Competition Rocketry

6-C CLUSTER ALTITUDE

By Dan Wolf

Introduction and Event Rules

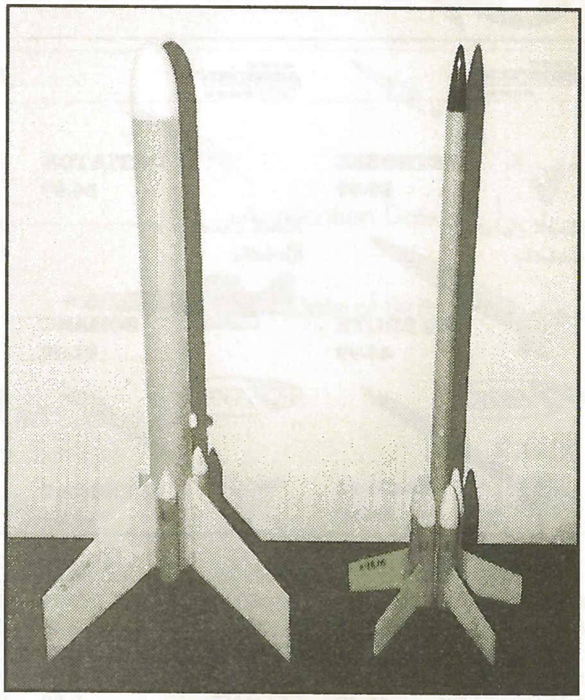
Of all of the events on this year's NARAM card, perhaps none is more intriguing than 6-C Cluster Altitude. Cluster Altitude started out as a provisional event several years ago. The idea was to introduce a competition event that emphasized the seemingly lost art of clustering motors.

6-C Cluster Altitude is one of the five cluster altitude events. Entries must be powered by a cluster of six C engines. The highest flight wins with each contestant allowed two flights.

The rules specifically prohibit staging (rule 23.1), yet at the same time, rule 23.6 allows delayed ignition of motors (commonly called "airstarts"). Some contestants employ "airstarting" in order to increase performance. Although this may seem like a good idea, keep in mind that the definition of a stage in the "Pink Book" is that of a "distinct thrust phase." It would seem possible that an RSO could interpret the flight of a cluster altitude model employing the airstart technique as having distinct thrusting phases and therefore disqualify it as a staged model (see definition of a stage in the Pink Book Appendix A- Glossary). It may be wise to get a ruling from the Contest Director before you fly to avoid a DQ later. Another important rule for Cluster Altitude is the requirement that all motors must remain in the rocket and that the rocket must be returned to show that they did (rule 23.3).

Design Approaches

One of the arguments for introducing new contest events like cluster altitude is to get away from all rockets looking alike in an event. Many feel that some of the older events such as PD, SD, Egglofting, and B/G have been around so long that they have become stale. The winning strategies are well known and all the entries tend to look alike.



6-C Cluster Altitude Design #2. *6-C Cluster Altitude Design #1.*

In cluster altitude, there is more likely to be a variety of designs and unique looking entries. Indeed, since this event was announced as being on the NARAM card, a wide variety of approaches and designs have been discussed in various competition circles. In short, many feel that CLA gives one the chance to be a "rocket scientist."

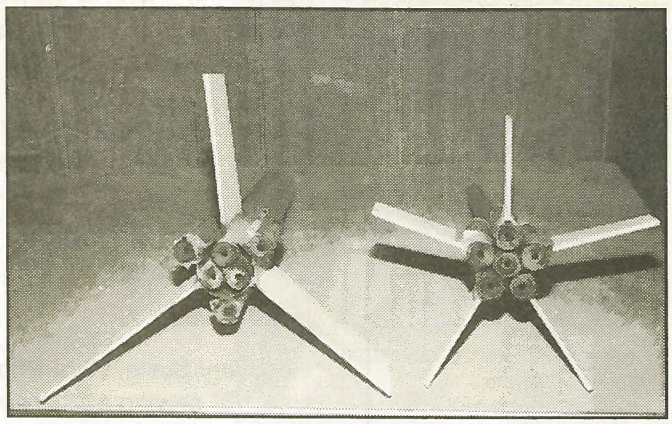
Having said that, in this article two simple and straightforward designs to this event are presented. These designs are not necessarily the highest performing or optimum solutions. But they are flight proven designs that should at least result in a qualified flight.

It has been stated by many that perhaps the biggest overriding concern for this event is stability. The six engines add a lot of weight to the model and if placed in the conventional location (the back end of the rocket), require the designer to pay close attention to the CG-CP relationship.

