

Tech Tip-013

Cluster Altitude Competition design & Construction:

Dedicated to the dissemination of detailed model building methods and techniques.

Materials and methods presented here are not intended as the best or only solutions to the modeling challenge(s) discussed, rather as methods and procedures which have a proven record of success in actual use. Please keep experimenting with new materials and techniques as this is the only way to expand the fields of knowledge.

Written by: John E. McCoy Sr. - NAR-15731 – 04-30-2016

This Tech Tip will look at each NAR Cluster Altitude Contest event by motor thrust level 2x1/8A thru 6C. We will explore these clusters by event impulse rather than by when the event was actually flown over more than a 13year time span.

On the following pages a bit of Narhams History will aid in the attempt to give the reader an over view of the processes involved in designing and building competitive multi-motor cluster altitude model rockets. Some will appear weird, others sleek and streamlined. Every effort will be used to explore various motor configurations with some of the many concepts designed over the last 13 years by the author and others. While it may not be possible within the limited space of this Tech-Tip to look at every design concept created for each of the 6 motor class events. It is hoped there will be enough detail included that the reader will gain greater insight into what can be expected from a set of motors for the thrust level of interest.

Two of the most important things to keep in mind while designing Cluster Altitude models:

A: Minimal Frontal Area: The Plan View of our models plays a vital but under appreciated roll in overall performance.

B: Optimal Mass: Each model will have a specific "Best Mass" or (Throw Weight) for the selected motor class.

With these few guidelines in mind let us begin with the smallest but not necessarily easiest motor group and model size:

2x1/8A Cluster Altitude: (Micro Maxx motor Powered): 08-2004 to 09-2005

While we are only going to need two 1/8A.5-1 MMX-II motors or one MMX-II and one MMX-II-NE too power this impulse class. These tiny rockets can require a good bit of ingenuity to get a model that will fly on two MMX motors with minimum **Frontal Area** we spoke of and **Optimum Mass** to obtain the highest possible coasting altitude. There is also the challenge of visibility for such small, very fast moving rockets over a given baseline. Over time it has been determined a 300ft baseline is preferred over the normal 1000ft baseline for tracking 2x1/8A Cluster Altitude events. It was observed that even at this shorter distance if tracking powder was not used or used properly the rocket would almost certainly receive a TRACK LOST report for the flight. We'll look a little deeper into the tracking powder problem shortly. For now let's get back to the basics design phase of our two motor clusters.

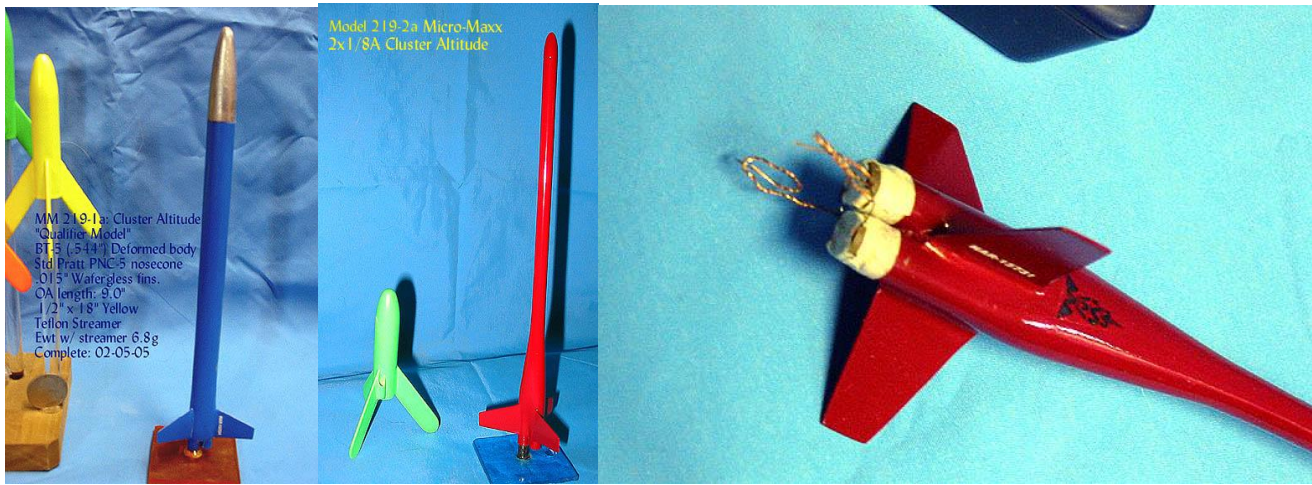
Side by side is of course the preferred configuration of this rocket. But that means we have a couple choices to make. Do we want to enter a Qualifier type model that will almost certainly be large and easy to track or some form where our side by side motors or motor tubes vent into a minimum diameter or smaller body tube? More bizarre could we build a stacked in-line 2 motor cluster? Materials are also something to be considered. Standard Craft tubes with .013" wall are fairly easy to find but considered on the heavy side at this model size, Tracing Vellum or single wrap .5oz fiberglass cloth could be considered if we have the talent, mandrel and time. There is also the possibility of combining a couple or all the above materials to create our vision of the most aerodynamic slippery rocket. Looking at the minimum diameter standard motor tube for MMX motors one can see the T2+ (.281"OD) side by side will just fit with a little distortion into a BT-5 Standard .013" wall body tube. With a little nudging our two 1" long motor tubes can be fitting into the BT-5 and sealed with a bit of white glue soaked tissue. Add a light weight Pratt Hobbies 2pc vacuum formed styrene nose cone and some light 3/64" 3ply plywood fins, 30" of 50 to 70lb Kevlar shock line and a 1/2" x 9" Teflon tape streamer-wadding I think we have a Qualifier.

Do we want something that has a chance to make it to the podium? Then we will have to do some serious streamlining to reduce the frontal area and overall mass. This will mean mounting two T2+ motor tubes side by side and notching them into a single T2+ main body tube. Our motor tubes will then be plugged to ensure all the ejection gas is channeled into the main body tube. Plugging can be done with small pieces of 1/8" epoxy coated balsa or white glue soaked tissue, whichever is lighter. My choice was the 1/8" balsa bulkheads. The next step will be to streamline the transition from a single T2+ to the dual motor tubes. We have a few possible choices to do this either turn a balsa transition hollowed out to slide over the main tube down over the motor tube joint, or build a cardstock oval transition, or the root I took creating a ultra light tracing vellum overlapping cone with a .281" apex and large enough base to deform into an oval capping our dual motor tubes. After CA fixing the transition in place over the motor tubes the entire transition is carefully trimmed as close as possible to the top of the motor tubes then Medium CA is paper towel mopped over the entire transition to harden our transition shell.

To form our shock-line 50lb x 30" Kevlar is attached directly to a small hole drilled between the center point between the motor tubes in the epoxy fillet. Our nosecone is a simple parabolic home made basswood turning, center drilled just enough to epoxy in a 50lb Kevlar attachment loop. To this shock-line we attach a 1/2" x 9" yellow military grade PTFE Teflon streamer/wadding.

3 fins for the streamlined bird will be 1/64" 3ply plywood in a dual tapered profile. Attaching these 120 degrees apart will be a little tricky on this oval section. Fins are attached with spot CA and very fine 5-minute epoxy fillets. This model will be tower launched, so no launch lug will be added. It is now time to start smoothing the model surface after application of 3 coats of grey primer.

Sanding and smoothing any and all joints to create as smooth a transitions as possible. Two coats of Dark Red enamel complete the model painting. Paint is not the end of our finishing effort. It is now time to use Finessit-II polishing medium to polish the dry color coat to a babies butt smooth over-all finish. Finally a coat of Nu-Finish polymer is applied to the entire rocket.

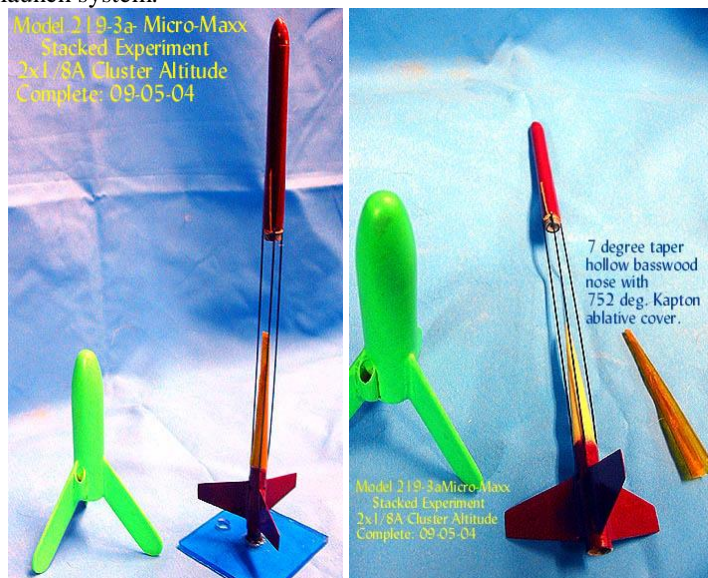


All right; we have a good looking model that should be competitive. Motors are matched by weight as closely as we can, installed using internal and external tape to ensure motors stay in the rocket. We baby powder the heck out of the streamer/wadding. Carefully install our shock-line and streamer, adding about .3g of red tracking powder atop the streamer. Install the NC and mount the rocket in the tower. After getting the tracking stations GO, the count down is given; 5, 4, 3, 2, 1 ignition, the tiny rocket instantly teleports high into the sky. The Pop is heard but NO streamer or tracking cloud is seen, shortly after the model streamlines in with only the NC ajar but the tracking powder is still just sitting there, intact even when the model is recovered. What the heck?

What Happened? Apparently in small volume tube situations our loose tracking powder works like a Liquid Solid under the stress & vibration of acceleration & deceleration. In other words instead of being a tracking cloud the vibrations within the body makes the tracking powder form a solid non-moving plug. CRUD! The Fix for is to use a wax paper or very thin onion skin paper tracking powder sleeve. This effect has occurred in models with main body tubes from T2+ (.281"), T2++ (.349") to T3 (.375").

The Third Option: Minimum Diameter In-Line Experimental model.: 09-05-2004

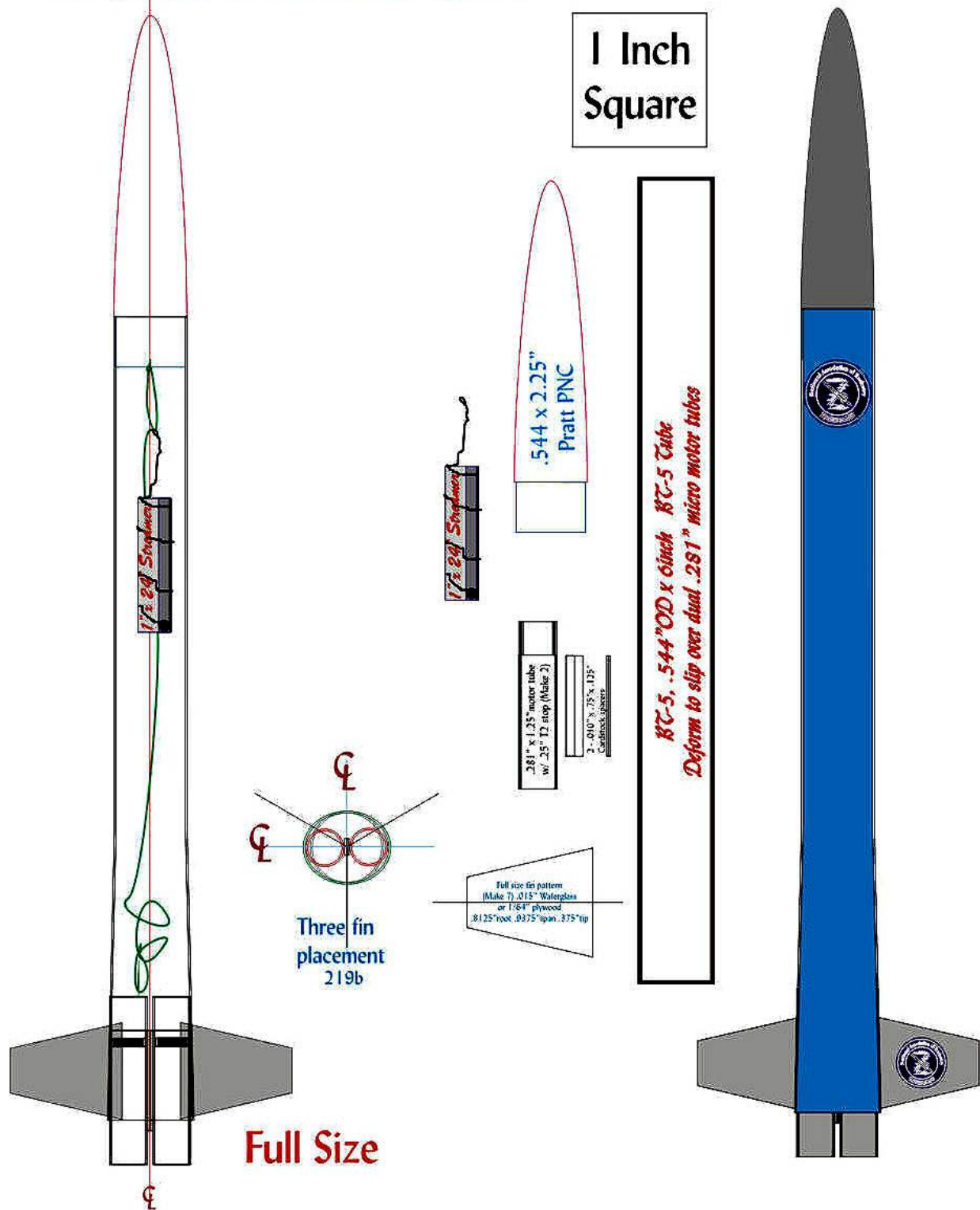
In an effort to design something a little unique with the absolute minimum frontal area while still a possible contender for the event podium finish. Two motors stacked configuration was created with use of T2+ body tube, turned steep sloop 7degree conical basswood nosecones, .010" Waferglass fins and special heat resistant ablative .001" thick Kapton coverings for the lower motor housing cone. Our two motor mounts are held in alignment by three .030" carbon fiber rods. Connections between unlike material are made with CA & structural 30minute epoxy. Fin fillets use my usual Devcon 5-minute epoxy. No doubt this is a strange looking bird but experiments say it does fly straight. However; in flight testing the little bird did not get the altitude expected. I'm sure this underperformance can be explained by the thrust vectoring caused by the protective lower motor housing ablative cover. I only include this experimental profile to encourage design thinking outside the box. This configuration also required a special clip-whip extension add to the relay launch system.



The next two pages are MMWW 1-page Plans for our Qualifier (BT-5) and Streamliner (T2+) with In-Line Stacked (T2+) models. During imbedding in this writing they may not be quite full size. Check the 1 inch square on each drawing to ensure they are the proper size.

