# TECHNICAL REPORT:

# *RELIABLE MOTOR CLUSTER IGNITION*

*Clustering* is the act of using two or more motors in a group (or cluster), and having them all ignite simultaneously; as opposed to *staging*, which ignites motors in succession (one after the other). At the right is a picture of our TMRK 9808 Pegasus lifting off after all three motors have ignited properly. Look closely and you can see all three motors ignited and producing thrust.
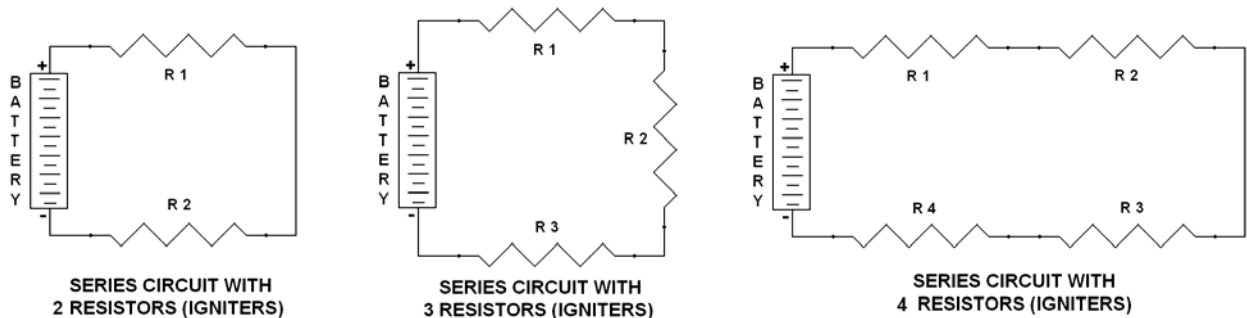
Whether for more thrust, increased payload capacity, or dramatic effects, clustering is used in many different model rockets. For example, our 9811 NIKE Smoke comes in version that uses a cluster of two A thru C motors and our 9810 Jupiter C / JUNO 1 (with our exclusive interchangeable motor mount system) uses a cluster of four D thru F motors.

Clustering rocket motors presents a challenge and level of difficulty all it's own. All the motors in a cluster must ignite simultaneously. If all the clustered motors have not ignited by the time the rocket leaves the pad, the rocket may veer off course; as the center of thrust under the rocket is no longer in line with the center axis of the airframe. Thrust under a rocket that is not in line with the center axis will cause it to continually push to one side, which in most cases will cause the rocket to arc under thrust. When this happens, the rocket may not be at the minimum required altitude for proper recovery deployment. *NOT GOOD*!

The purpose of this report is to inform the rocketeer in the basic principles, and concerns, needed to reliably ignite multiple motors (clusters). To fully understand the concept and associated concerns with clustering, one must understand two basic electronic terms. *Series Circuits* and *Parallel Circuits*. Both are very simple to understand, as we will describe in the following paragraphs.

## SERIES CIRCUITS

Think of TV programs. A *Series* is a show that has more than one episode, and they happen in succession (the second one starts where the first ends, etc,). A *Series Circuit* operates basically the same way. Current flows through one circuit, then the next, and so on, until it has come to the end of the line. Below is a simple diagram showing a battery connected to resistors (represented by the zig zags) that are in *series*. Note that one comes after the other. Think of the resisters as rocket motor igniters. As soon as one burns out (ignites the motor), power is no longer applied to the others, so none of the other motors will ignite.

**SERIES CIRCUIT WITH
2 RESISTORS (IGNITERS)**

**SERIES CIRCUIT WITH
3 RESISTORS (IGNITERS)**

**SERIES CIRCUIT WITH
4 RESISTORS (IGNITERS)**

This is **NOT** how you want clustered rocket motors to ignite! You want all the motors in the cluster to ignite at the **same time**. To accomplish this you must use *a Parallel Circuit* to ignite your motors.
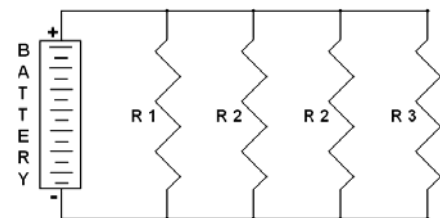
## PARALLEL CIRCUITS

Using the same metaphor as above to describe a *parallel circuit*, think of several different TV stations broadcasting the *same show* at the *same time*. Circuits that are in parallel all operate at the exact same time (power and ground are applied to each and every circuit, *individually*, at the same time). Now here is a basic diagram showing a battery connected to resistors that are in parallel.
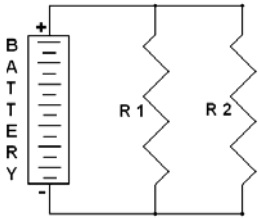