The simplest (and perhaps the most reliable) approach to this event is to find the smallest body tube that you can fit all the motors into and build a six engine motor mount for it. From the outside, this design is your basic "three fins and a nose cone" rocket. If the motors are arranged in a star pattern (one motor in the center, the remaining five spaced equidistant around it, the entire motor mount assembly will fit comfortably inside an FSI RT-22 tube. LOC 2.14 tubing can also be used, but the fit will be a little snug. A rocket using a full length 34" length of the LOC tube or two sections of the FSI tube works well here.

However, based on experience with 3-1/2A Cluster Altitude (flown at NARAM-35), this type of design would probably not be competitive in this event. At the first contest I attended where 3-1/2A Cluster Altitude was flown, some contestants flew a design with three BT-5s inside a Quest T30 tube, the minimum diameter tube that will accept them. These rockets faired poorly against rockets that simply used three 13mm (BT-5) tubes.

These latter designs had a long piece of BT-5 in the middle, with two short BT-5 engine pods on either side. The advantages to this design are many. First, the frontal area is significantly less, lowering drag considerably. Skin drag and base drag are also reduced. The three BT-5 model also weighs less. Finally, the smaller diameter airframe can use smaller fins, further reducing drag and mass. Rockets of this design were the top performers in this event at ECRM-20 and NARAM-35.



The two cluster altitude designs use different arrangements of the six C motors. Design #1 (right) should give superior performance.

Applying this approach to 6-C Cluster Altitude results in a rocket that has a long 18mm tube in the center, with 5 short 18mm pods surrounding it. There are several concerns with this approach however.

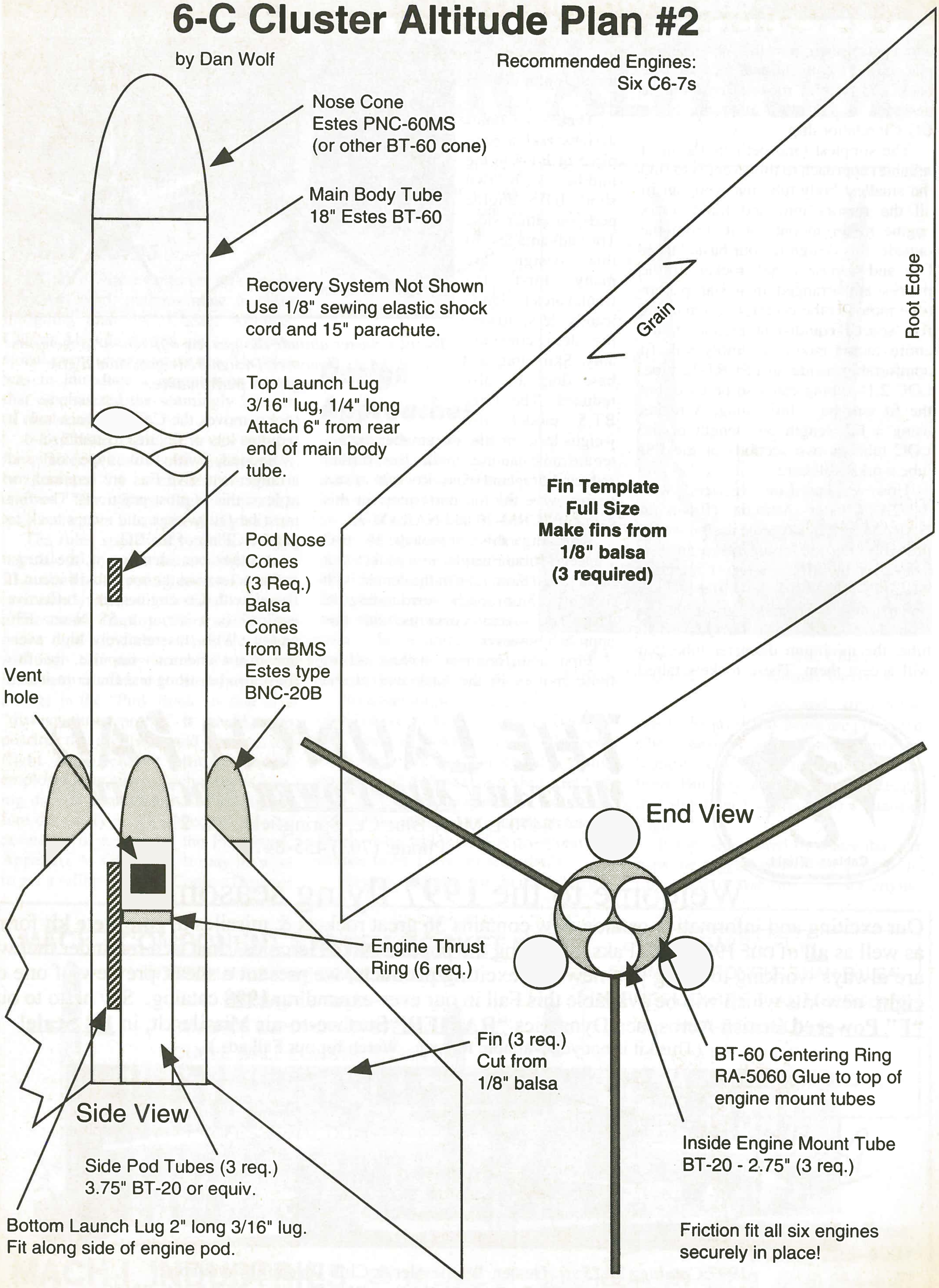
First and foremost, having all of those motors in the back end of the rocket moves the C/G way back too. It requires lots of fin area to stabilize.

