Issue 640 / December 3rd, 2024

PEAK OF FLIGHT NEWSLETTER

Apogee Components, Inc. / ApogeeRockets.com / Colorado Springs, CO

Nike Hercules Electronics for Staging

Also in this issue:
Cloud-of-Bats Plan

PEAK OF FLIGHT NEWSLETTER
Issue 640 / December 3rd, 2024

COVER PHOTO

Nike Hercules Launch Preparation

Martin works on prepping the Apogee Nike Hercules for launch, complete with staging electronics.

FEATURED ARTICLES

Airstart Capable Electronics for Staging the Nike Hercules

by Martin Jay McKee

A complete guide on the best electronics to be used with our new Nike Hercules Kit, written by our Product Designer, Martin

Cloud of Bats Rocket Plan

Learn about how this rocket came to be, and build one yourself! Guides, Part Files, Materials list all provided to YOU for free!

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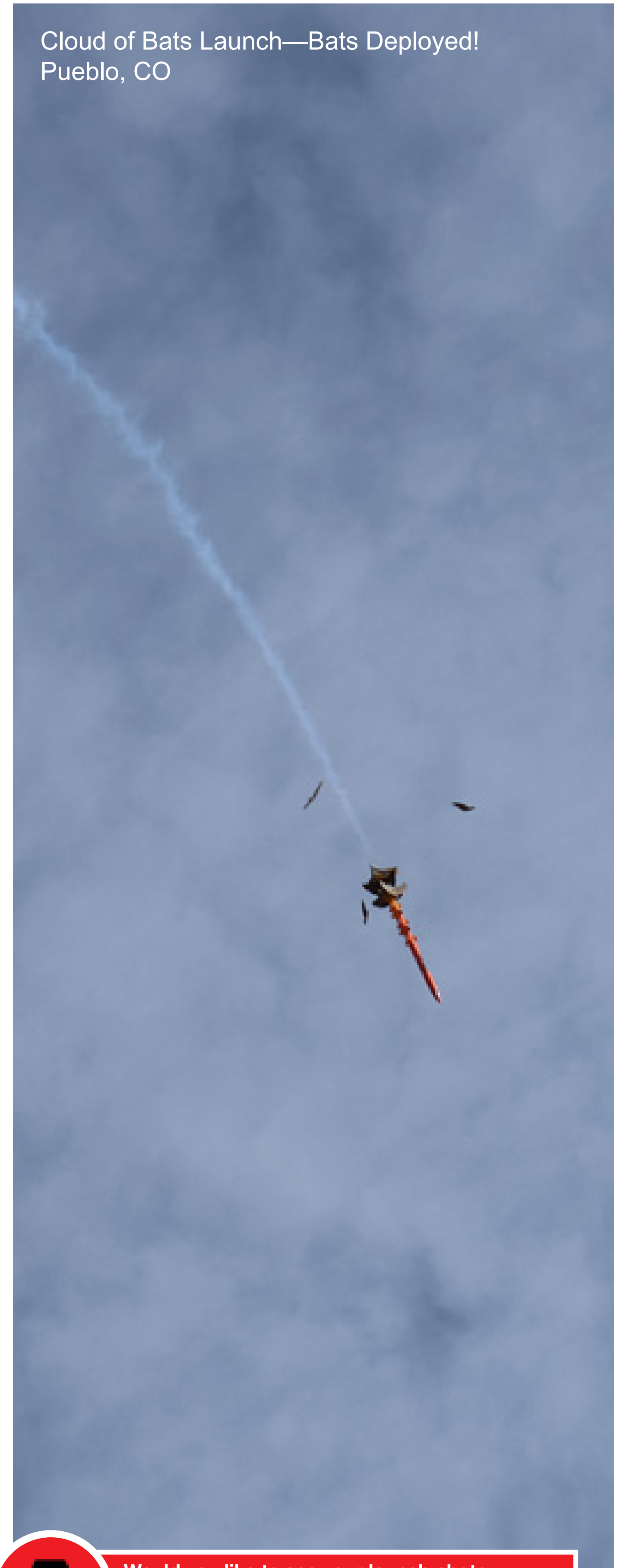
Cloud of Bats Launch—Bats Deployed!
Pueblo, CO



