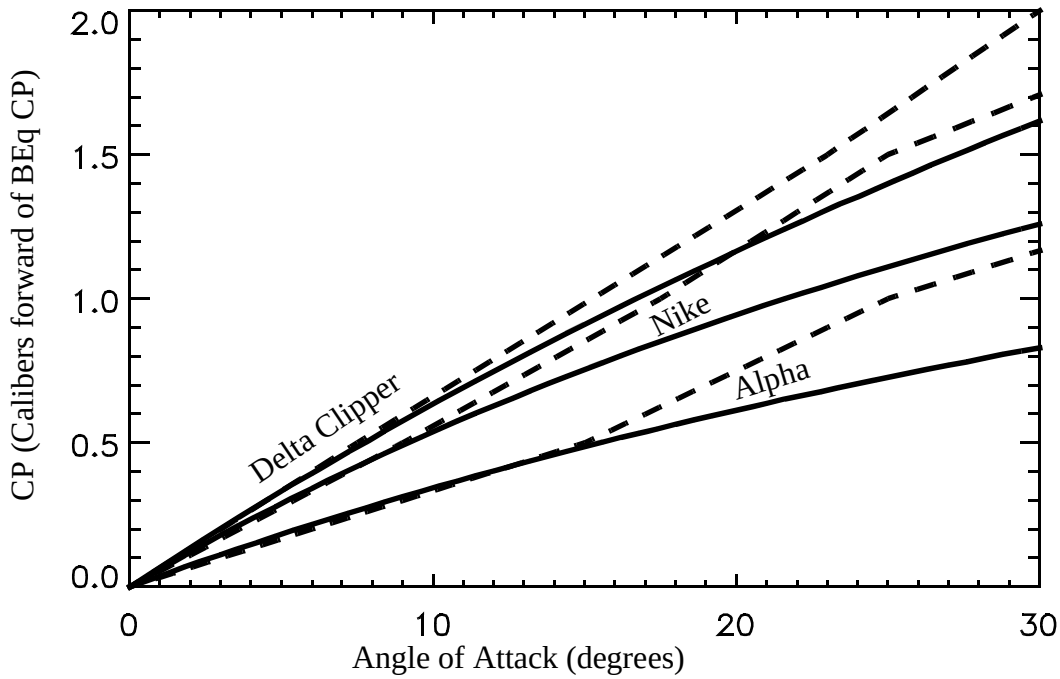


Figure 3: Experimental vs. Predicted CP Variation

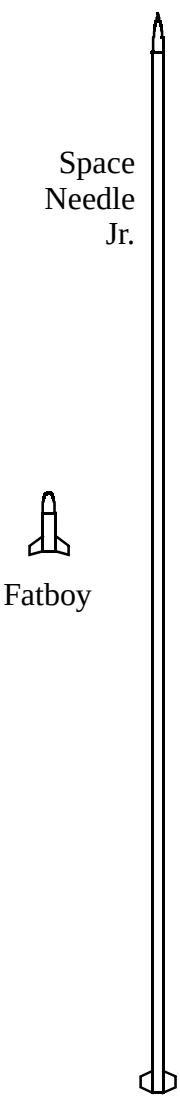


Figure 4: Two Extreme Rockets

Model	CP Equation
Alpha II	$CP = \frac{127.4 + 67.4\alpha}{14.7 + 11.6\alpha}$
Nike-Smoke	$CP = \frac{168.2 + 110.2\alpha}{13.7 + 13.0\alpha}$
Delta Clipper	$CP = \frac{1029.6 + 376.1\alpha}{50.7 + 28.5\alpha}$

Table 2: CP vs. AOA for the Test Rockets

ably due to some other BEq assumption being violated, such as the fins stalling. These results indicate that this method of adding body lift into the BEq is a good approximation.

In extracting the experimental points from Bob Dahlquists's article, I left out one point which deviated substantially from the trend of the rest of the data for the Delta Clipper just as Bob did when he drew lines through his data. Using a larger value for K of about 1.2 would give a better match at large angles but slightly worse at small angles.