Second, with this type of pod arrangement, five fins are required (or at least this is most practical). The fins must be fairly large and swept back to get the CP aft of the CG.

Another consideration is the thrust and acceleration the rocket will incur. If flying with C6 engines, the "effective engine" is a about a 55 N-sec F36 engine. With this relatively high average thrust and total impulse, the fins must also be strong and flutter resistant.

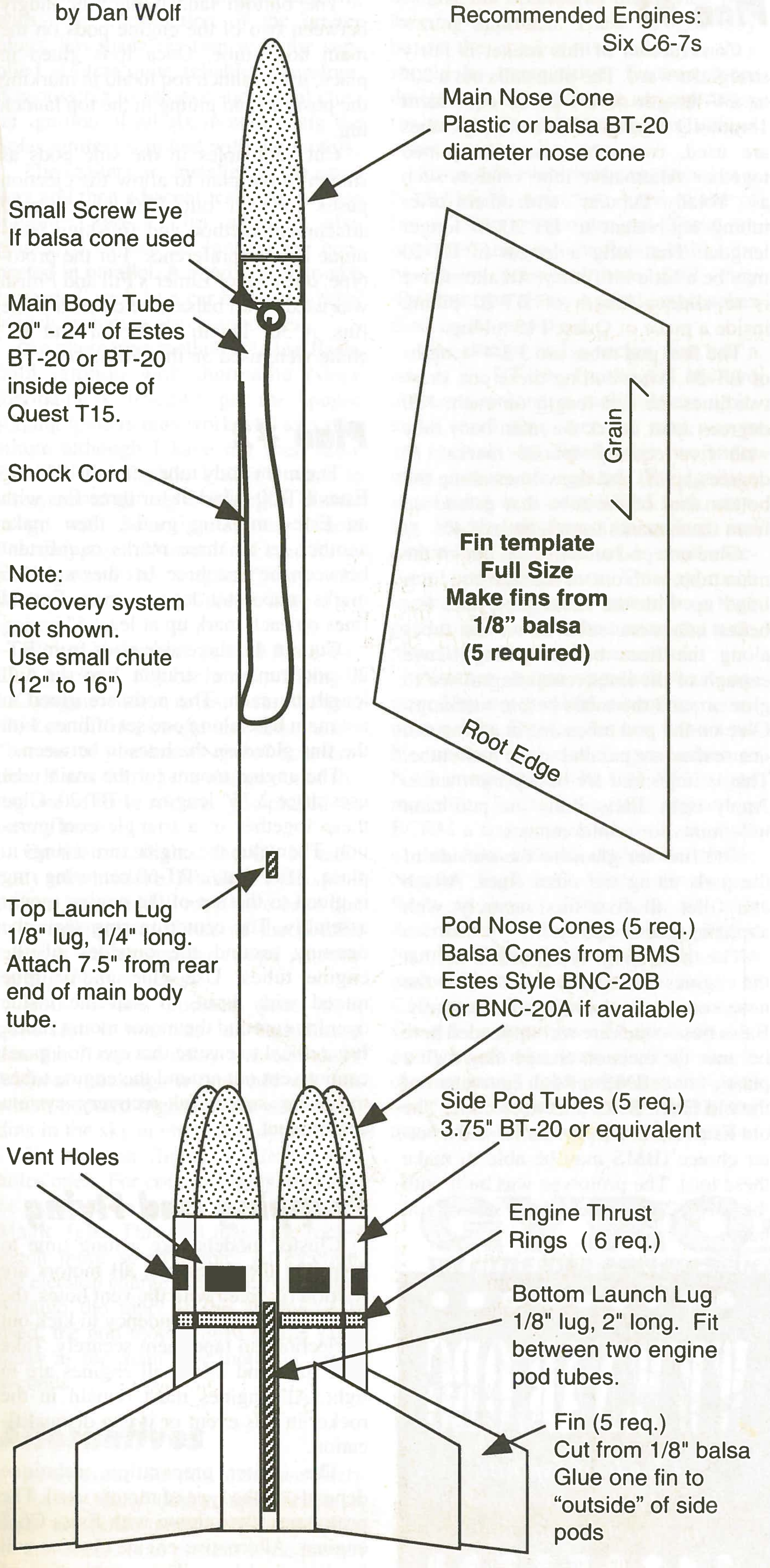
6-C Cluster Altitude Plan #2

by Dan Wolf



6-C Cluster Altitude Plan #1

by Dan Wolf



the current Estes packaging style, along with their introduction of the igniter plugs, has made ignition with the supplied igniters quite reliable. Therefore, it is possible to achieve successful cluster ignition of all six motors using the Solar igniters supplied with the motors.