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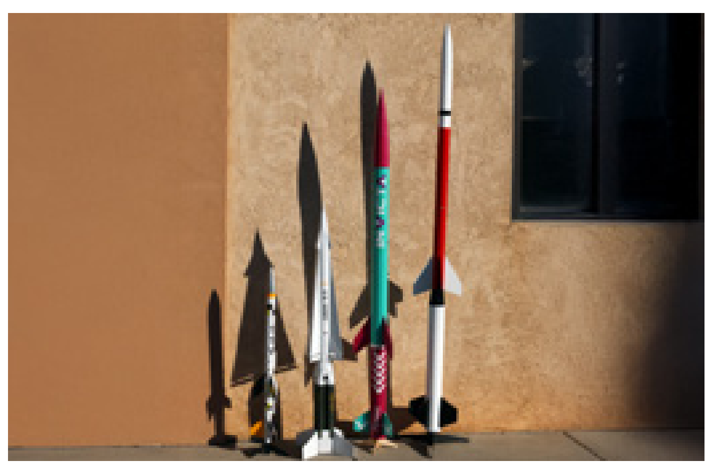
Airstart Capable Electronics for Staging the Nike Hercules

by Martin Jay McKee

With the initial release of the TTV (Timer Test Vehicle) in 2023, Apogee took a step into the world of electronically staged model rockets that are accessible to the majority of the rocketry community. The TTV can be flown on inexpensive motors, without a waiver, and from small fields. Where the LOC Terrier-Sandhawk that we have sold for years is a moderately expensive high-power kit that requires modification by the customer, the TTV is a small model that is designed to be an easy entry point into electronic two-stage flying. With the recent release of the Apogee Nike-Hercules and the soon-to-come Invicta (the TTV's bigger sibling), there are even more kits that require such electronics so we felt it would be beneficial to explore the electronics we provide that are usable for triggering air start events (e.g. separation charges and motor ignition).

One question that we get quite often at Apogee is some variation of, "what is the best X for my rocket" where X can be just about anything: a motor, parachute, adhesive, paint, or, indeed, electronics. This is a difficult question because the answer depends upon

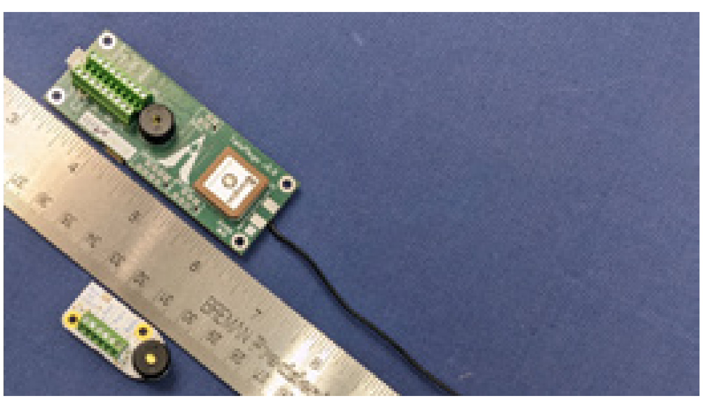


Two-Stage Rockets That We Sell | (From Left to Right) Apogee TTV, Nike Hercules, Invicta, LOC Terrier-Sandhawk

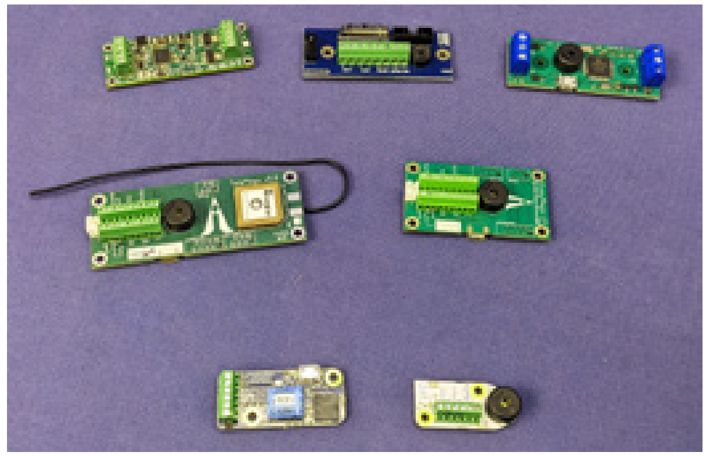
your goals. Our motto, "Your success is our mission" is not just for show. We genuinely want to provide our customers with the best parts to reach their individual goals. The difficulty (for both us and our customers) is in understanding those goals. This article is intended to do two things. First, it will explore a set of features that are available in different products that ostensibly can complete the same task - firing pyro channels during ascent to either separate stages or air start motors for clusters or staging. Simply listing those features alone does not make it clear which device is best for any one person or application, however. As such, we will look a bit more closely at what features might be most desirable for different applications. The second goal of this article is to provide a basic tutorial for each of the electronics systems so that once someone has chosen the "best" device, they are able to use it effectively in their rocket.