Other Predictions

The three rockets discussed so far have been relatively "normal" rockets. It is interesting to examine two extreme casesin terms of aspect ratio, a very long/skinny rocket and a short/fat one to see how the CP moves in these cases. These two rockets are shown in Figure 4.

At a recent CMASS launch, Sean Lannan launched a Rogue Aerospace Space Needle Jr. that he had flown successfully before on ½A and A engines. On this particular day, he used a B and the model went unstable. Applying the BEq to this rocket gave stability margins of 20, 16 and 12 calibers for the ½A, A and B engines respectively. That would appear

to be quite sufficient for all of the engines. However, since the body is quite large relative to the fins, the body lift is very important even at relatively small angles of attack. The variation of this rocket's CP with AOA is shown in Table 3 and is plotted in Figure 5A (Note the 15 times scale change from Figure 3). This rocket loses over 12 calibers of stability at only 5° AOA! Clearly here, the body lift is very important and the usual 1 caliber rule of thumb is quite insufficient for stable flight even in relatively light winds. This also shows why the ½A and A flights could be stable but the B went unstable.

Model	CP Equation
Space Needle Jr.	$CP = \dfrac{886.8 + 4107.6\alpha}{13.2 + 100.3\alpha}$
Fatboy	$CP = \dfrac{188 + 19.2\alpha}{40.5 + 6.2\alpha}$

Table 3: CP vs. AOA for Two Extreme Rockets

The CP movement of a short/fat rocket, the Estes Fatboy is and is plotted in Figure 5B. Note that in this plot, the full scale is only 1 caliber. Even at 30° the CP moves forward less than ⅕ caliber. Clearly here, the full 1 caliber stability margin is not necessary even in relatively high winds.

This CP prediction may be used to estimate the maximum allowable winds to allow stable flight for a given rocket/motor combination. First use this method to predicts CP vs. angle of attack. Measurement of the CG location then gives a maximum angle of attack, α_{max}, where the CP equals the CG. If the rocket velocity as it leaves the launch rod, V_{launch}, can be estimated, then a maximum wind velocity for stable flight can be found: $V_{max} = V_{launch} \tan\alpha_{max}$. This can be done through a wRASP-like altitude prediction code or by estimating the initial acceleration of the rocket through the initial motor thrust and rocket mass. There obviously still needs to be some CP-CG margin but what minimum value is acceptable is not clear. A more involved simulation including the actual turning moment and moment of inertia would be required to answer this question.