The igniters are installed in the usual way and then adjacent leads are twisted together and a clip whip is also employed so that all igniters are connected in parallel. A good power source is needed, such as a car battery. A relay launch system is also a good idea.

An alternative method is to use flashbulb ignition with thermalite (since thermalite is difficult to get, the Apogee staging igniters may work well as a substitute although I have not tried this). For the test flights, I didn't want to worry about getting a six engine cluster to go with Solar igniters on a cold February day in Wisconsin. I used flashbulb ignition the "original" way, with wicks from the old Centuri Sure Shot igniters.

Flying is the best part of these 6-C CLA rockets. I'll be honest: Flying a 6-C engine cluster is just a fun thing to do. Lots of fire, smoke and noise, and a "bat out of you-know-where" acceleration. If you don't get a charge out of flying one of these rockets, you picked the wrong hobby.

On the test flights, the BT-20 main body tube model exhibited a wide spiral roll on boost which may have been due to misalignment of one of the pod/fin tubes. It was an impressive and successful flight nevertheless.

Both models boosted quite high, quite fast. It was clear on both flights that the 7 second delay was too short. Without tracking, it was not obvious which boosted higher. Both were small dots in the sky at chute deployment.

For the test flights, I left the vent holes open. For contest flights, they can be covered up with a layer of Scotch Magic Tape. This will make the rocket much more aerodynamic. At ejection, the ejection charge will easily melt/burn through the tape. If this technique is used, the pod motors must be the same delay as the main tube motor(s), seven seconds.

Alternatives

In an event like this, there are likely to be as many design approaches as there are NAR members. The purpose of this article is to present some proven designs, not necessarily the highest performing approach. These designs may be on the conservative side, yet they should be competitive. Further, these designs are here to serve as inspiration for your own solution to this unique event.

Since this event was announced as a NARAM-39 event, we have heard of lots of other unique designs. These are unproven and yet to be flown, unlike the two plans presented here. Still, they illustrate the many varied approaches that can be employed.

One design had a rocket that had a row of six BT-20s. On the pad, the two outboard motors on each side are ignited. A small time later, the next two in are ignited, and finally the two inner most motors are ignited. The ignition sequencing is accomplished with varying lengths of fuse (thermalite) and airstarting, or by use of a small electronic timer/sequencer. This approach appears "on paper" to indeed be a high performance one, if the timing and technique of airstarting is successful.

Another unique approach was suggested by my good friend and top competitor John DeMar. John is known for his unique and novel approaches to NAR competition. His D12-E22 staged model in E Dual Eggloft altitude at ECRM a few years back is an example of this. John calls his design the "Prime Number Exploder". Here's an excerpt from an email John sent me that describes it "This one I call the Prime Number Exploder. It would require an electronic stager that would light (1) C10, then 3 C6's, then (2) C4's. Apogee C's at $7 a pop, plus a $5 pack of C6's, pretty much takes care of all the single digit primes!" John proposed this idea somewhat tongue in cheek, but he has another novel approach that he's hard at work on.

John's suggestion does bring up a couple of other points though. First it may be possible to boost performance in a couple of other ways. One is the use of composite C motors instead of Estes C6 motors. While an Estes C6 has a total impulse of 9 N-sec, an Apogee C10 has a total impulse of 10 N-sec (NAR S&T values). Also, the C10 is available with a 10 second delay. While the all BT-20 design may not be able to withstand the thrust of 6-C10 motors without significant reinforcing, one possibility is a design with a center C10 motor and the five pod motors all C6's. However a key drawback to using mixed motors types or even all composites is successful ignition of all motors.

The other idea is the use of an electronic timer to sequence ignition and ejection. This adds some weight, but offers better performance since simulations show that a seven second delay is too short by about 1.5 to 2 seconds (the test flights appeared to support this). Again, there is an added element of risk and reduced reliability here but the upside could be an addition 10% or more altitude. Of course these more elaborate approaches should only be attempted with lots of test flying.

I hope you enjoyed this brief look at this relatively new and interesting event. The designs presented are proven to get qualified flights and should get you going, or inspire you to come up with your own solution. I would like to hear from others as to their thoughts and approaches to 6-C CLA, how they have worked, and the altitudes achieved. It will be interesting to see what kinds of techniques are tried and what the winning models are like when this event is flown at NARAM-39. Whatever they are, they'll be fun to watch.