About the Features

There are far too many features available on modern model rocketry electronics to describe in detail in this one article. Indeed, even the features that apply specifically to air starting motors will be described at only a superficial level to conserve space. These features fall into three general categories: physical size, number of channels, and control capabilities. One – perhaps surprisingly – missing data point is price. This has been left out for a number of reasons. To begin with, including such changeable characteristics unduly ages the article with out-of-date information. Beyond that, however, the point of this article is to provide the information to make an informed technical decision. While there is no doubt that price is an important variable when making the final determination of which device is best suited for any particular person, it has little bearing on the decision from a technical standpoint.



All Flight Computers Pictured Together



All Flight Computers Pictured Together

The physical features of each flight computer are things like the dimensions and weight. These features define whether or not the flight computer can be used on a rocket simply due to physical constraints. A flight computer that is too large or heavy simply cannot be used. When planning for a large high-power rocket, these constraints are much less likely to be a major limitation. For smaller rockets however, either the weight or size constraints can be of critical importance.

If the staging electronics are used in a way similar to the TTV (or the Nike-Hercules, or the Invicta) the flight computer need only control the motor ignition, an apogee charge, and, potentially, a separation charge. In this case, the number of needed pyro channels will be two or three. It would also be possible to use the same electronics to do dual-deployment; however, in such cases, three or more pyro channels will be needed. It is important to realize the programmability of different flight computers, however. Not all pyro channels are able to be used for all events; and, many of the options examined here have pyro channels that are unable to be used for air starts, even when some can.

For instance, the Simple Timer has an apogee channel that is not programmable in any way. It will always trigger when the rocket tips past 90 degrees from vertical. This leads to the simplicity of the system but means that the Simple Timer is unable to trigger both a separation charge and motor ignition despite having two pyro channels. Other electronics are similarly constrained while some devices (such as the Blue Raven and Entacore AIM) can have all their pyro channels programmed for any event.

The final limiting factors that can cause a flight computer to be entirely unsuitable for use in a two-stage rocket come down to the available configuration capabilities. These include things like safety features (liftoff detection, minimum altitude lockout, and angle lockout) as well as triggering methods. To ensure that an air start can be safely initiated, it is important to verify that the rocket is flying as expected. The most basic way of doing this is to require a minimum altitude to be achieved before triggering an air start. In some cases, this altitude may be configurable while in others it is hard-coded into the flight control software. Once that minimum altitude has been reached, it is important to ensure that the rocket is traveling in an appropriate direction for an air start. This is handled by an angle lockout where the electronics track the orientation of the rocket with relation to vertical and it will inhibit (or “locks out”) firing air starts if the rocket is more than a certain angle from vertical.

As with minimum altitude lockout, the angle lockout can be hard-coded or configurable. The recommendation of NAR is for an angle lockout at no more than 30 degrees from vertical which means that the general recommendation is both that angle lockout be included and that it be set between 0 and 30 degrees. Electronics that do not meet the recommendations are still allowed at sanctioned launches. However, RSOs always have the freedom to deny a flight that they are uncomfortable with for any reason. In the end, tighter constraints on flights can lead to some disappointment on flights due to motors not being triggered (as happened during the development of both the Nike-Hercules and Invicta) but when used correctly, these safety features also allow for the safe recovery of the rocket despite a failure to light the motor. This safe recovery preserves the modeler’s investment and reinforces the culture of safety that has made model rocketry as safe as it has been. As such, I recommend electronics with the tightest constraints possible that allow the desired flight profile.