PARALLEL CIRCUIT WITH
2 RESISTORS (IGNITERS)
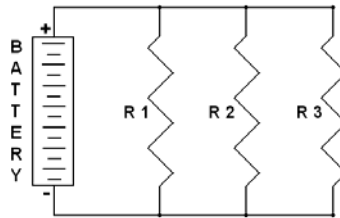
PARALLEL CIRCUIT WITH
3 RESISTORS (IGNITERS)

PARALLEL CIRCUIT WITH
4 RESISTORS (IGNITERS)

Note how the + and – terminals of the battery are connected to opposite ends of *each* and *every* resistor. Now think of each resistor as a rocket motor igniter. When power is applied, all the igniters are activated at the same time. Even if one burns out (ignites the motor a fraction of a second before the other), power is still applied to each and every igniter, and they will all ignite eventually (all of this happening within a fraction of a second, mind you).

## IGNITER LEADS

All igniters, no matter whose you use, are conceptually the same. You apply a current through the two wires to ignite the motor. It is irrelevant which wire is applied to the + (pos) terminal and which wire is applied to the – (neg) terminal of the battery.

The trick is that one wire from *every* igniter be applied to one side of the battery, and that the remaining wire from *every* igniter be applied to the other side of the battery *all at the same time*!

When installing igniters into motors be picky! Buy extra igniters and only use the ones that have no visual cracks (or voids) in the pyrogen. Make sure that the two wires from each igniter do not touch each other (or short out), as this will cause a misfire of one or more of the motors in the cluster.

## SIMPLE TWO MOTOR CLUSTER

This diagram shows the method of clustering the igniters for a simple two-motor configuration. When only using two motors, note how easy it is to keep the individual wires neat and separated. You simply twist *one* lead (wire) from *each* igniter together and connect this to one of the launch controller's alligator clips. Twist the remaining lead (wire) from *each* igniter together and connect this to the remaining alligator clip.

Ensure that neither the igniter wires, nor the alligator clips, come in contact with the metal launch rod or the metal blast deflector on the launch pad itself.



CONNECT THIS TWISTED PAIR OF IGNITER LEADS TO ONE OF THE ALLIGATOR CLIPS

CONNECT THIS TWISTED PAIR OF IGNITER LEADS TO THE REMAINING ALLIGATOR CLIP
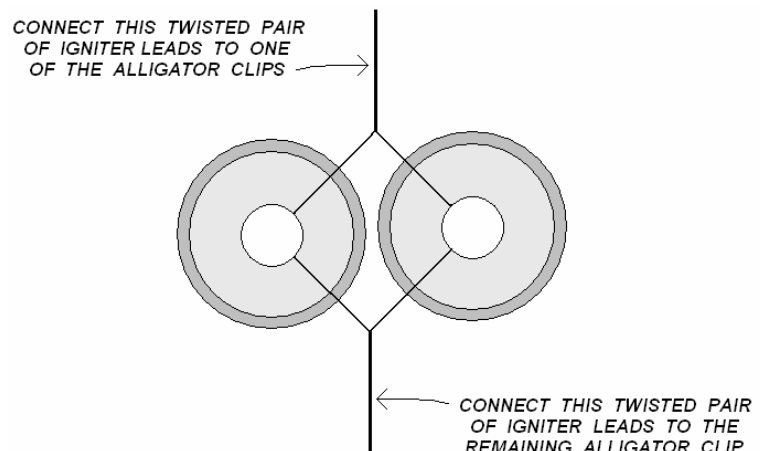
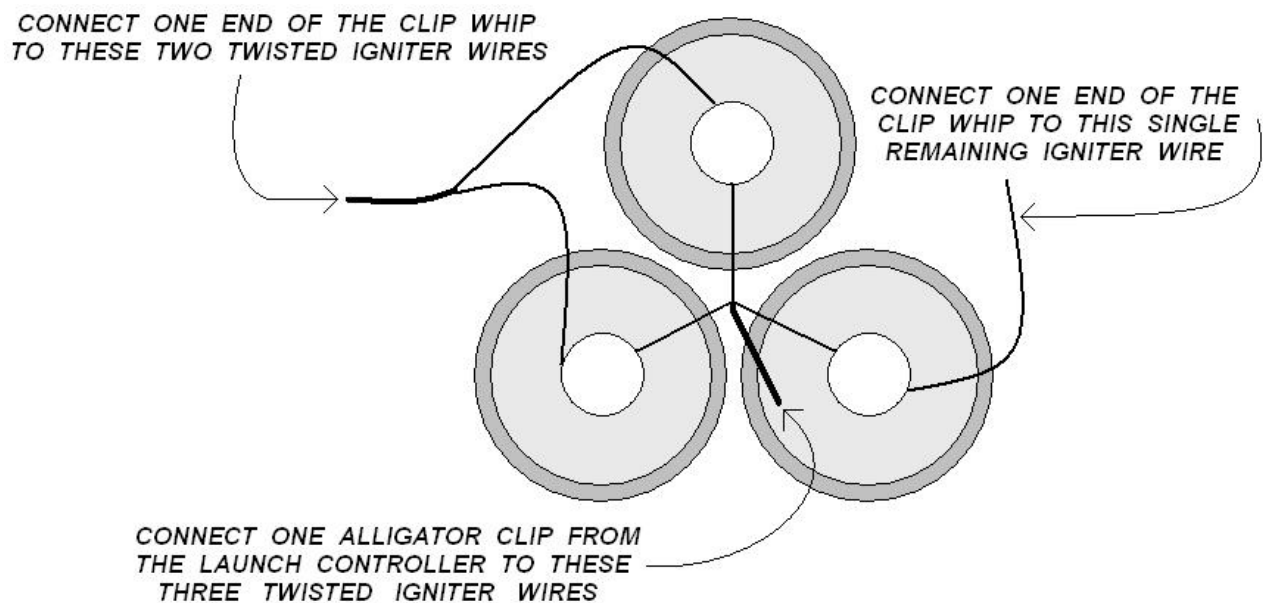**REAR VIEW OF TWO MOTORS AND THEIR IGNITER LEADS**