McCoy's Micro Wonder Works

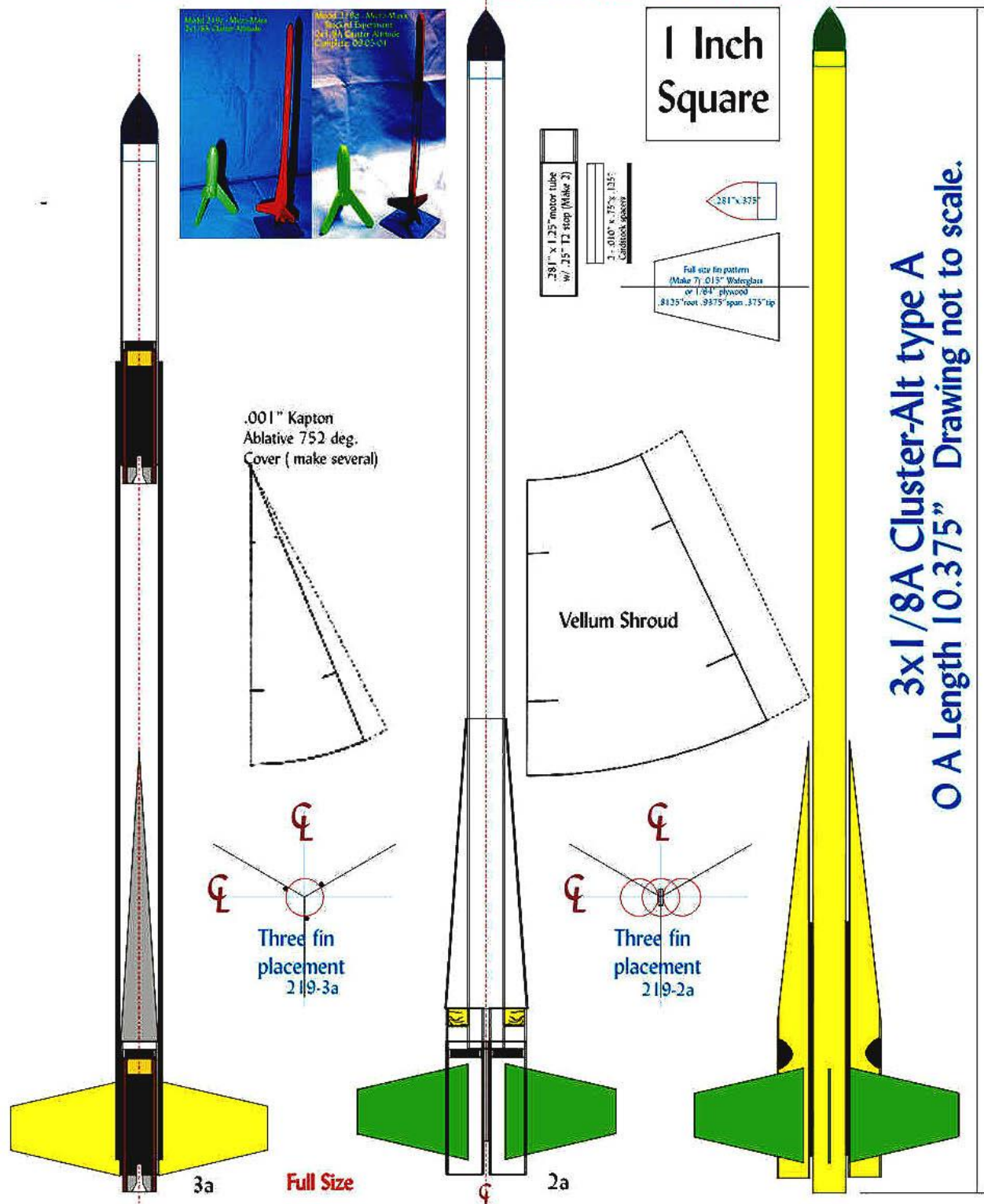
Micro-Maxx Model #219-1a (2x1/8A Cluster Altitude Qualifier))
 Drawing Complete: 01-25-2005, Model complete: 02-02-05



McCoy's Micro Wonder Works

Micro-Maxx Model #219-2a & 3a (2x1/8A Cluster Altitude EXP.)

Scale: as Noted: Dwg Complete: 08-22-04, Model Complete: 2a: 01-25-05, 3a: 09-05-04



2x1/4A cluster Altitude: 13mm 1/4A motors – (10-1998 – 05-1999)

BT-5 & BT-4 bodies for these two models seem to share the same building and finishing techniques as the 2x1/8A models discussed above, even though they were designed almost 6years earlier. With that in mind, I'll simply show the designs flown and you folks can go from there.

Two different body tube sizes were used for these 2-motor cluster models. The first 13mm version produced 10-10-1998 and a smaller second model 10.5mm version finished 05-08-1999 produced specifically for ECRM-26. Both were flown at that Contest with outstanding flight results.

Both are standard .013" wall 10.5(BT-4) and 13mm (BT-5) Brown craft tubing. The 10.5mm later model was designed around the newly available Apogee Components A2 10.5mm High Performance BP motors. Same basic side by side design as our 2x1/8A configuration using slightly larger 1/32" basswood fins on the BT-5 model and .015" waferglass fins for the 10.5mm model. Pratt vacuum formed styrene nosecones and Tracing vellum oval transitions for both. Transitions are CA soaked and sanded to smooth out joints to as uniform slippery air flow as possible. Both variations used 60" of 70lb Kevlar shock-lines with 3" x 30" Mylar streamers. Both use standard wadding. Both were flown at ECRM-26 from a competition Tower resulting in outstanding flights.



2-1/4A CLUSTER ALT. MODEL TYPE Q.) 10.5MM MODEL

DESIGN & DRAWINGS
BY JOHN E. McLOY SR.
MAR-15-73

DATE: MAY 21, 1998
COMPLETED MARCH 29, 1999

10.5mm
TO 2x10.5mm
CLUSTER ALT.
TRANSITION
MADE FROM
VELLUM ON
MYLAR STOCK.

★
.5025" x .930" = .4563"
OR, PAPER ALPH.

PARTS LIST

- 1-10.5mm CAST NOSE CONE
- 1-10" RC - 10.5mm BODY TUBE
- 2-2" RCS - 10.5mm BODY TUBE
- 1-.5025" x .930" x 2.78" LONG
TRACING VELLUM TRANSITION
- 2-.125" x 1" LONG RCS - CARD STOCK
- 4-.15 or 1/16" BASS WOOD
.5x.75 x .75" - FINS
- 2-1/16" CUSTOM CUT 10.5mm MOTOR BLOCKS
- 2 RCS - 10.5 SCALLOPED BASS WOOD BLOCKS
- 72" 70LB KEVLAR SHOCKCORD
- 8" MYLAR CHUTE OR
3x30 MYLAR STREAMER
- M&D C.A.
- 5MIN. EPOXY

CAST (HEAVY)
PARABOLIC
NOSE CONE

1.375"

8.0"

9.375"

72" 70LB
KEVLAR SHOCKCORD

10" RC
10.5mm
BODY
TUBE

OPTIONAL
.5025" x .930" x 2.875"
TRACING VELLUM
TRANSITION

11 7/8"
(11.875")

12 1/16"
(12.6875")

FILL WITH GLUE SOAKED
WADDING

1.375"
TRACING VELLUM
.4475 TO .930"
TRANSITION
COVER

EPOXY FILL APPROX 1/16"

1/4" BASS WOOD BLOCKS

2-2" RCS - 10.5mm (.4475) TUBING

2.0" 2-1/16" 10.5mm MOTOR BLOCKS

2 LAYERS FINE CARD STOCK

Full SIZE
PATTERN

.5"

.5"

NOTE! CAN ALSO BE 13mm. @ SOME
LENGTH. -SLIGHTLY LARGER SHROUD.

RECOMMENDED C.G. @ 10.21"
C.P. @ 10.66"

LOW. WT. w/ 2-1/4A2-4 MOTORS AND
8" CHUTE 23.95g

3x1/2A Cluster Altitude: 13mm 3 motor cluster; THE BEGINNING: (05-1992 – 08-1993)

Around May of 1992, Narhams decided to put in our bid to host NARAM-35 slated for August of 1993. One of the proposed events caught my eye. 3x1/2A Cluster Altitude initiated my fascination with Cluster Altitude competition model design. I had already been tagged by then Section President Tom Lyon as “MrCluster” since I’d been cluster converting everything that looked like it would take more than a single BP motor. Mostly a sport flyer, I had never considered clustered motor competition models.

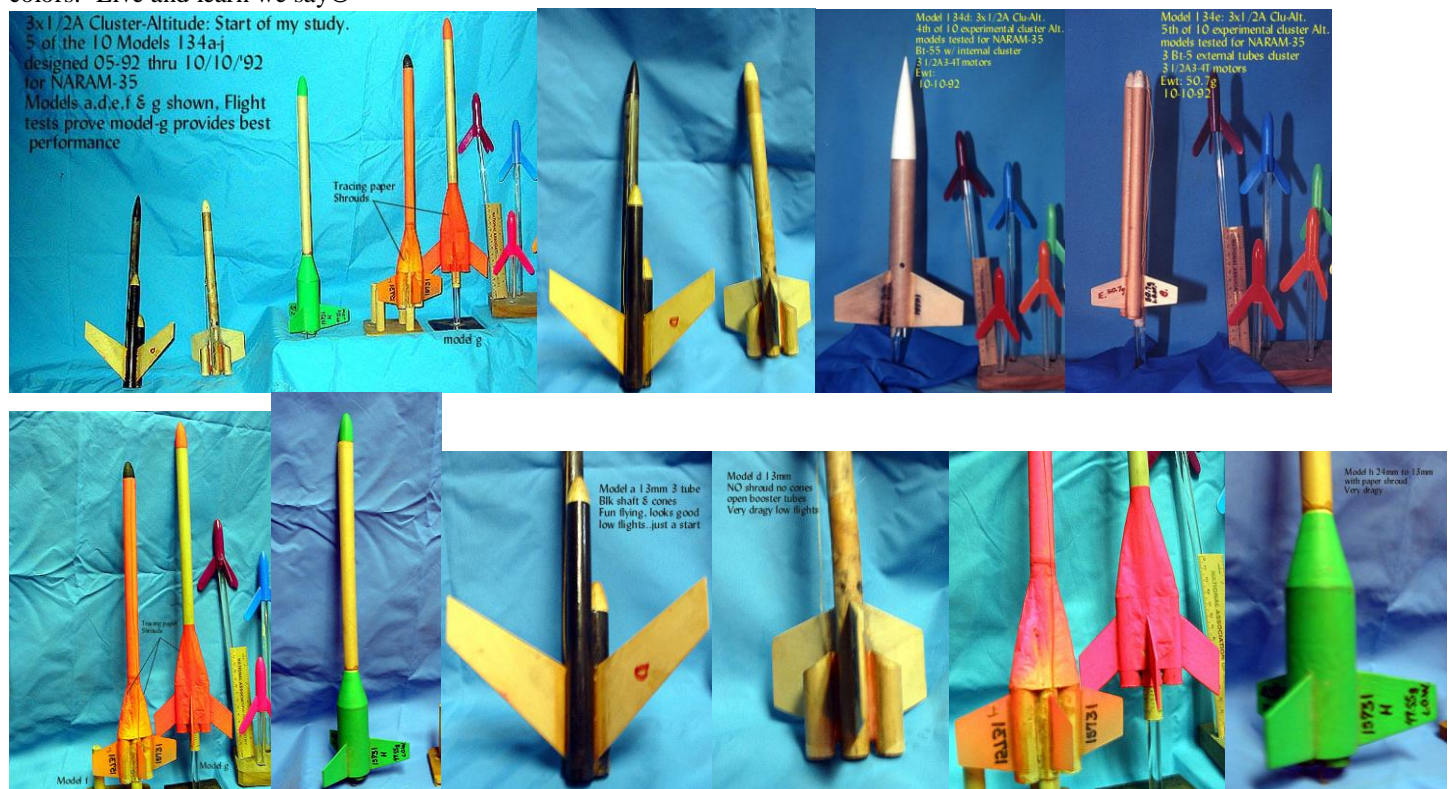
3x1/2A Cluster Altitude was actually my first dabbling into competition clusters. As a first attempt this particular motor selection presents some very interesting flying event options that challenge both design and construction techniques. Almost immediately the experimenting with design & construction started producing some wild, weird and wonderful 3 motor configurations eventually numbering 10+ designs. Not all these designs made the transition from drawing to flying model but the majority did. In the beginning there was no inkling of what would eventually evolve into a competitive, buildable design. One of the event rules at the time dictated all 3 motors had to ignite or the flight would be considered NO flight. Add to this all motor ignition issue various tracking problems either not closing within 10% or track lost, the NARAM-35 Staff were surprised at the number of contestants who never got a good flight tracked and closed during the meet. While each contestant had the ability to re-fly their model with a new set of motors, the time constraint would prove to be a major contributing issue especially when some had to re-fly as many as 4 or 5 times. My particular 10th design (Model G) ended up flying 4 flights without ever getting a closed track. Very nice altitude but just couldn’t get the tracking closed. If memory serves Dr. Bob Kreutz won the event with a single wrap epoxy-.5oz fiberglass model making an amazingly high flight. Unfortunately, I could not find the exact altitude but it was nearly double that of every other contestant. All this NARAM-35 History has been included as an example of what can be learned and accomplished, beginning in a new event or technique starting with absolute zero information or experience.

Looking at construction materials for these 3x1/2A models they begin with our standard Estes BT-5 .013” wall body tubing. With this motor configuration we have all kinds of options. The main concern in my mind was reliability of ignition and deployment.

Authors note: In the early stages I was not aware that the burn through gas build-up was enough to eject tightly fraction fitted motor casings from the rocket.

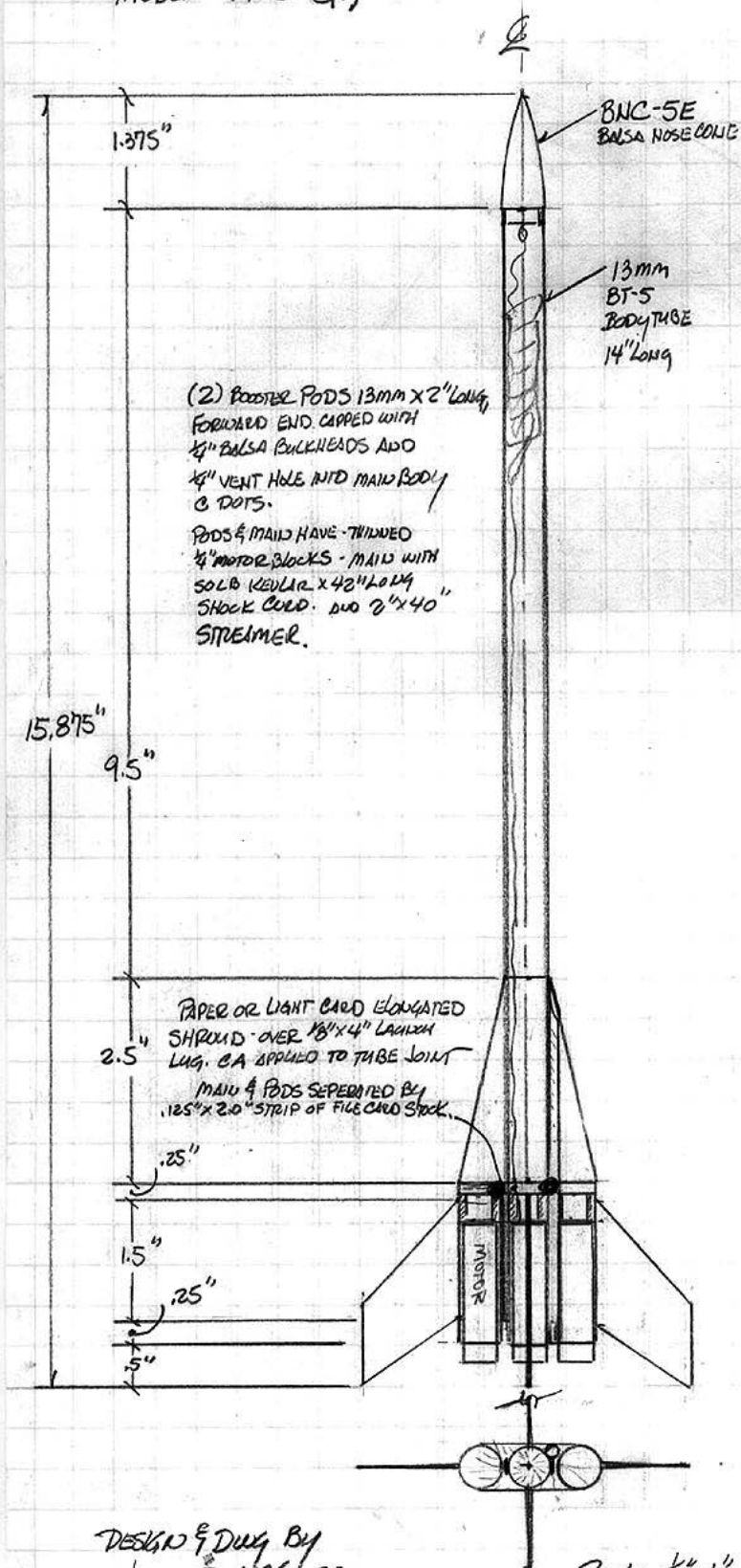
As time and flying went on it was discovered there had to be a way to either vent ejection gases into the core tube or using A10-0 booster motors in the outer pods, find another manor to relieve the burn through internal gas pressure within the very short strap-on tubes. In a couple designs the model used 3 individual body tubes. But over the year of research an inline 3 motor configuration reduced to a single core 13mm tube proved to be the best performing design.