Triggering Air Start Motors

There are a number of events that can trigger air start motors. Three types of events are explored in this article. The first type is the oldest and that is time based. Time-based triggering is simple. The electronics simply delay a specified time from the detection of liftoff and – assuming other safety checks are passed – the motor will be triggered. Such time-based staging derives from the very earliest electronic staging devices and fuses before that. It should be understood, however, that while modern time-based triggering is derived from the “dumb” timers of the past, the safety issues inherent in the design have in many cases been entirely fixed. On the one hand, the addition of internal sensor-based launch detection has removed the danger of a damaged break-wire leading to a ground firing of a motor or charge while altitude and angle lockout features ensure that the rocket is headed in the correct direction when the air start is expected.

Name	Size	Weight	Channels	Airstart Channels	OS	Altitude Lockout	Angle Lockout	Time Triggered	Velocity Triggered	Angle Triggered	Data Logging
Simple Timer (P/N 09142)	2.5" x 0.9" x 0.8" | 64mm x 23mm x 20mm	0.41oz | 11.6g	2	1	n/a	No	45°	Yes	No	No	No
RRC3+ (P/N 09095)	2.56" x 1" x 0.49" | 65mm x 25mm x 13mm	0.48oz | 13.6g	3	1	Win LCD	Yes	No	Yes	No	No	Yes
AIM USB (P/N 09139)	2.56" x 0.98" x 0.59" | 65mm x 25mm x 15mm	045oz | 12.8g	2	2	Win	No	**No**	Yes	**Yes**	No	Yes
TeleMega (P/N 09200)	3.25" x 1.25" x 0.63" | 83mm x 32mm x 12mm	0.88oz | 25g	6	4	Win OSx Linux	Yes	Yes	Yes	Yes	**Yes**	Yes
EasyMega (P/N 09208)	2.25" x 1.3" x 0.5" | 57mm x 33mm x 12mm	0.5oz | 14.2g	6	4	Win OSx Linux	Yes	Yes	Yes	Yes	**Yes**	Yes
Blue Raven (P/N 09170)	1.8" x 0.8" x 0.5" | 46mm x 20mm x 12mm	0.24oz | 6.8g	4	4	IOS Android	Yes	Yes	Yes	Yes	Yes	Yes
Blue Jay (P/N 09175)	1.45" x 0.66" 0.5:" | 37mm x 17mm x 12mm	0.16oz | 4.6g	2	2	IOS Android	Yes	Yes	Yes	Yes	Yes	Yes

Intended as a Warning   Qualified Feature, Further Explained in the specific usage section

Data Logging Devices

A final feature that may be important for more advanced rockets that require air starts is the ability to log flight data. While this is not required for a staged flight to be successful, it makes later analysis of the flight (and any potential failures) much easier to do. The different recording flight computers described have sample rates ranging from 10 Hz (samples/sec) to 500 Hz (samples/sec) and also record a wide variety of sensor data. Some of the flight computers only record barometric data. Other things like temperature data, acceleration and gyroscope data, GPS location, voltages, events, etc. are recorded on the flight computers outlined in this article. Only the Simple Timer is entirely without data logging capabilities (in the list of airstart capable electronics), but the absence of accelerometer data, or igniter continuity data may be critical in troubleshooting why a staged flight failed. So, it is worth considering if a record of flight data is an important capability.

This table includes basic data that may be useful for the selection of one electronic device over another. The dimensions and weight represent direct physical limitations while the channel count, compatible OS, and available features may make one device preferable over another.