## THREE OR MORE MOTOR CLUSTERS

Once you have more than two motors in the cluster, things get a little tricky trying to keep the igniter wires from touching each other (or shorting out). One easy way around this problem is a to make a Clip Whip; basically just two wires, with an alligator clip installed on one end of each wire, and the other ends soldered together as shown here (*you can find alligator clips at most any hardware store, Radio Shack, and even at Wal-Marts*). To make things easier, 2-wire clip whips as shown below are available through TMRK at a cost of $4.50 each plus shipping. Order part #CW-02.

6" - 8" Of Lead Wire

Flat - Jawed
Micro Clips

Solder Tab
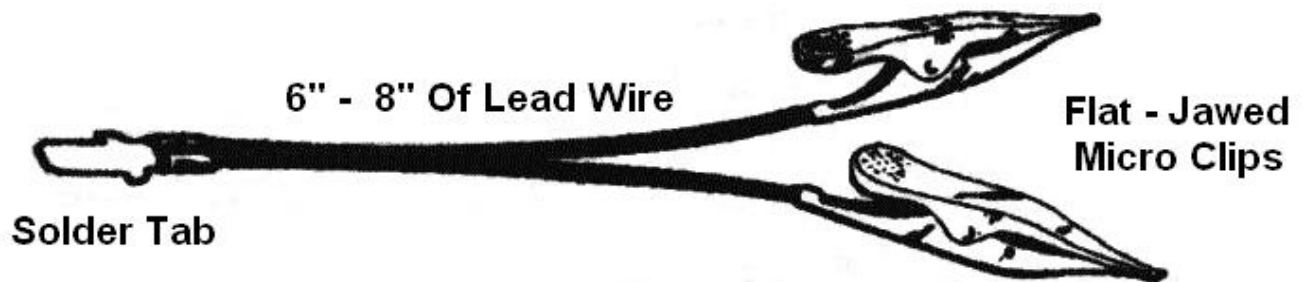
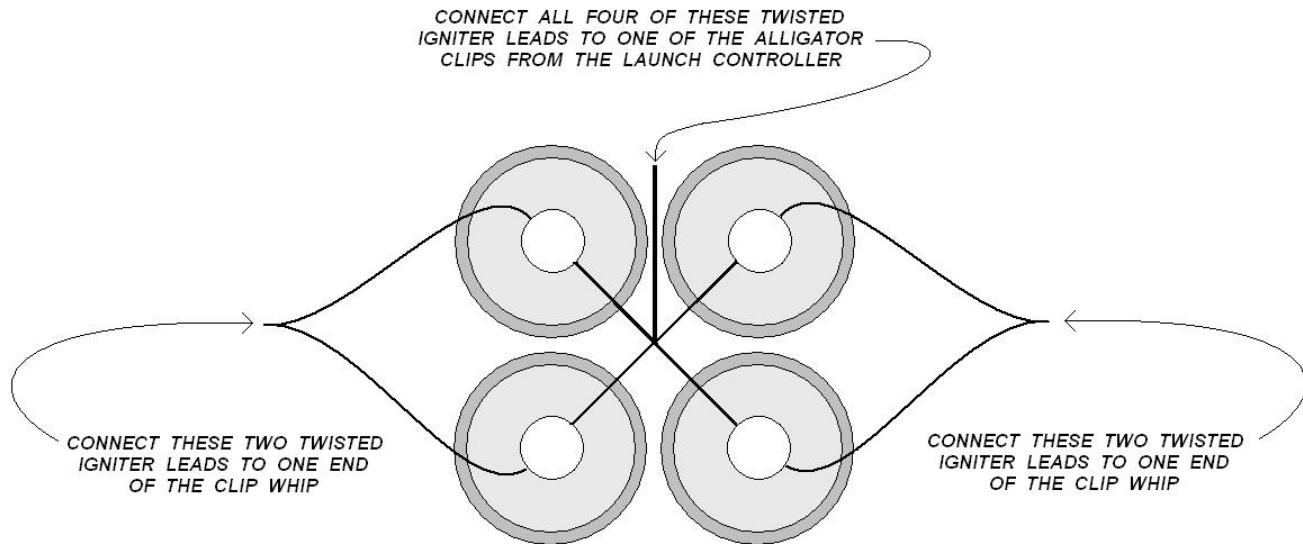## WIRING A THREE- MOTOR CLUSTER