All the remaining parts and components were standard model rocket vendor available materials. One thing to always keep in mind is finding that optimum mass without adding a bunch of altitude killing nose weight. It was discovered lengthening the core body tube reduced or eliminated the need for nose weight. Fin materials varied from .032” to .063” basswood. Slightly heavier than Balsa but the fine straight grain filled and smoothed to a finer, slicker finish with minimal extra weight added. As a first look at competition clusters we were still using light coating fluorescent orange paint with and without fillers on these models. Yes; today I’d change base fin materials, CA fill the nosecone and tracing vellum transitions so I could use either tissue or magic marker fluorescent colors. Live and learn we say! ☺



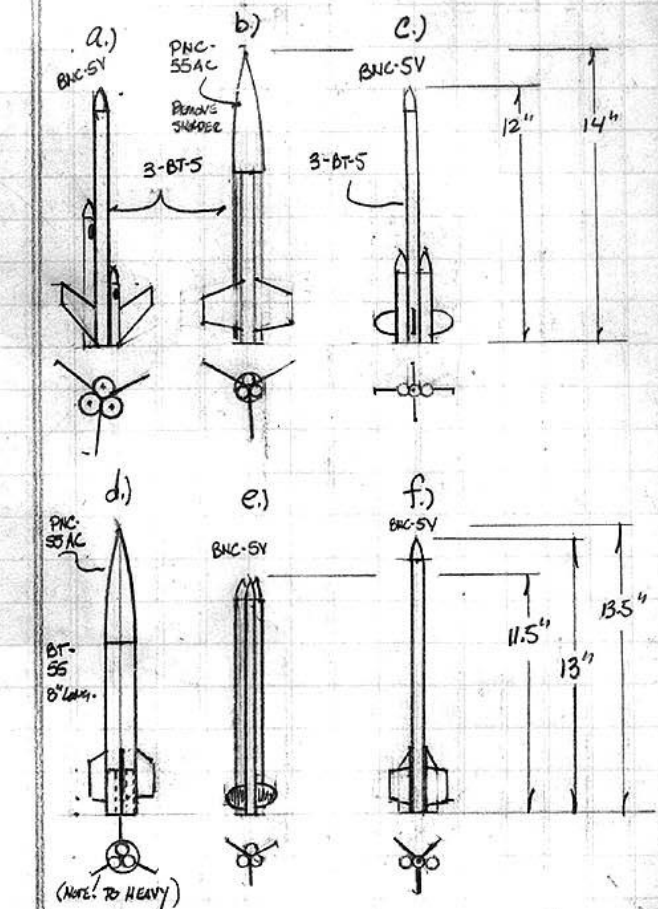
None of the above models were heavily primed but didn’t have the CA soaked tracing paper shrouds that later motor class models received. I’m sure if 3x1/2A were to be flown again today, design G would be altered making it much more aerodynamically slippery by increasing the shroud taper to 7 degrees of CA soaked tracing vellum which would greatly decrease the drag and mass allowing it to be nearly as competitive as Dr. Bob’s .5oz Fiberglass BTC model was in 1993.

3-1/2A CLUSTER ALTITUDE MODEL TYPE G.)

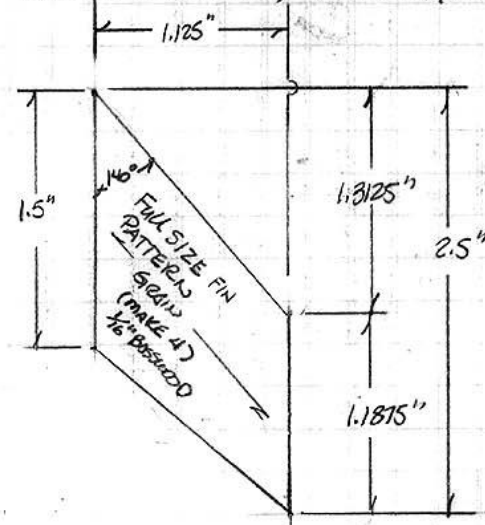


DESIGN & Dwg BY
JOHN E. MCCOY SR
NAR-15731

OTHER CONFIGURATIONS TESTED.
OCT. 7, 1992 THROUGH AUG. 3, 1993
SCALE: .125" = 1"



4 FINS TAPERED TIP TO ROOT, EPOXIED TO POD & MAIN



DWG: 01-3xV2A
DATE: SEPT 5, 1993

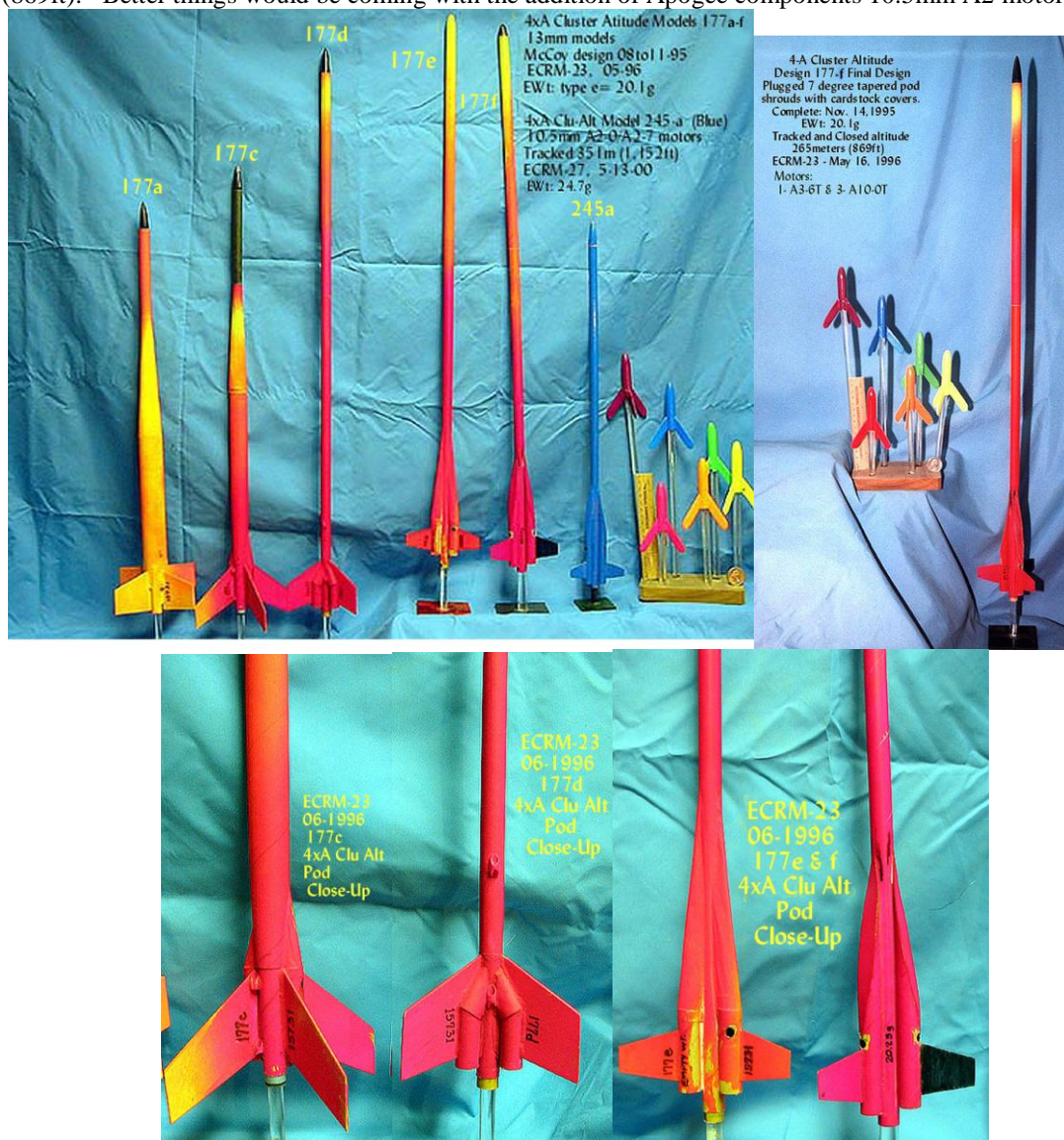
4xA Cluster Altitude: 10.5mm(T4), 13mm (BT-5), 13/ 18mm(BT-20) models: 1995-96, 1999-2000

4xA impulse motors gives quite a number of interesting configuration options. During the early 90's 4xA Clu-Alt designs were limited for the most part to Estes 13mm mini brute motors. These motors had at best a 4second delay giving many designers fits, as we knew the designs would be ejecting long before the model coasted to apogee. With this fact in mind a large number of competitors looked at a combined 18mm core with 13mm booster pods. Within this 18mm/13mm configuration we had the option of using 18mm A8-5 certified motors.

Below are photos of some of the early not so sleek designs along with what would end up being the very best flying 4 motor cluster designs at that time.

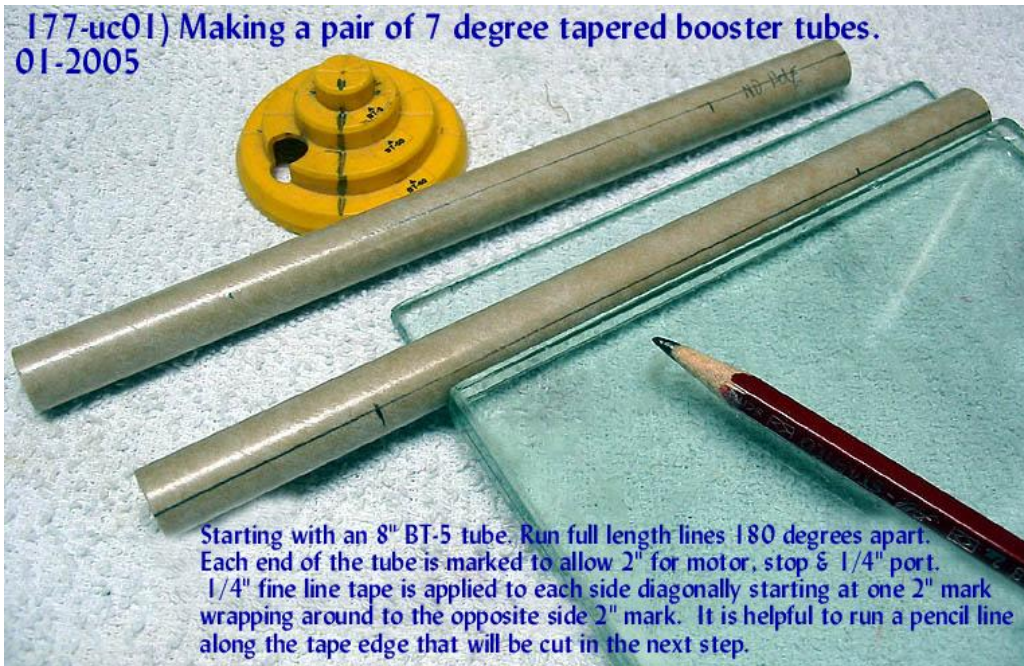
ECRM-23 to be held in May 1996, gave us a chance to look at designing 4 motor clusters using mainly 13mm BP motors. These first attempts showed some improvements over our 3x1/2A models although there was still the nagging concern about the maximum 4second delay with Estes A3-4T mini motors. That said; in the beginning the first couple examples were almost as crude as the best 3x1/2A models starting in August through November of 1995. Our model numbering system shows these Cluster Altitude models as 177-a thru f with 177f being what I believed would at very least get on the podium at ECRM-23 in May of 1996.

Take a look at some of the earlier models with much larger OD bodies with long tracing paper transitions. In theory these models were intended to house all 4 13mm motor tubes within or sliced into BT-20 & BT-50 airframe to create the least interference drag as could be expected. Most did not fair so well in flight testing. After experimenting with models 177a thru e, it was determined onion skin tracing paper and regular tracing paper shrouds should be abandoned being too flimsy and hard to control wrinkling. A new approach was needed. Booster pods would take on a much longer sliced, 7 degree taper with a flat or as nearly flat as possible cardstock or .005" waferglass (G-10) pod covers. Cutting the taper to form these pods took awhile to get the knifing procedure perfected. Over time cutting our tapered booster pods became a 2 pod from one piece at a time layout saving a good amount of 13mm tubing in the process. While our final design (177f) proved to be the best design at ECRM-23, our tracked & closed altitude was a mere 265m (869ft). Better things would be coming with the addition of Apogee components 10.5mm A2 motors introduced in 1996.



The next page will show the set-up and cutting technique used to produce 7degree taper pods and rough fitted flat covers. These pods & covers do take some time but the resulting reduction in drag has been proven worth the trouble.

177-uc01) Making a pair of 7 degree tapered booster tubes.
01-2005



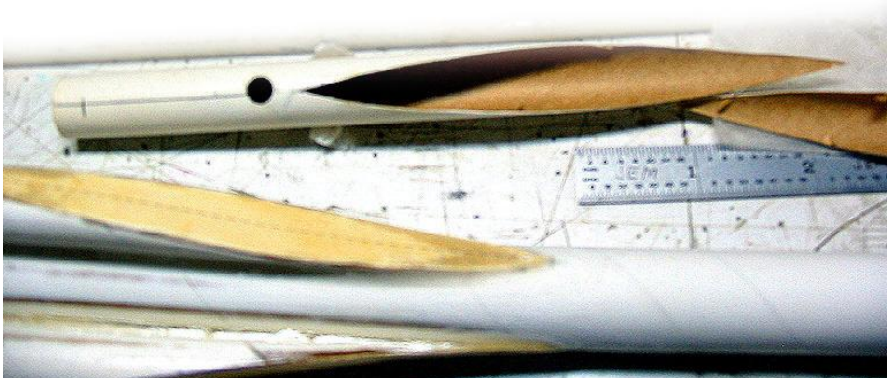
177-uc02: Making BT-5 7deg. taper booster pods.
01-05

Cutting mandrel for BT-5 tubes
is a 1/2" dowel.



177-uc04a: Making BT-5 7deg. Tapered Booster Pods:
01-2005

Punch 1/4" round port 1/2" from bottom of V cut.
Make and install 1/4" solid balsa bulkhead between top of port hole and bottom of V cut.
It is helpful to coat the motor side of the bulkheads with epoxy.
Apply cardstock or .005" Waferglass flat covers with medium CA.
Repeat for remaining booster pods.



later 4xA 10.5mm design: (11-04-99 – 08-01-2000)

Early in 1996 Apogee introduced their 10.5mm BP high performance contest certified motors. With these 10.5 mm motors certified ECRM-27 and NARAM-42 out west in Canon City, Colorado would again test the bounds of 4xA cluster altitude competition. The A2 10.5mm mini diameter motors opened an entire new level of competition design concepts which immediately went into high gear. 10.5mm motors are housed in T4 (.448") diameter body tubes allowed for some very sleek and slippery streamlined designs. During early 1999 and 2000 creations for ECRM-27 & NARAM-42 design phase had many cluster altitude modelers, attempting uncounted cluster configurations before zeroing in on our best guess at the highest performing design(s).

Concentrating hard on keeping model mass and frontal area to a minimum, conventional "stock" building materials were chosen over other more exotic materials such as Fiberglass & Carbon fiber. Over the last decade or so conventional, easy to obtain model rocket materials had performed well for cluster altitude events. Preparing for one of NARHAMS Pre-ECRM-27 design discussion meetings, the hope was to give the members easy to obtain building materials for this 4xA event along with a fairly simple to follow building plan. At the time, Grumpy Old Men partner Paul Miller and I were flying as a team so our discussion would also be pointed to individual a, b & c division building efforts.

It was also around this time in 1999 we were testing a lot of A2 high performance motors from Apogee components for the purpose of reducing the frontal area and overall mass of 4xA Cluster Altitude models for ECRM-27 and upcoming NARAM-42. Working from the last successful 4xA Cluster Altitude design the 10.5mm model seems very aerodynamically slippery indeed. At ECRM-27 the 10.5mm "Blue Streak" set a new NAR Team division National Altitude record at 371m (1,217ft) as well as taking 1st place in the Division. Knowing that the Colorado launch site would be at a much higher ASL elevation I was sure our design was going to be very competitive. Middletown Park, Md. elevation is only 269ft ASL, where Canon City, Colorado elevation is 4,724ft ASL. Competitors at NARAM-42 could pretty much bank on having considerably lower humidity in the high dry air in which to fly.

After ECRM-27 one of NARHAMS extended NJ family members Steve Humphrey decided to go with a more exotic model body of fiberglass lay-up with a short aft transition to an open motor shell designed that just fit 4 squeezed together 10.5mm motors. To this day I'm not quite sure how Steve lariat loop retained the motors but they did in fact stay with the model posting an outstanding 480m (1574ft) flight taking 1st place in C div at NARAM-42. Unfortunately; Paul & I did not attend NARAM-42 but we did do a side by side comparison of the two designs frontal area and optimum mass just for fun. Below you compare the designs and examine the interesting findings.



Frontal Area comparison of two 10.5mm (.448") Airframe layouts.