PEAK OF FLIGHT NEWSLETTER
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Issue 640 / December 3rd, 2024
www.ApogeeRockets.com

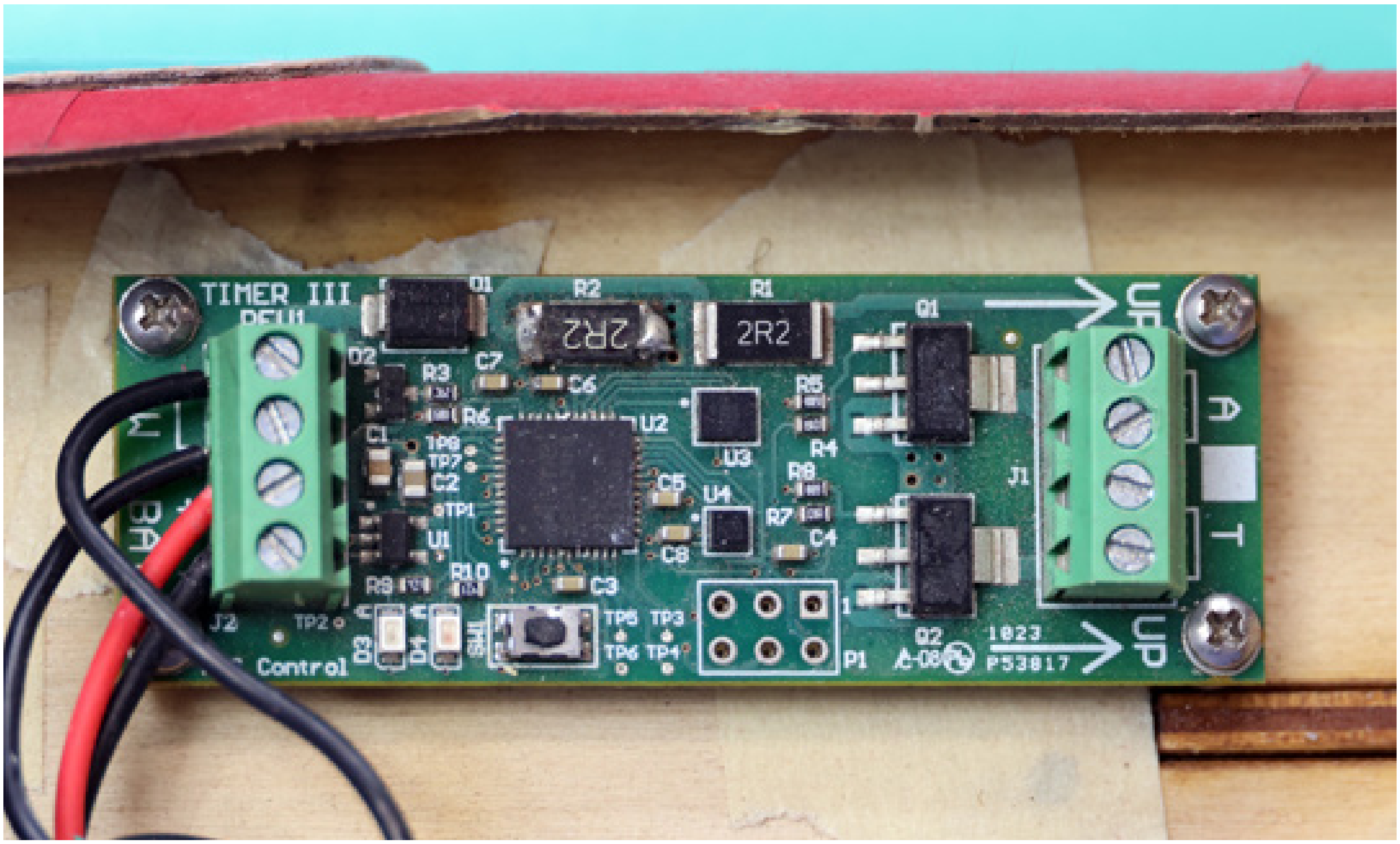

Photo of the Simple Timer, Sold at Apogee Components

Use of the Simple Timer

The Simple Timer has the advantage of being entirely self-contained as far as programming is concerned. The interface consists of two LEDs (red and green) and a single push button. The advantages of this interface are twofold. First, the flight computer itself is less expensive than competing products and no additional costly items (such as a computer, phone, or data cable) are required. Secondly, as no additional hardware is required for programming, the Simple Timer can be easily updated at the field, and even at the pad.

The flip side of this simple interface, of course, is that the display of data is not quite as clear as text on a screen. Unlike the computer, phone, or LCD displaying text, the Simple Timer displays errors, time settings, voltages, and modes using blinking patterns on the LEDs.