Using a Clip Whip similar to that shown above, below is the suggested method for wiring up a three motor cluster. Note how the motors have been positioned so that one wire from each igniter is aiming towards the center of the cluster. Twist all three of these wires together as shown and connect one alligator clip from the launch controller to this point. Now twist any two of the other wires together and connect one end of the clip whip to this point. Connect the remaining end of the clip whip to the one remaining igniter wire, then connect the remaining alligator clip from the launch controller to the solder tab of the clip whip. Again, make sure that none of the wires, alligator clips, or the solder tab are touching each other or any metal part of the launch pad.

CONNECT ONE END OF THE CLIP WHIP
TO THESE TWO TWISTED IGNITER WIRES

CONNECT ONE END OF THE
CLIP WHIP TO THIS SINGLE
REMAINING IGNITER WIRE

CONNECT ONE ALLIGATOR CLIP FROM
THE LAUNCH CONTROLLER TO THESE
THREE TWISTED IGNITER WIRES

## REAR VIEW OF 3 MOTORS
## AND THEIR IGNITER WIRES

## WIRING A FOUR – MOTOR CLUSTER

Again using a Clip Whip, below is the suggested method for wiring up a four motor cluster. Note again, how the motors have been positioned so that one wire from each igniter is aiming towards the center of the cluster. Twist all four of these wires together as shown and connect one alligator clip from the launch controller to this point. Now twist the two pair of outer-most wires together as shown and connect each pair, individually, to one end of the clip whip. Connect the remaining alligator clip from the launch controller to the solder tab of the clip whip. Again, make sure that none of the wires, alligator clips, or the solder tab are touching each other or any metal part of the launch pad.

CONNECT ALL FOUR OF THESE TWISTED
IGNITER LEADS TO ONE OF THE ALLIGATOR
CLIPS FROM THE LAUNCH CONTROLLER

CONNECT THESE TWO TWISTED
IGNITER LEADS TO ONE END
OF THE CLIP WHIP

CONNECT THESE TWO TWISTED
IGNITER LEADS TO ONE END
OF THE CLIP WHIP

### REAR VIEW OF 4 MOTORS
### AND THEIR IGNITER LEADS

## KEY POINTS TO KEEP IN MIND

- Be picky about your igniters! Select ones that look good, without kinked wires or broken/cracked pyrogen
- Keep the wires neat and tidy, and do not let them touch each other or any metal part of the launch system
- Use a Clip Whip to make connections easier and to keep the igniter wires from shorting out
- ALWAYS use a fully charged car battery (or automotive jump battery) when igniting clusters! Flashlight batteries, even new ones, often cause cluster ignition failures by not being powerful enough to ignite *all* the igniters *at the same time.*

When launching your cluster rocket, remember to keep the launch button depressed until the rocket has cleared the launch rod. The single most common failure of cluster ignition is releasing the launch button after one motor ignites (as soon as you see smoke), but before *all* the motors have ignited! No matter how well manufactured, some igniters may take a fraction of a second longer to ignite the motor than others. The safest rule is to depress the launch button and **keep it depressed** until the rocket has cleared the launch rod.

If you have any further questions or concerns about cluster ignition, ask an experienced fellow rocketeer for advice, or you may contact us via eMail at *info@TrueModeler.com*. We will be more than happy to assist you in any way we can!

### *HAPPY FLIGHTS FROM ALL OF US HERE AT TRUE MODELER'S ROCKET KITS*