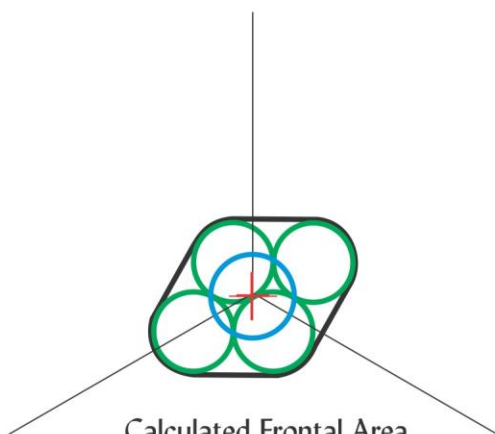
Current NAR National 4xA Cluster Altitude Records as of 01-18-05:

A div: = 420m (1,378 ft) 12/15/01 by Ariana Williams

B div: = 257m (843 ft) 08-01-00 by Tracy Wuebkenburg

C div: = 480m (1,574 ft) 08-01-00 by Steve Humphrey

T div: = 505m (1,656 ft) 12-15-00 by Paranoid Androids



Calculated Frontal Area
approx. 1.6231 Sq-In.

Flown with 4 Apogee A2-7 10.5mm motors
Initial Mass 6.95g each = 27.8g 4 lot total
Casing Mass 3.95g ea = 15.8g 4 lot total

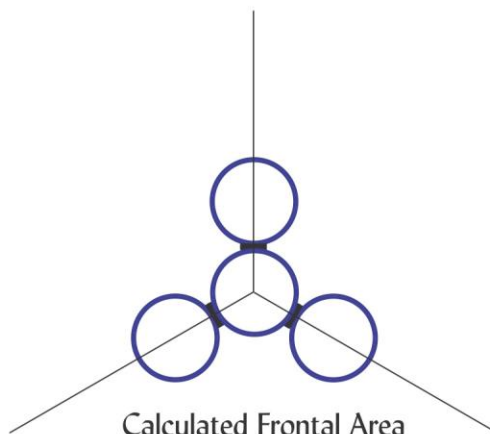
Estimated mass:

Ewt w/ 2" x 20" streamer: 15.34g
LOWt: w/ 4 - A2-7 motors: 42.64g
Coasting Wt: 30.64g

Environment:

Tracked Altitude at NARAM-47_ 08-01-00
480m (1,574ft)

Location: Canon City, Co
Elevation ASL: 4724 feet
Approx. Barometric pressure: 11.89 lbf/sq-in
Air Temp: ?
Winds: ?



Calculated Frontal Area
.448x .448x .7854
x 4 = .6305 sq in.

Flown on 3 Apogee A2-0 & 1 - A2-5 10.5mm motors
Initial Mass 5.65gx3 + 6.95g = 23.9g 4lot total
Casing Mass: 2.65g x3 + 3.95g = 11.9g 4 lot total

Mass:

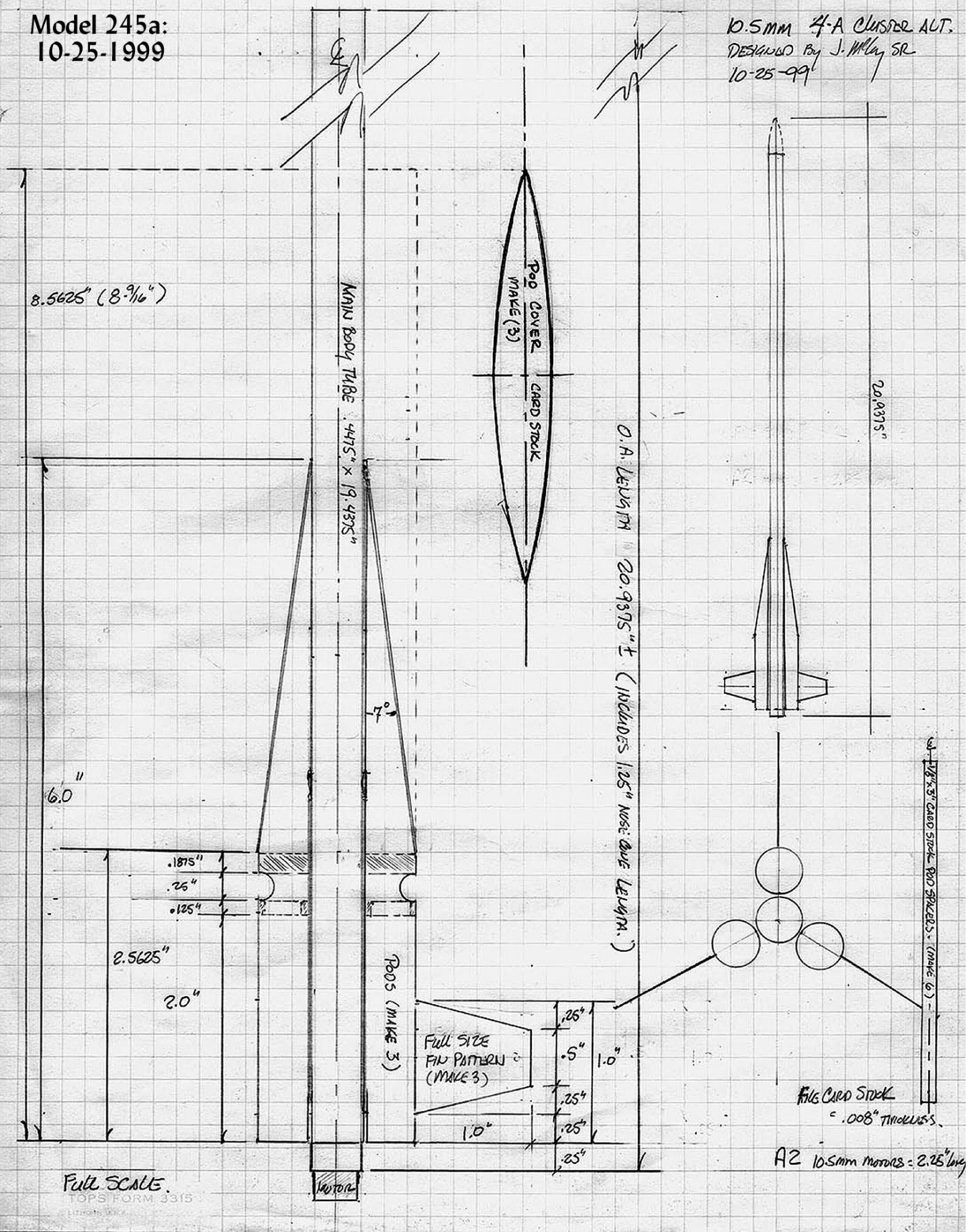
Ewt: w/ 3" x 30" streamer: 24.8g
LOWt: w/ A2-5 & 3- A2-0: 48.7g
Coasting Wt: 36.7g

Environment:

Tracked Altitude at ECRM-27 06-10-2000
371m (1,217ft)

Location: Middletown, Md
Elevation ASL: 269 ft
Approx. Barometric pressure: 14.26lbf/sq-in. (30.08"ris)
Air Temp: 70.0 degrees F
Winds: 8-12mph gusts to 20 S - S.W.

10.5mm 4-A Cluster ALT.
DESIGNED By J. Miley SR
10-25-99



Another 4xA Cluster Altitude Combination: 18mm core with 13mm pods: (01-05-2005 – 06-2005)

Another 5 years pasted before 4xA cluster altitude would be back on ECRM-32 and NARAM-47 event lists slated for April and July of 2005. Unfortunately during those intervening years a couple motor limiting events occurred. First in 2001, Apogee discontinued production of their 10.5 A2 high performance motors. Then around the same time Estes stopped production of the A10-0 booster motors due to a huge backlog of inventoried motors. Because these booster motors were out of active production for more than three years, the NAR dropped them from the certified contest motors list. This mistake by the NAR really hurt Cluster Altitude potential as we were left with only Estes A10-PT Heavy plugged booster motor.

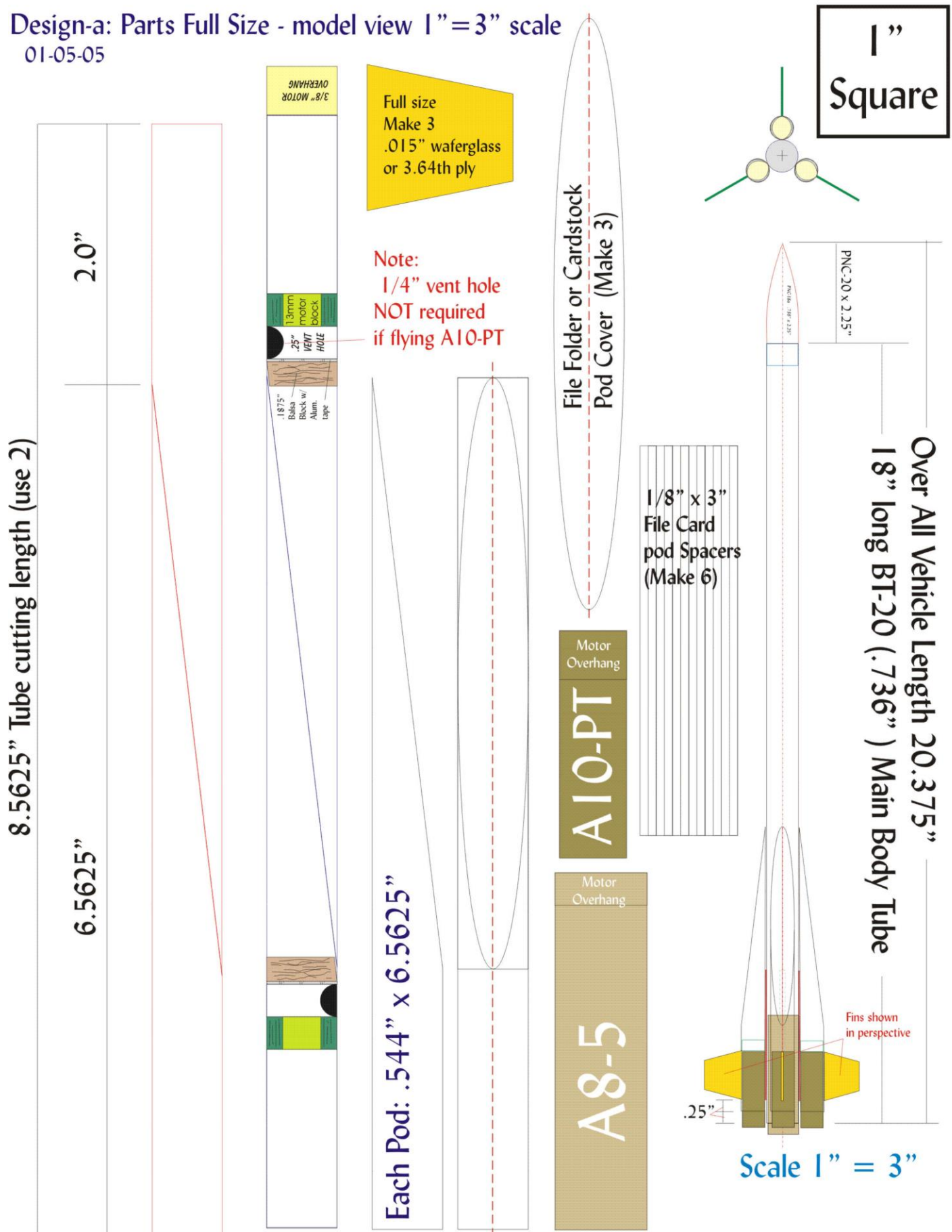
While our choice of core motors in 13mm were still limited to Estes A3-4T or A10-3T mini brutes. There was always Estes 18mm A8-5 or Quest Aerospace 18mm A6-4 which actually has a higher initial thrust then the A8 motor. Being forced to go with either 4 motors with ejection charges or choosing the HEAVY A10-PT adding .6g per motor too the liftoff mass and .3g pre motor during coasting phase left much to be desired.

All these altitude limiting concerns only made the new design phase a bit more nerve wracking. After doing a bunch of early altitude calculations it seems obvious the best chance for decent altitude would be a combination 18mm core vehicle with 3- 13mm 7degree taper pods. Designing with standard BT-20 tubing for the model core and BT-5 for the 3 Pods the calculated frontal area worked out to 1.13 sq-in. An Apogee black styrene competition nose cone was chosen which would be highly polished without paint. The pod covers are CA soaked file folder. While the pods themselves would be spaced off the last couple inches of the main on two stacked paper 1/8" wide spacers to allow full diameter external taping of the booster and core motors. Fins are .015" Waferglass with light epoxy fillets. Shock-cord is a combination of 36" 70lb Kevlar knotted to a 24" piece of 1/8" oval elastic. Intended as a streamer recovery model, a 4" x 40" 1mil Mylar accordion folded streamer was prepared. I decided this one would be primed and paint while trying to keep the additional mass down to a minimum. After filling all pod to main joints with Micro Balloon filled epoxy all joints were smoothed and rounded down to 400 grit sandpaper. A single coat of grey auto primer was applied, allowed to dry then sanded almost completely off, leaving only a very small amount in areas that needed a bit of filling. After about a week dry time, two coats of Krylon (Old Formula) 1501 gloss white was applied. Giving the model another week to cure, the entire white surface was first 1000 grit wet sanded then Finessit-II worked until the entire surface was as blemish free as practical. Thinking back on this process I recall spending several hours longer polishing the surfaces then it took to build the entire model. Once satisfied with the surface finish a couple simple decals & NAR numbers were applied. Than the entire vehicle was Nu-Finish polymer applied and buffed to a very high Gloss. A really good looking rocket if I do say so. That and a couple Weird options would be presented to the NARHAM membership in our usual Pre-ECRM event discussion meeting. We'll look a bit more at that option shortly.



4xA cluster Altitude: 1 3mm Pods - 1 8mm core

Design-a: Parts Full Size - model view 1"=3" scale
01-05-05



Aerodynamic factors effecting cluster altitude design

Feb. 2, 2005

Aerodynamic Drag Forms:

Induced Drag: a by-product of Lift. Vortices and Angle of attack

Parasite Drag: Friction with surfaces, appendages and structures.
(Three types)

* Form Drag: Form and effective frontal surface area.
(Reducing frontal area.)

* Friction Drag: Friction between the skin of the object
and the air flow.
(Mirror smooth finish and Wax.)]

* Interference Drag: Surfaces at angles to each other
create turbulence at joints. Most
frequently at intersections with appendage
intersections with the main body.
(Reduce by smoothing and rounding.)

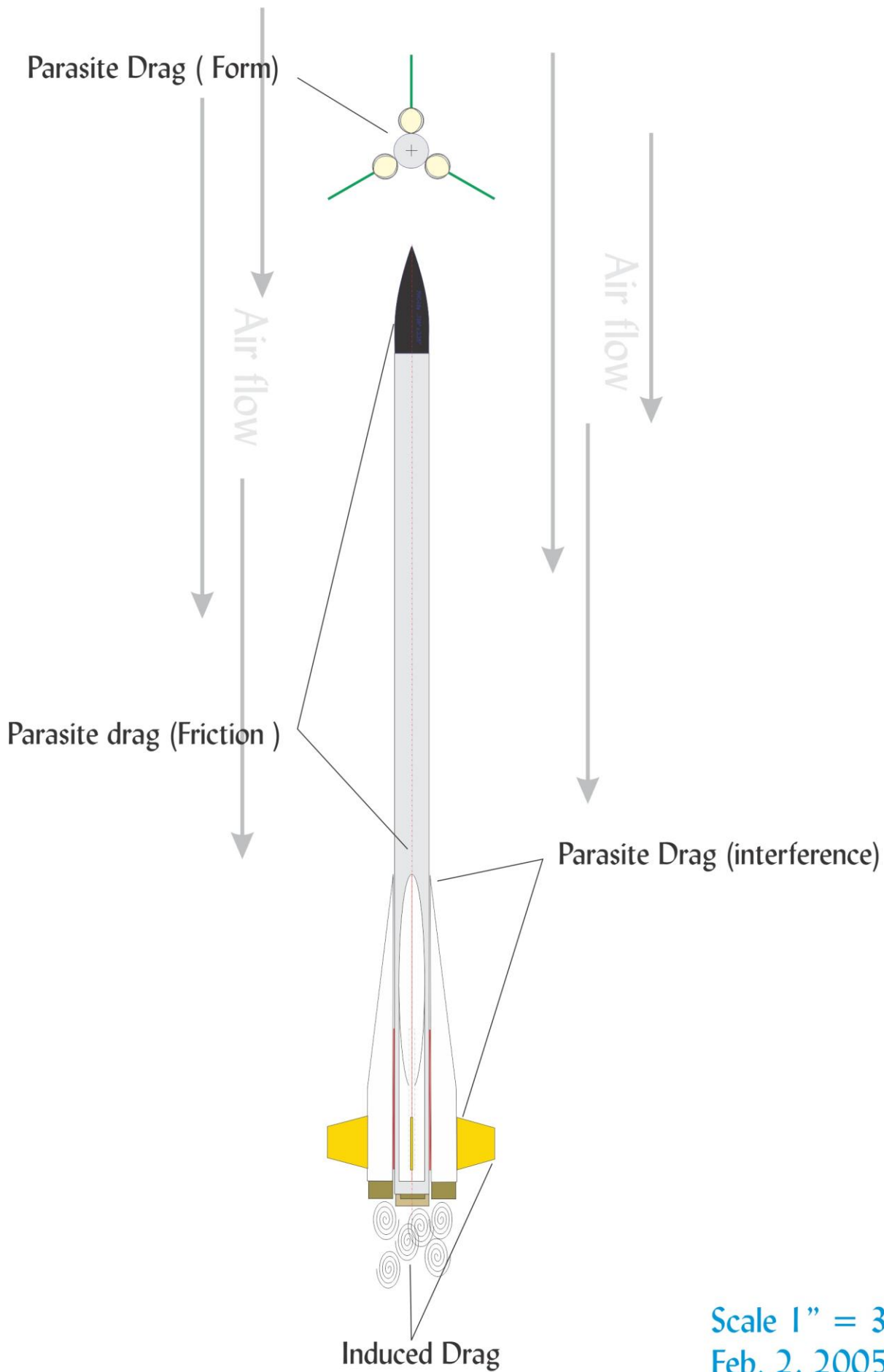
Environment:

* Elevation at launch site: As ASL elevation increase,
air density, humidity and other
factors change.