This article will not seek to provide a complete outline of the operation of the Simple Timer as there are very complete instructions on the Apogee website. That said, because the Simple Timer is a device purpose built for air starting motors, its use is actually quite… well… simple. There are two pyro channels on the simple timer. One, the apogee channel, cannot be configured in any way. It will simply fire when the device detects tip-over of the rocket. The timer channel is triggered at liftoff and will fire after the configured time delay (0.7s - 99.9s) given that the rocket is within 45 degrees of vertical when the time delay has expired and the rocket has never detected tip-over prior to the delay expiring. The time delay is set by entering the time delay setting mode (as described in the instructions) and pressing and holding the button for the desired delay time.

The Simple Timer also supports ground testing of both pyro channels separately but, as such testing must be done by navigating through the modes by pressing the button, it is not recommended to do full separation tests with black powder charges. The ground testing function does, however, work well to ensure igniter/battery compatibility.

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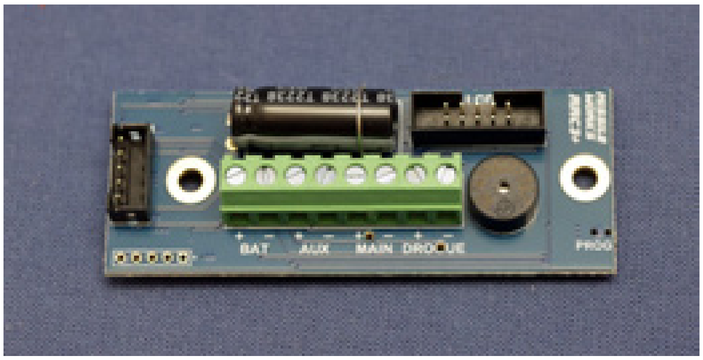


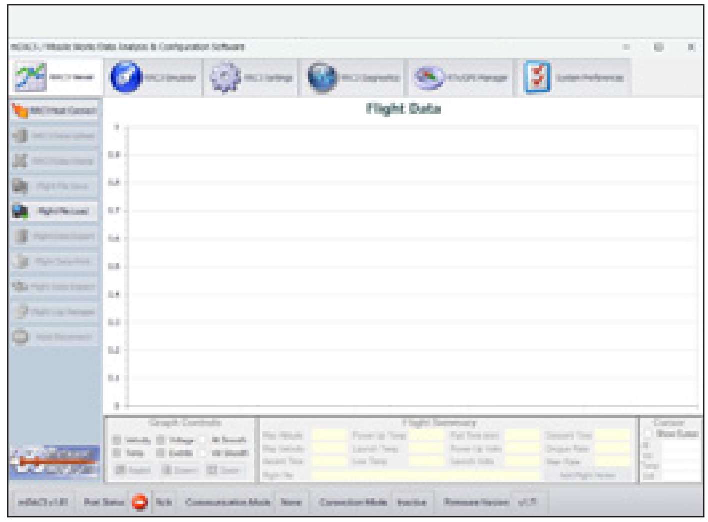
Photo of Missleworks RRC3+ Flight Computer

Use of the RRC3+

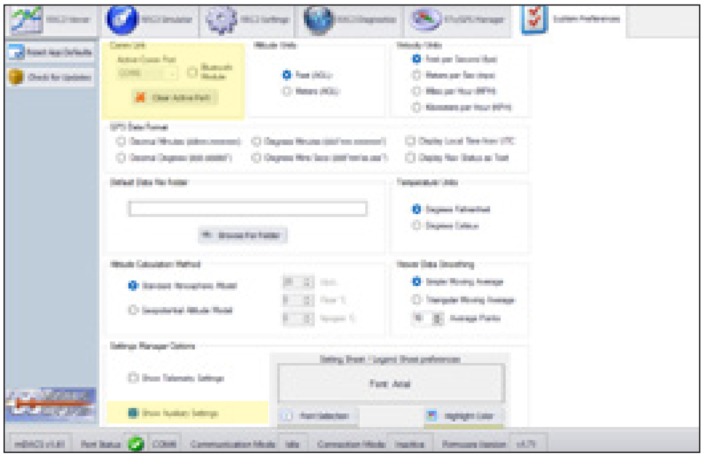
The Missileworks RRC3+ is a new reduced-size version of the RRC3 flight computer. It can be programmed either through a computer (Windows only) and data cable, or through a purpose-built LCD interface. In this article, we will only examine the process of configuration through the computer as this article is concerned more with the event capabilities of the electronics than with the user interface. However, the programming method is very similar when using the LCD interface and the logic of the auxiliary events remains the same.