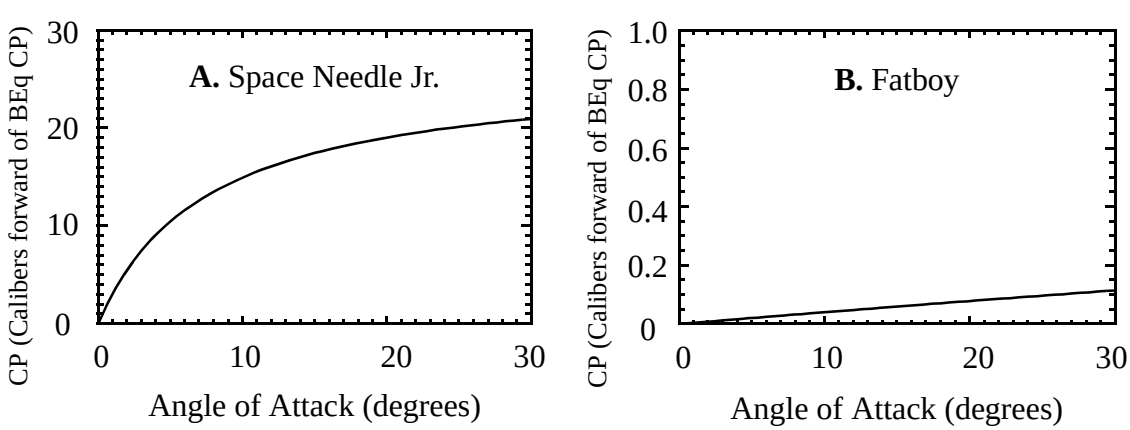


Figure 5: CP Variation for Two Extreme Rockets

Summary

An extension to the Barrowman equations was presented that includes the effects of body lift. This extension fits Bob Dahlquist's experimental results quite well and explains an unstable flight of a long/skinny rocket. Using this extension increases the ability to predict CP out to about 15° angle of attack. For "normal" rockets, the one caliber stability rule of thumb appears to be a good rule of thumb. However, for long/skinny rockets, upwards of ten calibers may be called for and for short/fat rockets less than half a caliber may be sufficient.

A VCP-like CP prediction code with this extension combined with a wRASP-like rocket flight prediction code could be used to predict a maximum acceptable wind speed for stable launch of a given rocket/motor combination.

References

1) J.J. Jerger, "Systems Preliminary Design," Principles of Guided Missile Design, pg. 354,367, D. van Nostrand Co, Inc., Princeton, NJ 1960

2) S.F. Hoerner, "Fluid-dynamic Drag," pp 3-11,Midland Park, NJ 1965

3) P. Zarchan, "Tactical and Strategic Missile Guidance," 2nd Edition, pp 370-373, American Institute of Aeronautics and Astronautics, Washington, DC 1994

4)T.C. Cannon Jr., "A Three Dimensional Study of Towed Cable Dynamics," University Microfilms, 1991

CMASS MEMBERS WIN TOP AWARDS AT NARAM 40

At this year's NARAM in Muncie, Indiana, members of CMASS received two of the NAR's highest service awards.

1998 President's Award

awarded to C. D. Tavares for his founding work on the NAR web site at http://www.nar.org.

1998 Howard Galloway Award

awarded to the NAR Standards and Testing for their hard work certifying motors, contributing to standards, and conducting experimental *sparky–motors* tests. S&T is completely staffed by CMASS members.

PAST AWARDS FOR CMASS

While we are at it, perhaps it is time we did a little bragging. Over the years, CMASS members individually and collectively have received several other NAR awards:

1994 President's Award
for the CMASS members of Standards and Testing.

1993 President's Award
for Bill Spadafora for his work revitalizing the NAR Technical Service (NARTS).

1991 Howard Galloway Award
for C.D. Tavares for finding an insurance carrier for the NAR.

1987 Howard Galloway Award
for the Modelers of Massachusetts for the elimination of rocketry permits in Massachusetts. The award was shared by CMASS and SNEAR, collectively known as "Permit Busters."

COMMITTEE MEETING REPORT

(continued from page 7)

Boy Scout representative also mentioned that, in spite of the trampling that all the people and vehicles did to the field, a few weeks later you couldn't tell it had been used.

We left after this part of the meeting. It's clear that these people are committed to putting Woodsom Farm Park to good use and I didn't hear anything that would lead me to believe that they have a problem with us.

One other thing should be mentioned. At the beginning of the meeting they were discussing access to the field. It seems that the town doesn't have an easement or right of way for the section of the dirt road from the street to just past the cow barn. It belongs to Mr. Woodsom and their negotiating with him for it's use. They are also working on two other backup plans. I want to remind everyone to drive slowly through that area (and all the way for that matter). We don't want to loose access to the only way to drive on to the field.

Confused?
Amused?
Or just owe dues?

If you'd like to know more about sport rocketry, and want to participate in our regular launches, join CMASS!

If you enjoyed reading this newsletter and would like to receive it as it's published (whenever *that* is), join CMASS!

If your mailing label says your dues are due, do your duty ("doobie-doobie-doo…") today, with the handy form below!

Wow! I'm psyched! I want to join CMASS!

Name:_____ Date of Birth: _____

Street: _____ Age: _____

City: _____ State: ____ Zip Code: _____Phone:(_____)_____

Internet E-mail (if any): _____Work:(_____)_____

❑ I am a NAR member. (Number:_____) HPR Certification Level: ❑ none, ❑ H/I, ❑ J/K/L

❑ I am not a NAR member and wish Associate status.