* Air Density: Atmosphere = 76cm (760mm) Mercury
or 29.921 inches of Mercury or 14.696 lbf/sq-in.
(1atm)@15degC (59degF)ASL - Change -3.6degF/1000ft.

* Gravity: Acceleration of Gravity = 32.17ft/sec/sec
(directly effecting deceleration during coast)

* Winds: Surface and aloft winds will effect both
launch angle and disturbance in flight.



The 4xA Cluster Altitude 18-13mm Option: *Odd looking stacked in-line 4 motor design – (08-2004 - 02-2005)*

If you'll recall our 2x1/8A Cluster Alt builds we discussed a stacked in-line 2 motor option. Apparently another well known micro and all around decent NAR model designer Jeff Vincent expanded on that micro rocket option to build a 4xA in-line stacked cluster altitude model which he tested in August of 2004.

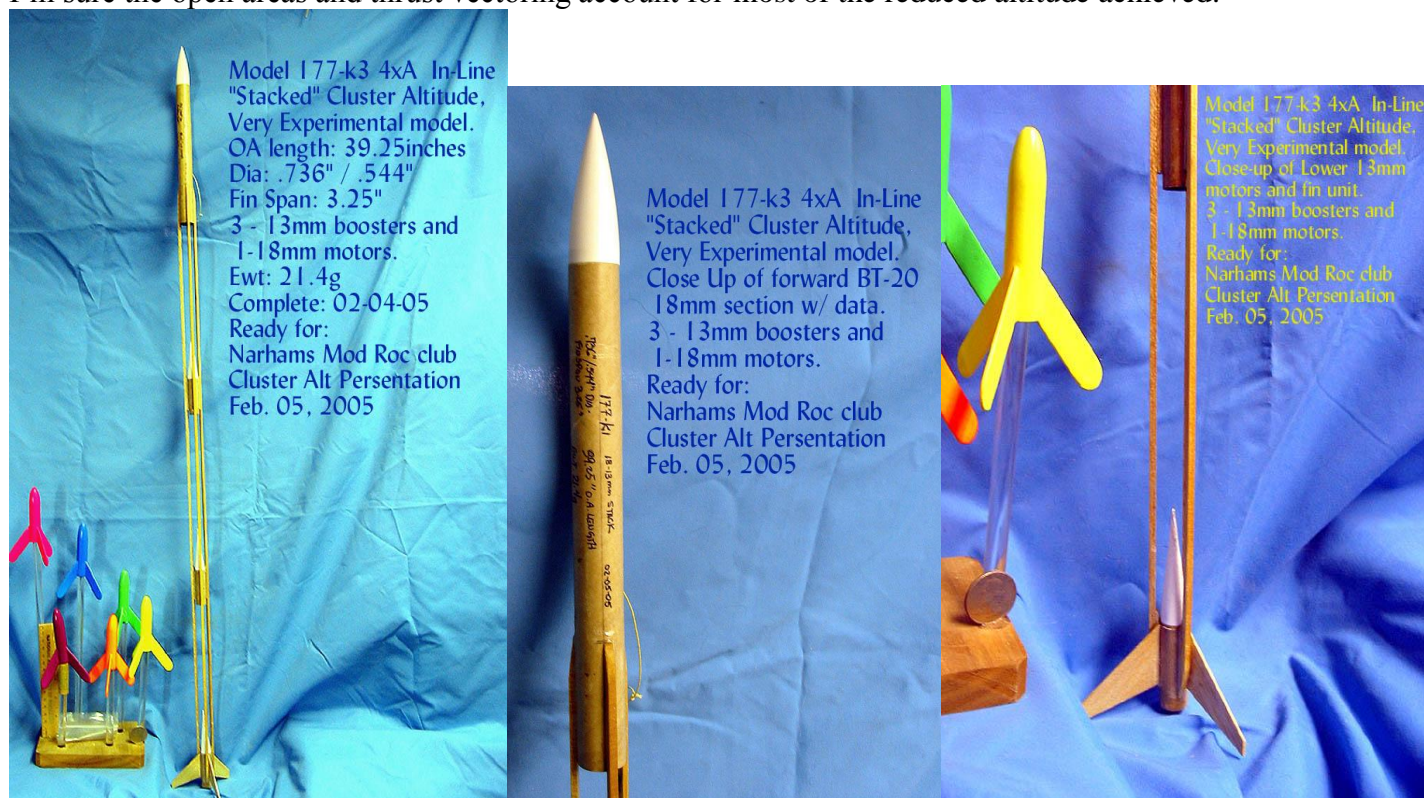
Around the same time in preparation for our Feb 2005 NARHAMS pre-ECRM build discussion meeting I also put together a 4 motor in-line stacked contraption based on the earlier micro stacked rocket. Jeff's and my designs are somewhat similar though I didn't learn of Jeff's design until some time later. This does show that thinking outside the box does often lead to nearly simultaneous invention of some rather strange flying machines.

Using an 18mm forward pod to contain the recovery system, nosecone and A8-5 motor the lower 13mm short pods we stacked leaving as much room between as practical without turning the model into a super-roc. Tying all 4 motor pods together were 3- 1/8" square Spruce dowels with basswood spacers as needed to keep everything aligned. For this model 3- 3/32" Basswood fins were chosen. Over all the thing ends up being 39- 1/4" long.

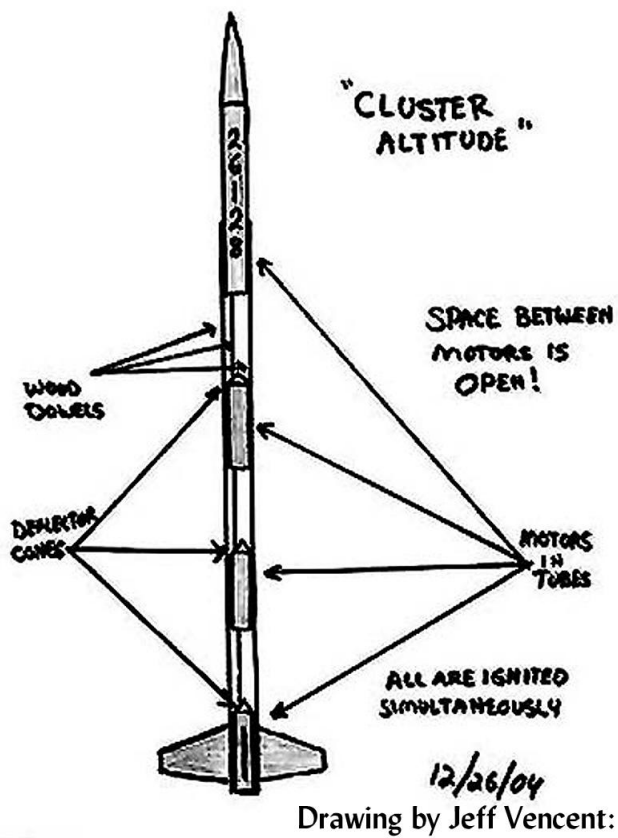
There are two main draw backs to the In-line stacked configuration, needing two somewhat specific accessory elements. First the 3 lower motor housing will need some form of nose cone with ablative or protective material covering the forward section of each lower booster to prevent the lower motors from being back burned by the exhaust of the motor ahead of it. In my design I used sharply turned long Basswood nosecones with .001" Kapton covers rolled to snugly fit in an attempt help protect the wood cones and motors below.

Second these very long models also require a special set of extended micro clips with ohm matched lengths to eliminate any slight hesitation in amp delivery to the ignitions for this weird set-up. Another consideration is to have an add-on fall away tether rod to pull the clips away from the model as it begins to rise.

In flight testing I was surprised this configuration 177k3, didn't get higher altitudes then the standard side pod cluster as the unfinished model is considerably lighter then 18-13mm design 177i described earlier. I'm sure the open areas and thrust vectoring account for most of the reduced altitude achieved.



Now that Estes has returned the A10-0 to contest certified production, it may be worth another look as these strange looking cluster altitude models.



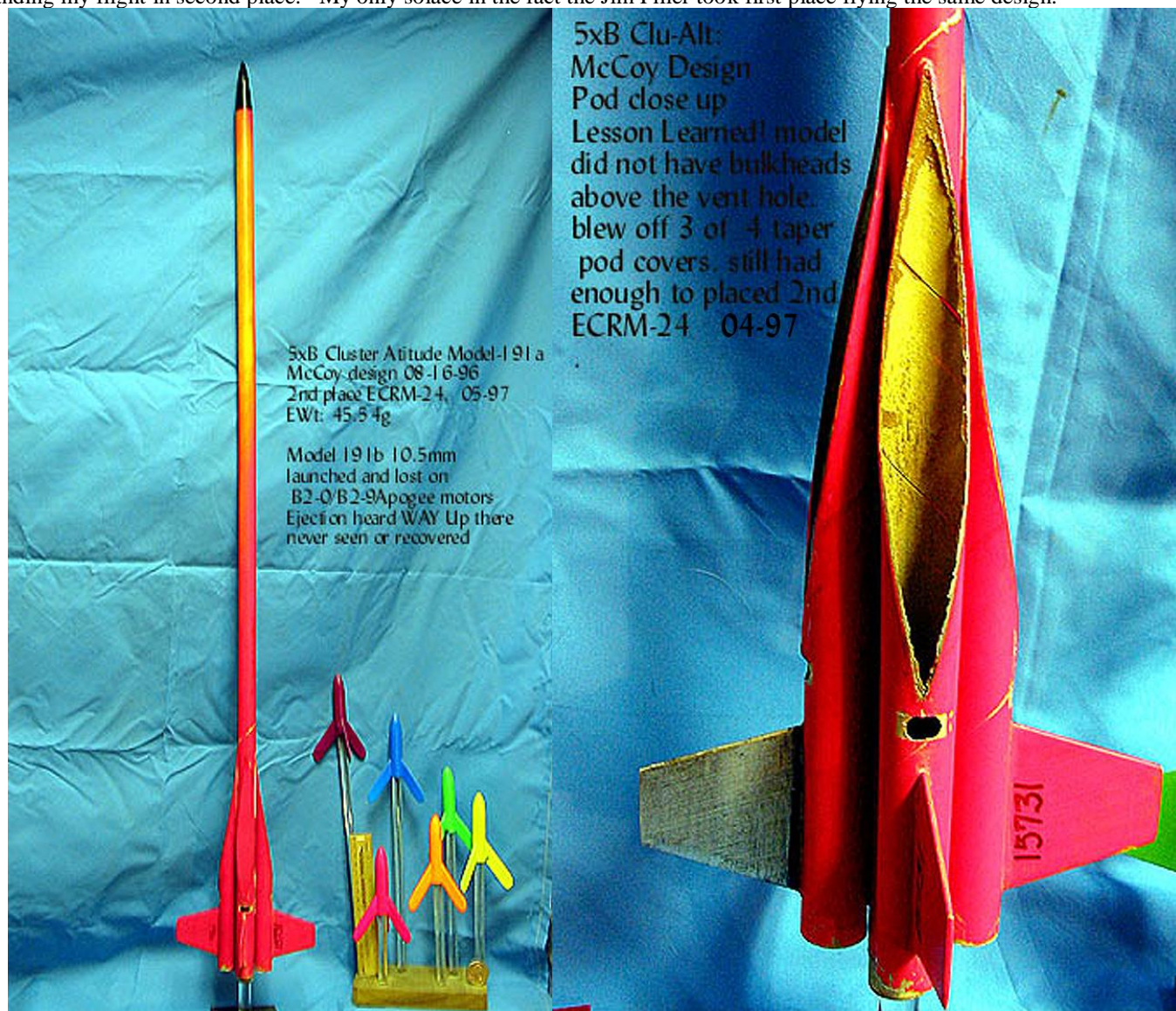
A couple looks at NARHAMS Cluster Altitude presentation 02-05-2005 preparing for ECRM-32 04-16/17-05 and NARAM-47 07-29-2005.

5xB Cluster Altitude: 18mm long vehicles. (08-16-1996 – 04-1997)

Now this even gets really interesting. Five B Cluster Altitude events require a good bit more length to offset the mass in the aft end. As it turns out an 18mm BT-20 x 36" long worked out just about right. Having 36" long "stock" tubes has been a blessing ever since a few of us in the club went in on a truck load of all Estes size .013" wall craft tubes from BT-5 through BT-101, all one piece 36" long. To this day I'm still using the tubes purchased in the early 1990's at fantastically low prices.

To cover 5xB Cluster Altitude flown at ECRM-24 April 1997, we will have to regress just a bit. After NARAM-35, NARHAMS decided during our yearly planning sessions for the next few years to work our way through all 5-6 motor class events progressing one motor class a year at our ECRM contests with or without a matching Cluster-Altitude event at the Nationals.

Building on what had been learned with last years 4xA rockets. A few sketches were prepared and shared with the membership for comment. Our basic model would be a long core BT-20 with 4 Short motor pods with parabolic balsa nosecone, 5-double taper Balsa fins, having the usual internal parts made up of the usually Kevlar/Elastic/Mylar Streamer recovery system. While this particular set up would certainly get each builder a qualified flight, it would not likely earn a spot on the podium. Back to the drawing board: Below are the drawings which are more or less a take off on the previous years 7deg. tapered pod model. Increasing the body tube to BT-20 and increasing the length of both core and the tapered pod tubes. Our streamlined model has an Apogee components black plastic high polished nosecone. Still learning, the first prototype model #191a did not have solid Bulkheads above the 1/4" exhaust ports. During test flying the CA hardened file card pod covers held up fine during booster motor burn through. However: when finished and flown at ECRM-24 I blew off 3 of the 4 covers at burn thru which I'm sure cost several hundred feet landing my flight in second place. My only solace in the fact the Jim Filler took first place flying the same design.

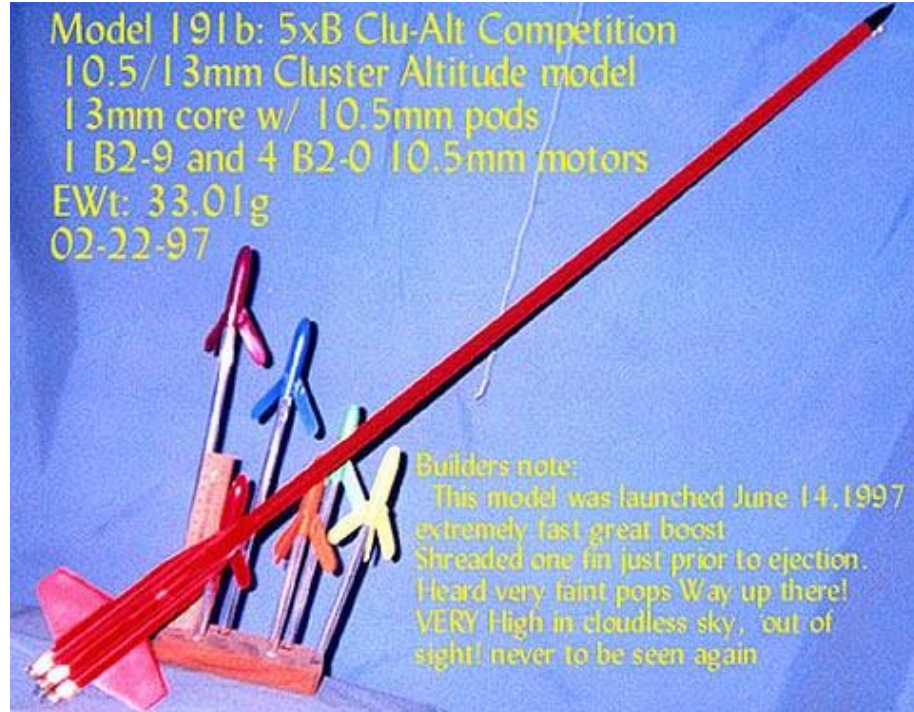


5xB Cluster Altitude 10.5mm: 5- B2 BP T4 Airframe Model – (09-1996 – 06-14-1997)

While working on the standard design for the club using BT-20 size body. I decided to create a 10.5mm (.448") OD design set-up to use Apogee B2 high performance BP motors.

Building and finishing this sleek little T4 body rocket as smooth and sleek as I could I decided to fly it at ECRM-24 as a sport flight using a core B2-7 and 4 B2-0 motors. Setting up this model for the "Demonstration Flight" most of us expected the model to get a couple thousand feet but I had no idea just how high it would actually fly.

At ignition, the B2 powered rocket teleported out of sight in an instant still under thrust. The tracking teams reported "Track Lost" saying they never saw anything but did hear a faint pop very high in the sky. No sign of the 4" x 40" Mylar streamer. The model simply disappeared never to be seen again. It was a fantastic flight that I will be happy to do again. I still have a stash of the sweet little 10.5 mm B2 motors.



Design & Drawing by:
John E. McCoy Sr.
Nar-15731 - date: 08-16-1996

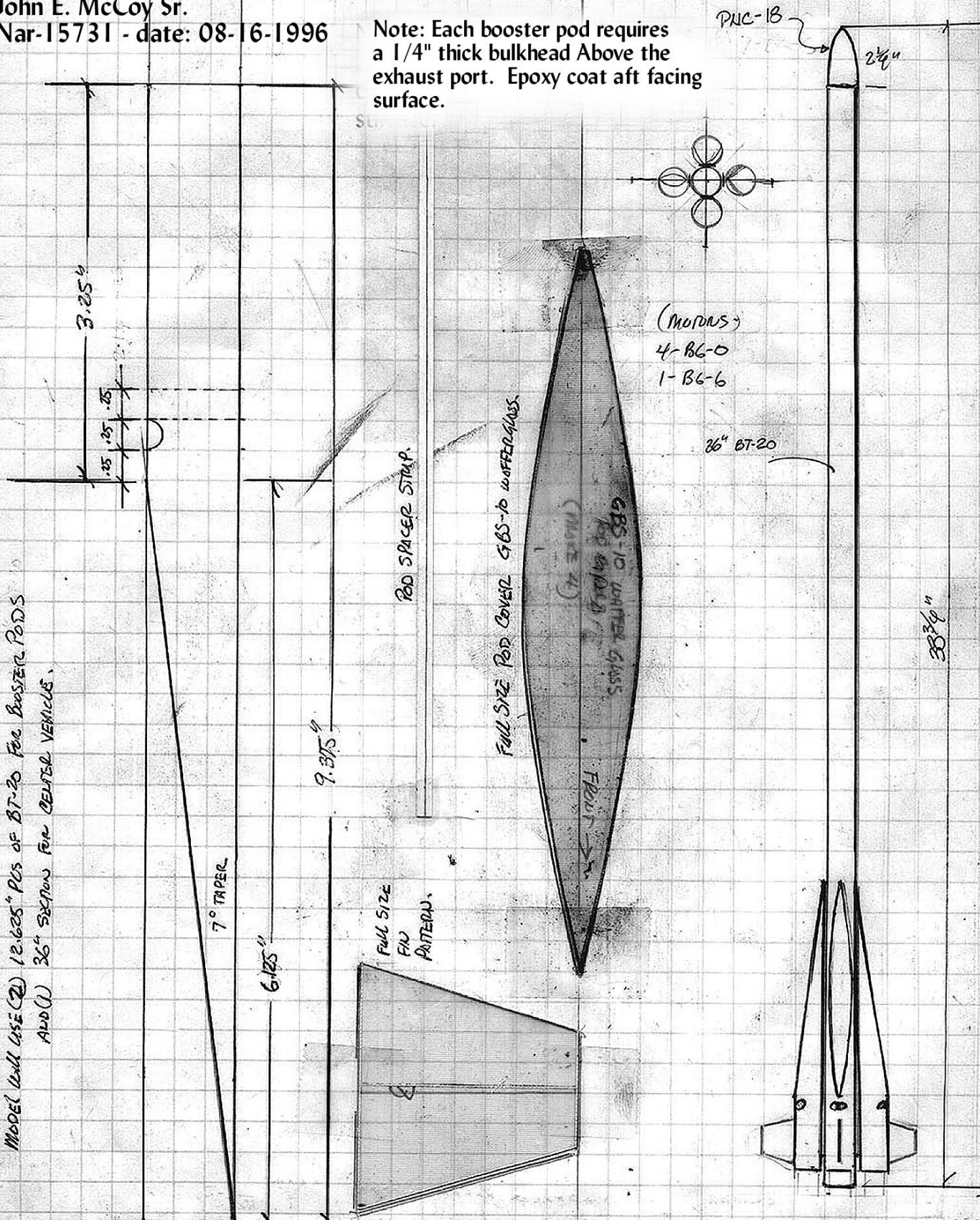
DESIGN I.
ECRM-24 5-B CLUSTER ALTITUDE
COMPETITION MODEL.

#191a Dwg 1-of-3

PNC-18

Note: Each booster pod requires
a 1/4" thick bulkhead Above the
exhaust port. Epoxy coat aft facing
surface.

MODEL WILL USE (2) 12.625" PODS OF BT-20 FOR BOOSTER PODS
AND (1) 36" SECTION FOR CENTER VEHICLE.



Design & Drawing by; John E. McCoy Sr.
Nar-15731 - date: 11-29-1996

5-B Cluster Altitude/Duration

Model

Proposed for ECRM-24 - 04-1997 **2nd Place**

General Notes:

1. This model is based on 18mm (BT-20) body tubing. 36" main, & 9.375" Boosters.

2. Nose cone may be either Estes BNC-20AM or Apogee 2.25" PNC-18.

3. Booster tube closures can be .05 waferglass, 1/64" plywood, 1/32" Basswood, or File Folder cardstock. CA and epoxy in place. File and sand smooth.

4. 3/16" X 6" cardstock shims are attached to the pods first, than to the main body. *Shim should be applied 1/2" from the rear of the tube.*

5. Booster pods should be positioned 1/4" from the rear of the main body tube.

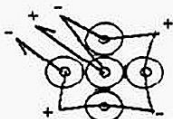
6. Fins can be 1/16" Basswood or .15 Waferglass....Remember this is a high thrust model... **EPOXY ALL FIN/TUBE JOINTS.**

7. *I intend to recover my model on a 4" x 60" mylar streamer. A small chute could also be used, either way we're in for a hike to recover these puppies.*

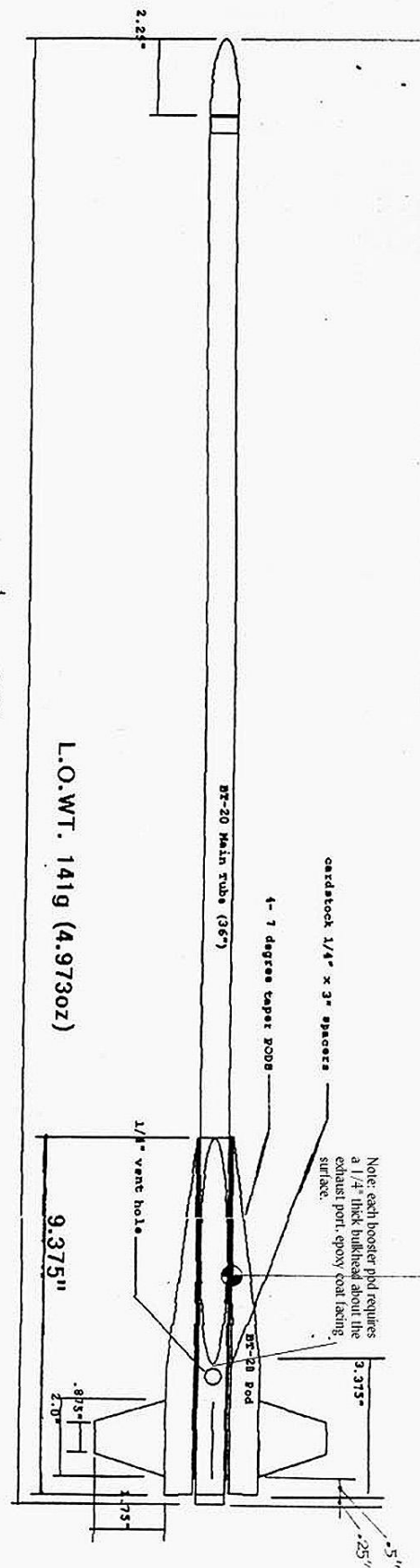
8. The 1/4" exhaust holes are covered before flight with a small piece of magic transparent tape, stick it to your finger a little to remove some of the tack.

9. Shock Cord is 5' of 70lb kevlar with 2' of 1/8" elastic. tie the kevlar to a EB-20 or 1/4" piece of "Thinned" spent motor casing. inset in the center tube as a motor block, about 2.25". The booster tubes have NO motor blocks.

10. Lightly pressure fit the core motor first, than wrap the tube/motor joint with 1/4" masking tape, repeat the same process with the other 4 booster motors, this process should eliminate being DQ'ed for motor casing ejections. *Recommended motors: B6-6 center, 4-B6-0 boosters*



5-B cluster wiring diagram.



5-B Cluster Altitude competition model
design and drawing by John E. McCoy Sr.
11/29/96 for ECRM-24 April 12-13, 1997

Proposed for ECRM-24 - 04-1997

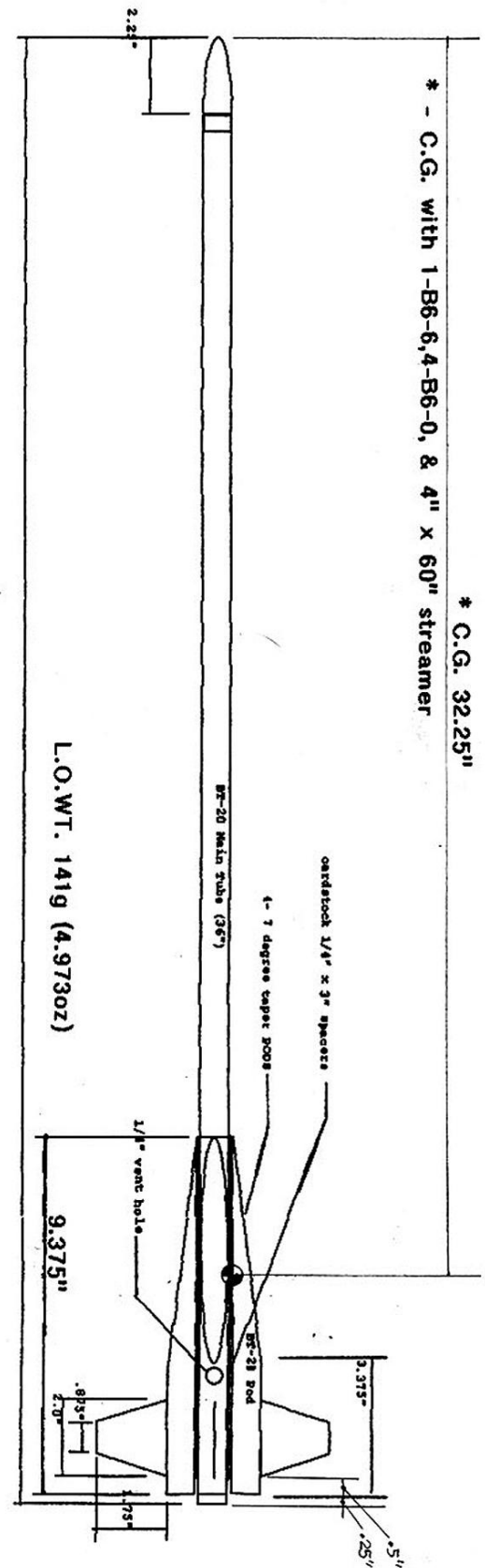
5-B Cluster Full Size Patterns

11/29/96 John McCoy 15731

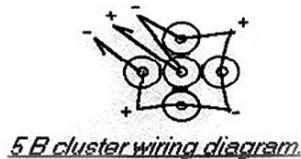
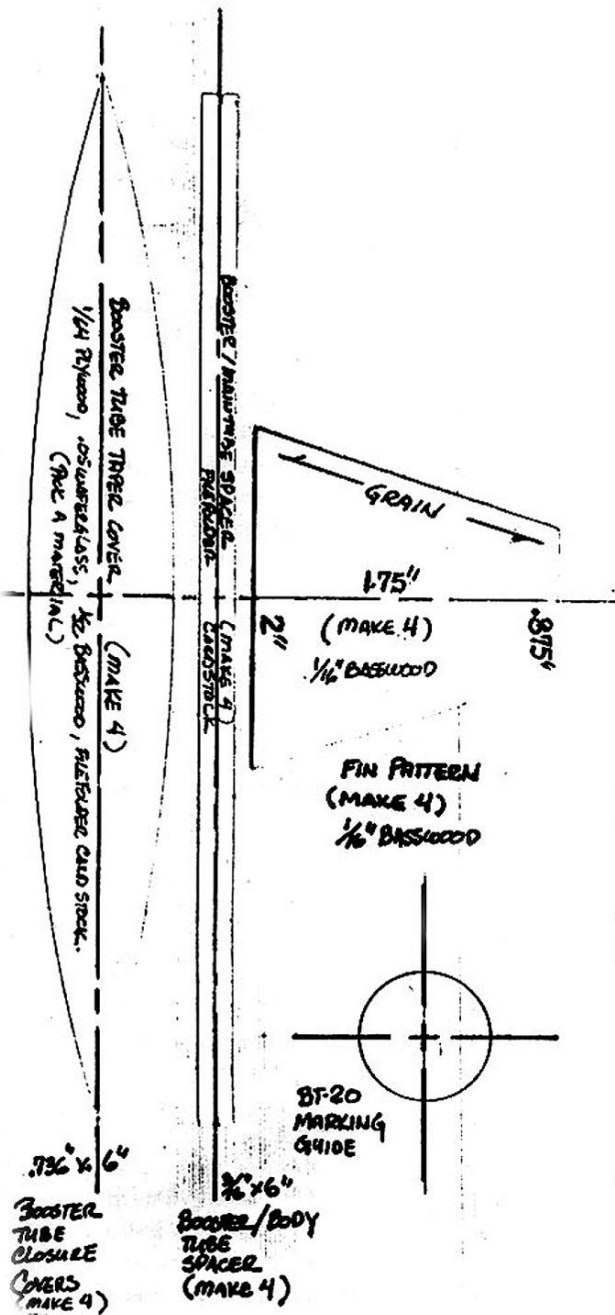
Dwg 3-of-3

* - C.G. with 1-B6-6,4-B6-0, & 4" x 60" streamer

* C.G. 32.25"



design and drawing by John B. McCoy Sr.



5 B cluster wiring diagram

6xC Cluster-Altitude: Very High Performance flying: (02-1997 – 05-17-1998)

Last up on NARHAMS Cluster Altitude ECRM events roster was 6xC, slated for ECRM-25, May 17, 1998. I do not recall how we got out of sequence with the Cluster-Altitude events at NARAM but according to the records somehow we did.

NARAM-39 held in August of 1997 out west in Tucson, AZ. (Elevation 2,346ft) with 6xC Clu-Alt as one of the events.

Earlier in 1997 Tim Van Milligan created an Apogee components paper "6 Cluster motor model general construction notes." published on their web page with an interesting set of short cardstock pod shroud patterns. Unfortunately this very nicely done write-up was completely missed until doing research for our NARHAMS ECRM model design around June of 1997. While working on model 607a 6xC design prototype, the decision was made to give Mr. Van Milligan's design a try along with the fresh off the drawing board 6xC Cluster ECRM-25 design. Building both models with an eye on the club meeting cluster altitude discussion coming up in April of 1998 made perfect sense. Having two different designs to actually test fly should make for some interesting data points. I did get both models built and flown in July of 1997, recovering both but having to rebuild the aft section of the Van Milligan model which crumpled badly on landing causing the entire aft motor pod section to need replacement. Neither flight was tracked beyond the many sport launch spectators watching. The general consensus gathered after the test flights by those watching was unanimous, giving #607a "much higher flight" over Tim's suggested design. After crude repairs to the Van Milligan model for use at the upcoming club discussion, that rocket has not flown again.