CMASS dues cover twelve months and are due January 1 or July 1. Check according to your age:

❑ 14 or younger: $4 ❑ 15-17: $6 ❑ 18 or older: $8

Make checks payable to **CMASS**. Send to CMASS, 72 Prendiville Way, Marlborough MA 01752.

(continued on page 7)

1999 COUNTDOWN CALENDAR

An up to date version of this calendar is maintained on the Internet at http://www.cmass.org/schedule

CMASS Meetings and Building Sessions

Meeting are held on the first and third Tuesday of each month from 7:00–10:00 P.M. Meetings alternate months between several different locations. These are:

Bill Spadafora's, 5 Granby Street, Saugus, MA 01906	(781) 233-0339
Doug Steinfeld's, 72 Prendiville Way, Marlborough, MA 01752	(508) 481-9337
C.D. Tavares', 339 Crawford Street, Northboro, MA 01532	(508) 339-6599

Please call for directions or to confirm a meeting. Changes in meeting date or location are announced on the meeting@cmass.org mailing list.

Scheduled Meetings:

April	6, 20	Marlborough
May	4, 18	Saugus
June	1, 15	Marlborough
July	6, 20	Saugus
August	3, 17	Marlborough
Sept.	7, 21	Saugus
October	5, 19	Northboro??

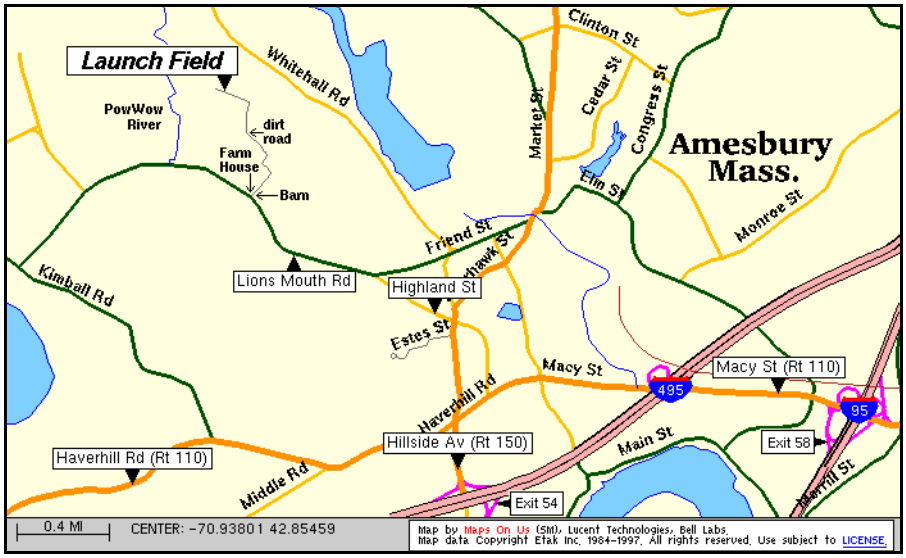
Sport Launches in Amesbury, MA

Launches at Woodsom Farm Park in have a 9:00 A.M. setup and a 10:00 A.M. start. Saturday launches may be postponed to Sunday in case of inclement weather. If the weather looks questionable on the day of the launch, call (781) 231-1018 before heading out to the field.

DRIVE SLOWLY ON THE DIRT ROAD!

Launches are **tentatively scheduled** for the following dates. These dates may change pending availability of the field and approval of the Town of Amesbury.

April 24	July 10	October 23
~~May 8~~	July 31	November 13
~~May 29~~	September 11	
~~June 19~~	October 2	



Other Launches

August 21	A2Z Rocket Day, Smith Academy, Hatfield MA. 11:00 AM setup. A-E motors. Directions available upon request.

NAR Launches

May 29-31	NSL99, Ardmore, Alabama.
August 7-13	NARAM41, Muncie, Indiana.

THE SENTINEL

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MARLBOROUGH MA 01752