Showing up shortly after our April club presentation Dan Wolf had an article published in the May/June 1997 Sport Rocketry giving plans for two contest qualifier type 6xC cluster altitude models. The first design was a BT-20 core with 5- BT-20 short pods with balsa nose cones and 5- 1/8" balsa pod mounted fins. The second design centered on a BT-60 core with Big Bertha plastic nose cone with 3- internal BT-20 motor mount tubes and 3- BT-20 external booster pods with balsa nose cones, spaced between 3 large 1/8" balsa fins. While both designs are interesting the larger frontal area and use of standard Balsa full nose cones on the pods seemed to suggest these would be pretty drag prone rockets. It is my understanding ECRM-25 had at least one or two of each design flown by contest competitors. However I do not recall these designs performance.

Somewhere along the line, the fact that 6xC had already been flown at the Nationals August of 1997, came to light. Searching for info we found C division, 1st place winner was Wally Etzel. He posted a winning flight topping out at 716m (2,349ft) on 08-1997. Still later in Sport Rocketry Jan/Feb issue 1998 published his 6xC 2- page plan. Wally's design is a very interesting but far more complex design than 607a. After much concentrated pondering, a model built from these plans was not included in the club presentation beyond referencing the Sport Rocketry article and NARAM-39 6xC Cluster Altitude results. It was also noted that the Tucson, AZ launch site elevation, 2,346ft ASL was certain to have played a role in the extraordinary altitude achieved. During the club discussion centered on Launch Site ASL level effect on model rocket achieved altitude, many long time NARAM competition flying members adding that "Out west" flights always seemed to fly higher. For some reason Wally's 716m flight was retired from the record books with no explanation.

ECRM-25; 05-17-1998, Model 607a, designed as an all 18mm model, flying on 1-C6-7 & 5-C6-0 motors set a new National record from our East Coast Middletown, Md. Launch site elevation 269ft ASL with a closed track of 666m (2,185ft) ASL. This record was also retired in 2000 again with no explanation? A look at NAR National records as of 2016 lists the current 6xC Cluster Altitude records still show; Mike Fillers A-div. record @ 657m, At ECRM-25 06-16-98 using the same design as my C Div. 666m flight flown on the same day. While C-div. Cluster altitude is shown as 513m flown on 04-17-11. There are no current records for either B or Team divisions. Go figure.

After flying all 6 of these Cluster-Altitude events there are a few conclusions I'd like to pass on to the next generation of Cluster flyers.

As stated at the beginning of this article the two most important elements in gaining the very most out of our clustered BP motors require:

- 1) Reduce overall Frontal Area as much as possible. In that respect it is my opinion Wally Etzel was on the right track, imbedding some of the booster tubes in the main could work if the overall frontal area were reduced to say BT-20 rather than BT-50.
- 2) Find by calculation and/or flight testing the Optimum Mass for the particular Rocket & Motor combination.

Followed by several other things the Cluster Altitude Builder should look for:

- * Purchase and Weigh several packs of motors to be used, picking the heaviest individual motors of each cluster group
- * Continuity Test All Igniter/Starters to be used, Before, During and AFTER installation in the motors to ensure all motors have a Good igniter.
- * Limit the use of "Clip Whips" to those that are no more than 16ga stranded copper and no longer than 22".
- * Clip whips should be Mechanically Fastened directly to both +/- sides of our RELAY not added to an existing control wire circuit.
- * If at all possible Always Fly Clustered models using a Relay Launch System with a HD 12V battery at the launcher.
- * Cluster-Altitude rockets should be Tower Launched, or Rail launched with minimal size rail buttons or fly away shoes.

On the next several pages are presented as many of the drawings, instructions and photos of as many of the above described 6xC designs as could be gathered. From these pages and the previous impulse events models shown: I am certain those interested in flying any of the 6 impulse classes of Cluster-Altitude competition should have a pretty good starting point on which to build.

We have covered a lot of ground in over a decades worth of flying different cluster impulse events. Keep in mind that some of the motor choices will or have changed as time goes on. Select the "Best Matched" sets of motors for your Cluster Flying. I have to say as a former competition flyer; Cluster Altitude has always been in the top 4 of my favorite contest events: Sport Scale, PMC, Cluster-Alt. & HD. Hope readers have as much fun with this or those events in the future as I've enjoyed over the years.

by John E. McCoy Sr. Nar-15731 setp. 29, 1997

1. This model is based on 18mm (BT-20) body tubing.
36" main, & 9.00" Boosters.

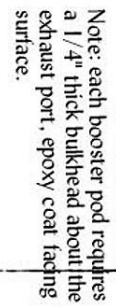
3. Booster tube closures can be .05 waferglass, 1/64" plywood, 1/32" Basswood, or File Folder cardstock. CA and epoxy in place. File and sand smooth. I strongly recommend the file cardstock closures.

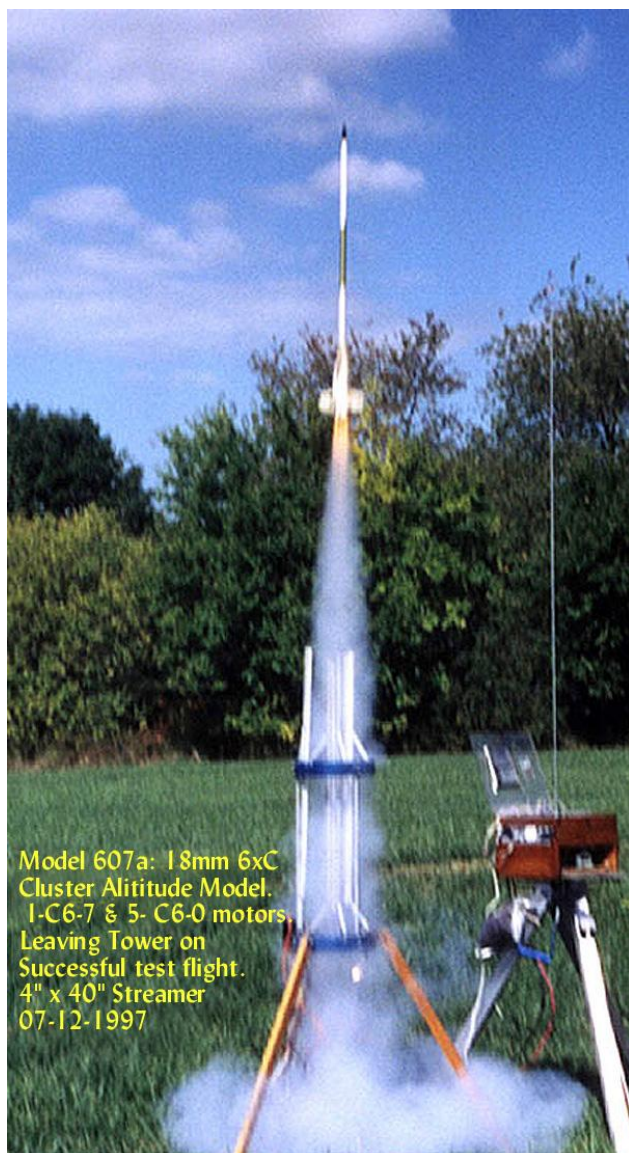
5. Booster pods should be positioned 1/4" from the rear of the main body tube.

7. I intend to recover my model on a 4" x 60" mylar streamer. A small chute could also be used, either way we're in for a hike to recover these puppies.

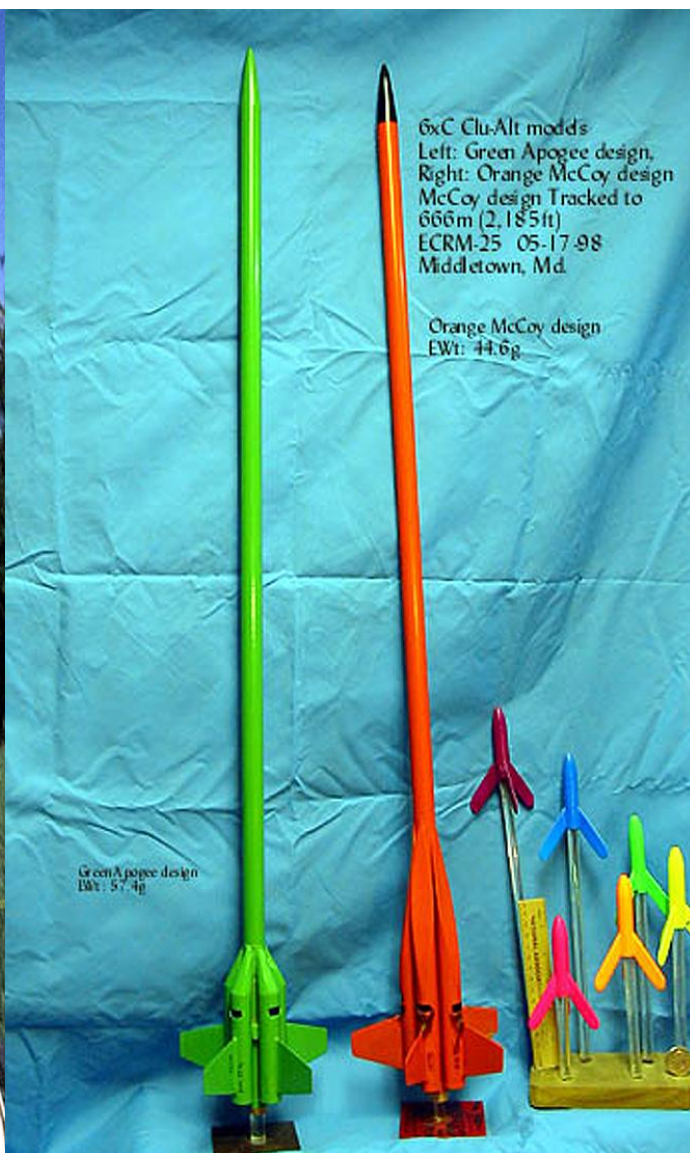
9. Shock Cord is 5' of 70lb kevlar with 2' of 1/8" elastic. tie the kevlar to a EB-20 or 1/4" piece of "Thinned" spent motor casing. inset in the center tube as a motor block, about 2.25". The booster tubes have NO motor blocks.

Recommended motors: C6-7 center, 5-C6-0 boosters





Model 607a: 18mm 6xC
Cluster Altitude Model.
1-C6-7 & 5- C6-0 motors
Leaving Tower on
Successful test flight.
4" x 40" Streamer
07-12-1997



6xC Clu-Alt models
Left: Green Apogee design,
Right: Orange McCoy design
McCoy design Tracked to
666m (2,185ft)
ECRM-25 05-17-98
Middletown, Md

Orange McCoy design
EWt: 44.6g

Green Apogee design
EWt: 57.4g



Model 607a:
6xC Cluster-Alt.
Close Up of Pod
exhaust ports.
After RECORD
SETTING
666m Flight.
ECRM-25
May 17, 1998



6xC Clu-Alt:
Apogee design
Pod close up
Heavier and Less
preformance.

After aft end
replacement
following
07-12-97
1-C6-7 & 5-C6-0
flight test.

6xC Cluster-Alt Qualifier design (1 of 3)
02-1997 **6 Cluster Motor Model**
General Construction Notes

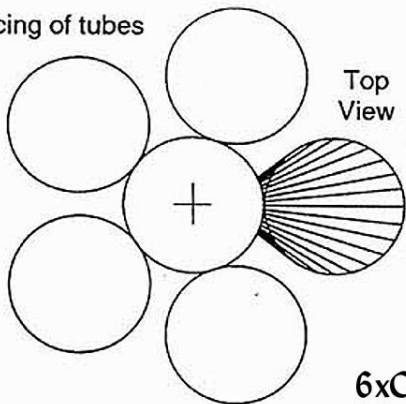
By Tim Van Milligan

The six "C" motor cluster altitude event at NARAM looks to be very interesting. Many people have been chewing over how to make the model, so I've created some neat paper shrouds that would work to minimize drag and weight. The shrouds, for the 18mm dia. side pods, blend into the core tube of the model. They are oblique cones, and the imaginary point of the cone would be inside the model. Because of this, you could use them to vent the ejection charge of the "pod" motors into the core tube of the model. The 5 piece shroud pattern set also includes a tube marking guide for the 18mm core tube. This marking guide has the vent ports cut-outs on it; if you choose to vent the ejection charge internally. The model shown on the patterns is incomplete. It doesn't say anything about the length of the model nor the external motor pods. This is left up to the modeler to design their own stable model. What I wanted to contribute was the hardest part of the model; the blended nose fairings. Making the blended fairing pods is hard. I would rank this as a skill level 4 project. But the advantages of the fairings may make it worth it. For starters, they reduce the drag of the model by keeping the frontal area low. Second, since the fairing are made out of paper, they are light weight, which should also increase the altitude of the rocket. Finally, the completed model looks really neat; you'll get lots of compliments from others about the design. Here are some suggestions that I have that may make assembly easier. The material of choice is light weight card stock; i.e., index paper. Take the patterns down to a local photocopy center and manually insert the heavier paper into the bypass to transfer the patterns. The exception is the tube marking guide. For it, use regular 20 lb bond paper. First, cut all the pod tubes to the desired length. DO NOT glue them to the core tube until you have glued to cones to the top of the individual tubes. Before you start any assembly, you should draw two lines on exact opposite sides of the pod tubes to aid in aligning the parts during assembly. I leave this up to you to do. Cut the individual patterns from the sheet using a sharp hobby knife. The first step is to carefully roll the parts into a cone shape. The lines on the patterns indicate the direction toward the imaginary point of the cone - so use them as a guide. I'd start by rolling the paper around the handle of a hobby knife. Then use a 1/8 inch diameter wood dowel to curve the "point" of the cone. Do some testing of the cone to see how the glue tab lines up with the rest of the cone. Next apply a very small amount of glue to the tab section, and glue the ends together. I'd do all the cones at the same time before gluing them to the tubes. To glue the cones to the tops of the pod tubes, you need a lip on the tube to keep the edges aligned properly. For this, I'd use a 18mm centering ring or tube coupler. If you are worried about weight, you can peel out the inner

layers of paper from the centering ring. Glue the ring into the top of the tube, but let it extend out the end by 1/32 inch (about 1 mm). Now test fit the cone on the tube. Before you glue the cone to the tube, lay the pod tube next to the core tube, and align it so that one of the pencil lines on the pod tube is against the core tube; try to be as exact as possible. To hold it in place, use tape. DO NOT glue them together. Now test fit the cone to the top of the pod tube. Reposition it as necessary so that the cone mates correctly with the core tube, and the pencil line on the tube aligns with the centerline of the cone. Make sure there are no gaps where the cone intersects the core tube. Remove the cone, apply the glue (use wood glue, not CyA), and refit the cone. At this point, you are gluing the cone to the top of the pod tube, and not to the core tube. After the glue has set, remove the tape holding the two tubes together, and set the pod tube aside until the glue has dried. Now repeat the procedure for the other tubes. If you want to have the pods vent their ejection charges into the core tube, you'll have to cut the openings into the core tube. The tube marking guide has the correct sizes for the cut-outs, but you must cut inside the perimeter by 1/32 inch so that the edges of the cone have something to glue against. NOTE: It may or may not be advantageous to have the tubes vent into the core tube; this is for you to decide! Using the tube marking guide is fairly straight forward, so I won't go into it. If you want to have the vent ports, you'll have to position the marking guide so the bottom edge is at the top edge of the pod tube location. Draw a line around the perimeter of the rocket at this point to make sure you line all the tubes up correctly when you go to glue them on. If you decide, cut out the vent ports as indicated. Gluing the pods to the rocket is a hard and tedious task. Start by placing a line of glue around the mating surface of the nose cone. To speed assembly, I put one small drop of CyA glue on the aft end of the pod tube. This will hold the pod on the centerline of the rocket while you fuss and reposition the cone to mate with the core tube. Once the glue on the cone has fully set, you can run a bead of glue along the joint between the two tubes to hold them together. Then run another thin fillet of glue around the perimeter of the nose cone where it intersects the core tube. This will fill any small gaps. Allow the glue to set before starting the next tube. After you have all the tubes in place, you can add your fins. You have two choices for locating them. You can go either between the tubes, or on the outside of the pod tubes. If you go between the tubes, it will provide additional strength. If you decide for the outside of the pod tubes, it will be more efficient, and less fin area (and weight) will be added to the rocket. But it is your design, so you can make a decision. Note: The 6-C cluster altitude event is not included as part of the \$500 Apogee Challenge contest. For a catalog of products from Apogee Components, send \$1 to:

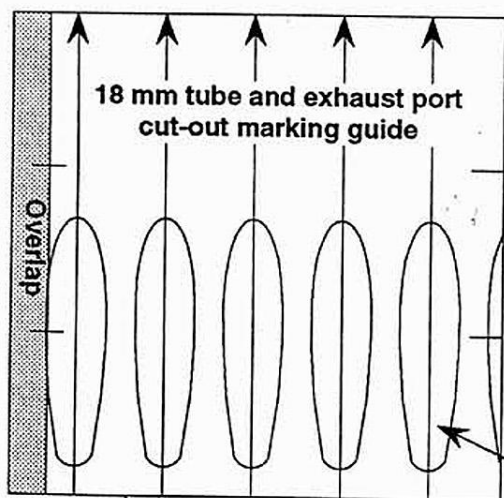
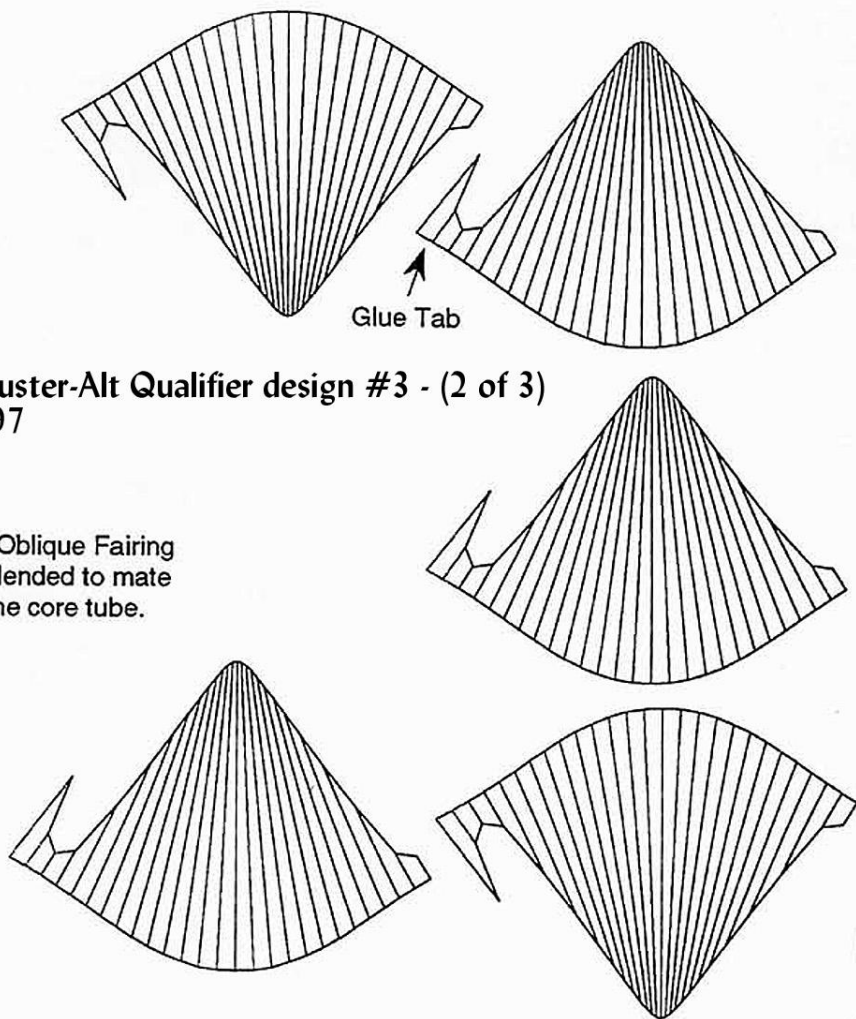
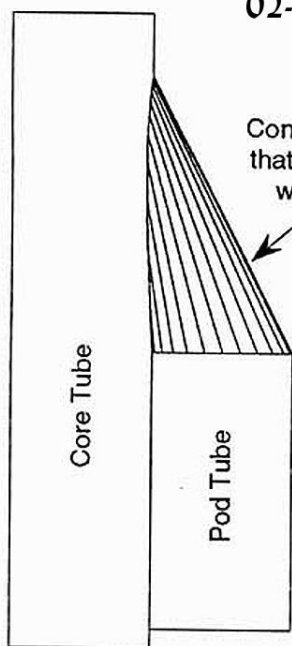
Apogee Components, Inc.
1431 Territory Trail
Colorado Springs, CO 80919-3323

72° spacing of tubes



6xC Cluster-Alt Qualifier design #3 - (2 of 3) 02-1997

Side View



Align this edge with top of pod tubes
(draw line around perimeter of tube)

Optional Vent ports --
Important: cut out
inside the perimeter of
the lines by 1/32 inch.

6 Cluster Motor Model Rocket Using a Conical Oblique Fairing that is Blended to Mate with the Core Tube.

Fairing Designed by Tim Van Milligan 2-20-97

If you enjoyed the paper fairings in this model, try out the *"Designer's Resource Pak"* from Apogee Components. It has a lot of different shapes you can use to create your own unique model rockets.

For a catalog of products from Apogee Components, send \$1 to:

Apogee Components, Inc.
1431 Territory Trail
Colorado Springs, CO 80919-3323
USA

6xC Cluster-Alt Qualifier design: 6-C Cluster Altitude Plan #1

by Dan Wolf

Recommended Engines:
Six C6-7s

Enjoy peace of mind

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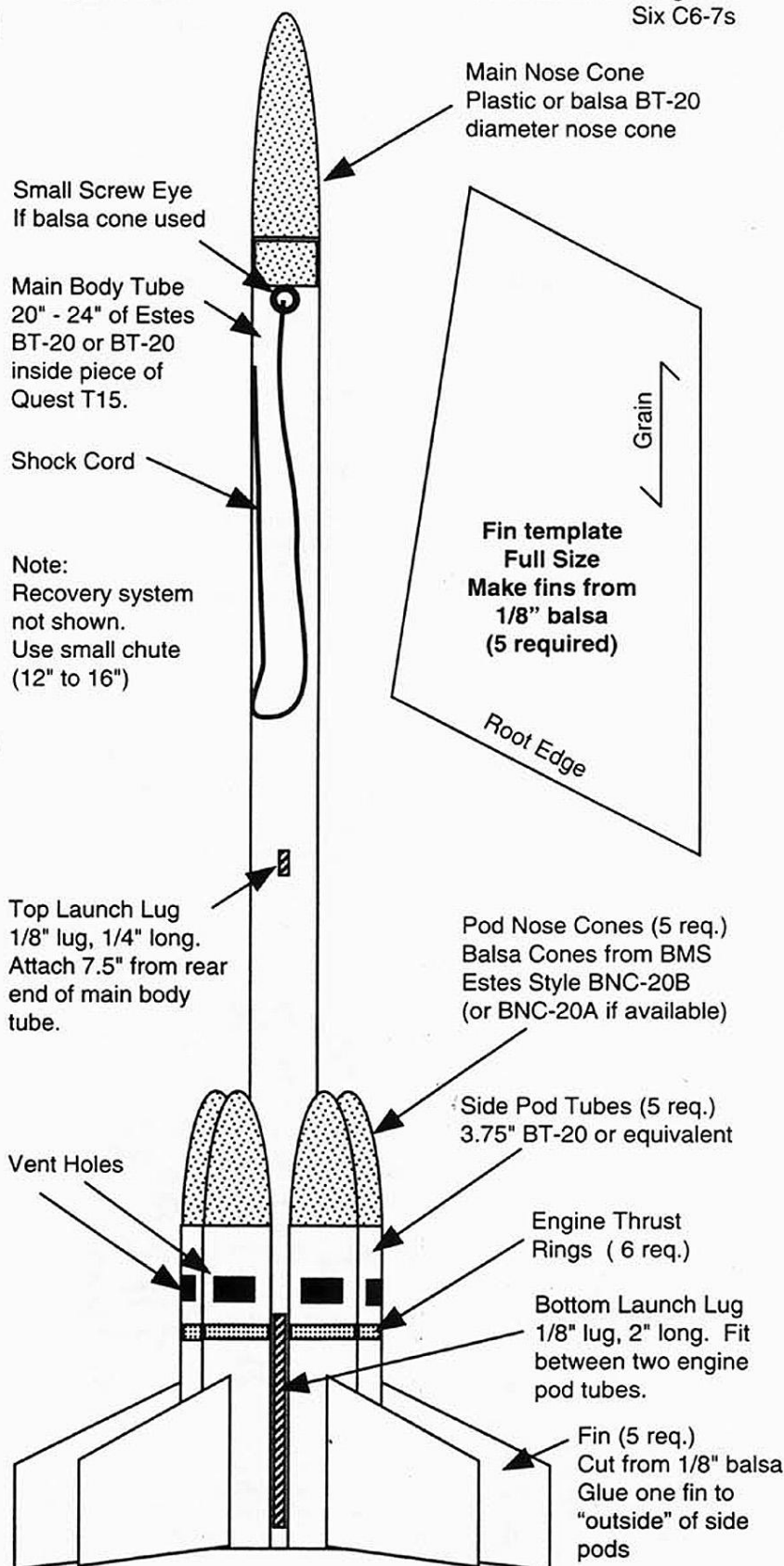
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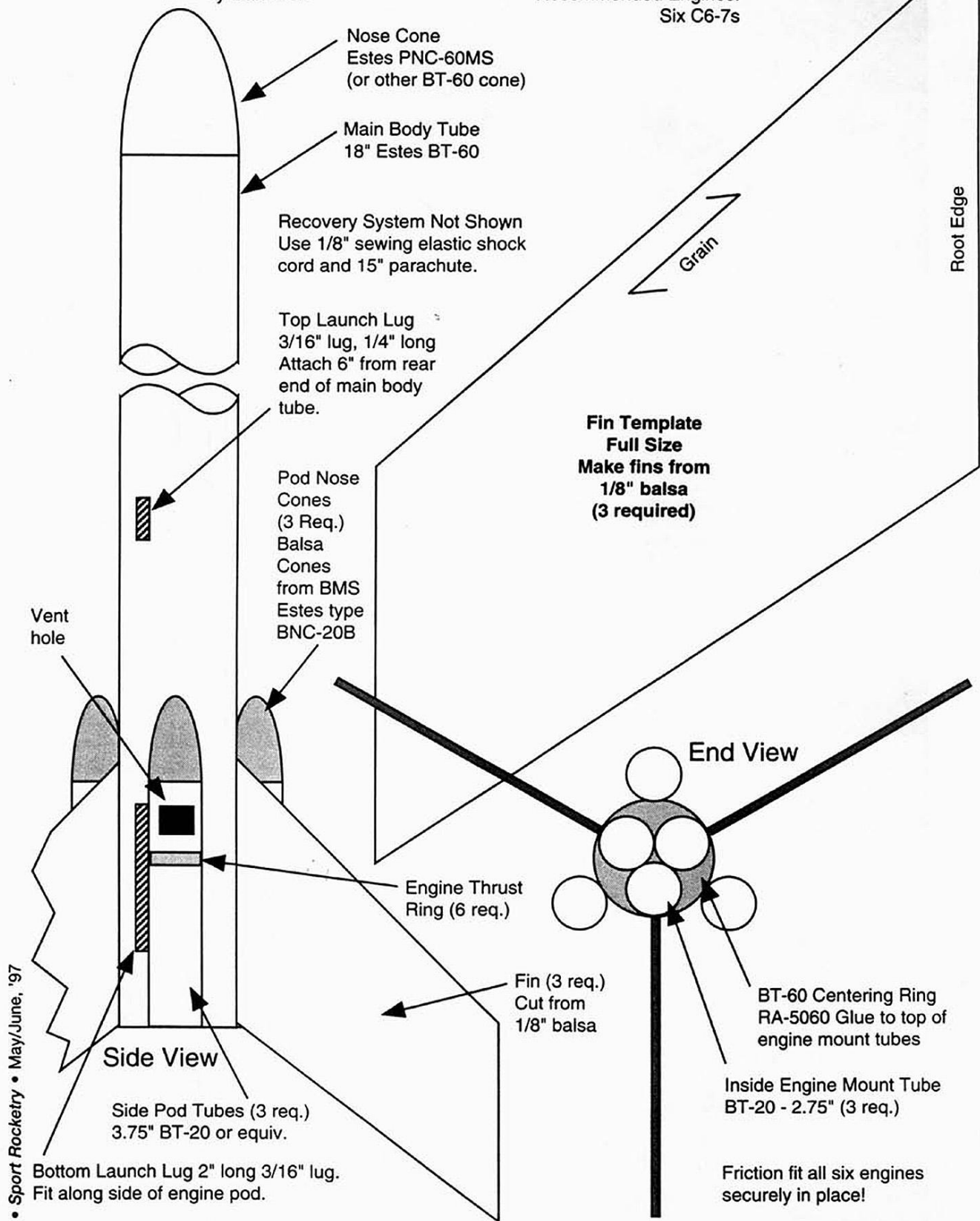
29 • Sport Rocketry • May/June, '97



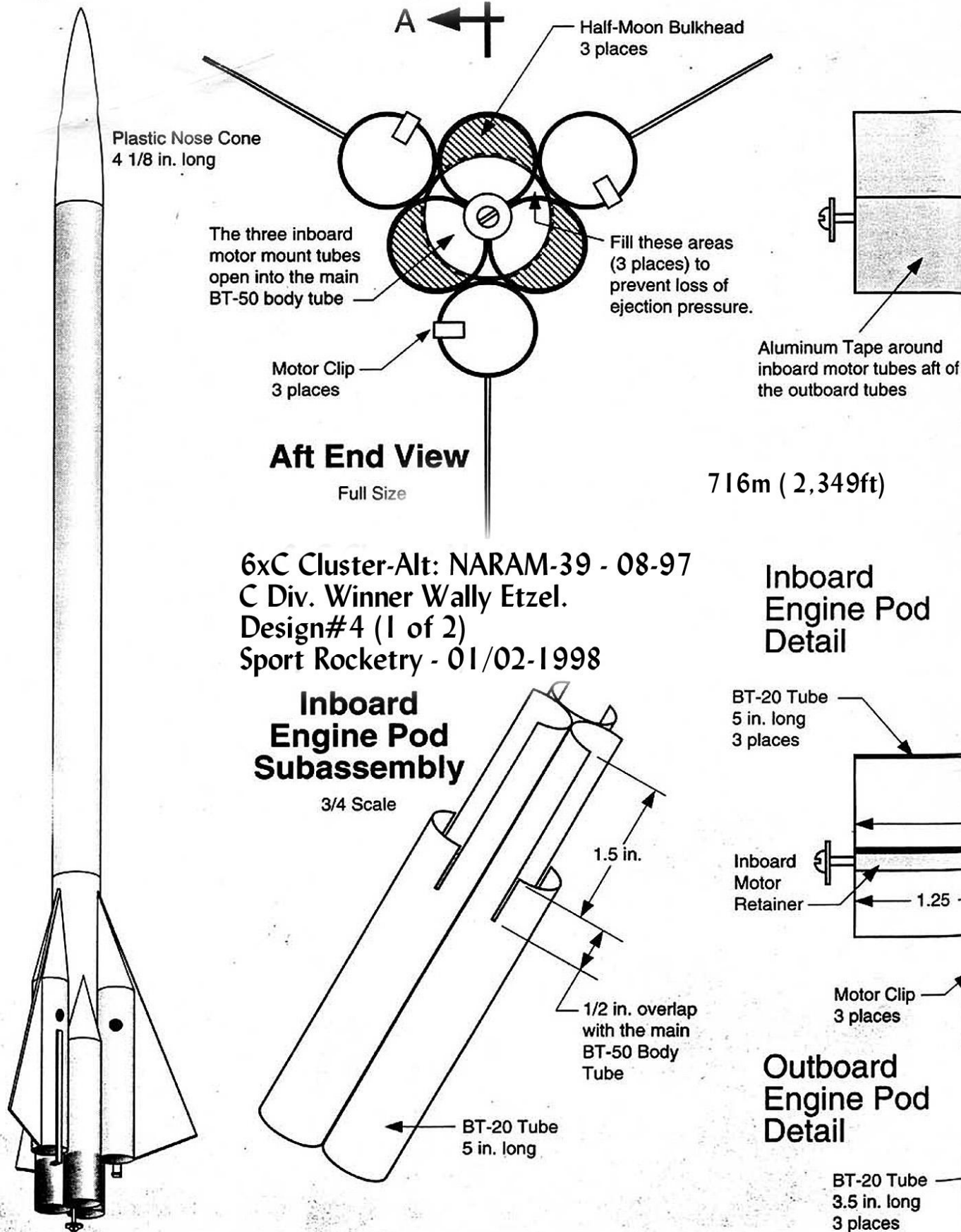
6xC Cluster-Alt Qualifier design #2: 6-C Cluster Altitude Plan #2

by Dan Wolf

Recommended Engines:
Six C6-7s



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Side View of Aft End

Full Size

CP Location

1.35 in.

CP

6xC Cluster-Alt: NARAM-39 - 08-97
C Div Winner Wally Etzel.
Design #4 (2 of 2)
Sport Rocketry - 01/02-1998

Six-C Cluster Altitude

by Wally Etzel, NAR 50638
First Place, C Division,
NARAM-39: 716 meters

Section A-A

Full Size