There are a number of small steps that need to be completed to configure the RRC3+ for air start using the mDAC software (available on the Missileworks website https://www.missileworks.com/downloads). After installing the software, and upon opening, the software opens to the “RRC3 Viewer” tab. Before being able to connect to the RRC3, the UDC (USB Data Cable) must be connected to the CONN port and the altimeter must be powered with a connected battery. Go to the “System Preferences” tab and select the UDC’s COM port (if multiple ports are present, disconnect the UDC from the computer, recheck the list, and then select the port that is added when the UDC is reconnected). Also, select the “Show Auxilliary Settings” option, so that the required settings are made available. Return to the “RRC3 Viewer” tab and click the “Host Connection” button. Once it connects, the software will display a dialog notifying of the successful connection. Click OK.

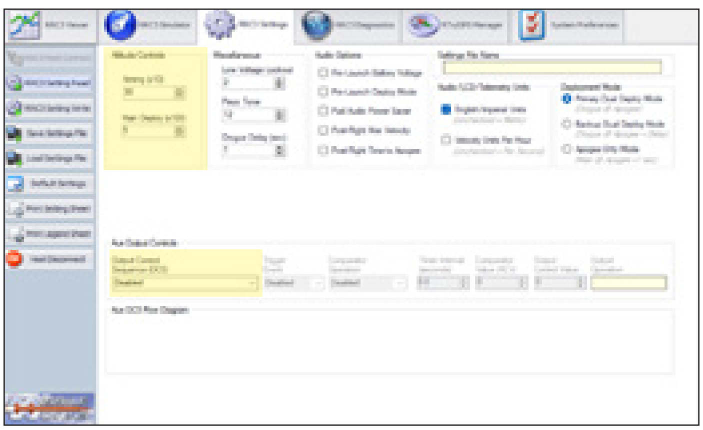
Go to the “RRC3 Settings” tab to configure the auxiliary channel for air start. While the RRC3 does not provide an angle lockout, it is possible to use the output comparator to do an altitude lockout. The best trigger option, however, is time-based. As such, the channel will be set to start a timer at launch then do a single comparison (1-shot) for altitude lockout; if the altitude is below the target, the channel will never fire.



The mDAC software opens with an empty plot for flight data, disabled controls along the bottom and left side, and a series of tabs along the top.

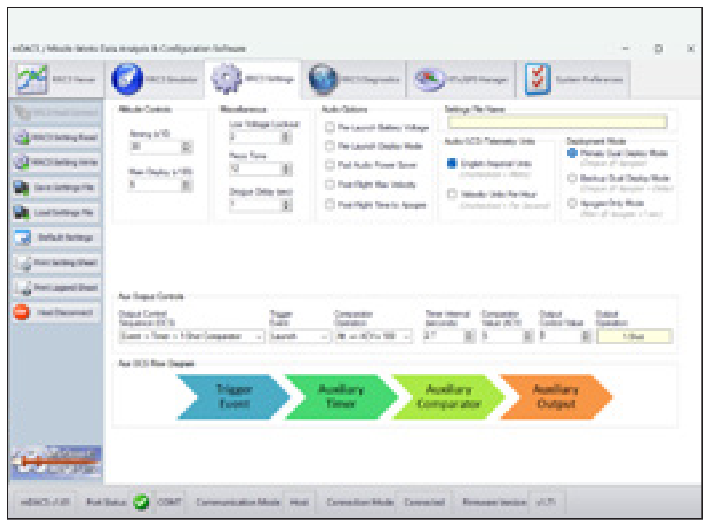


To configure the Auxilliary channel, the mDAC software needs to have the active COM port configured and the "Show Auxilliary Settings" option needs to be enabled."



The default config will have Auxilliary output disabled. Setting the arming altitude and main deployment altitude can be done in the altitude controls.

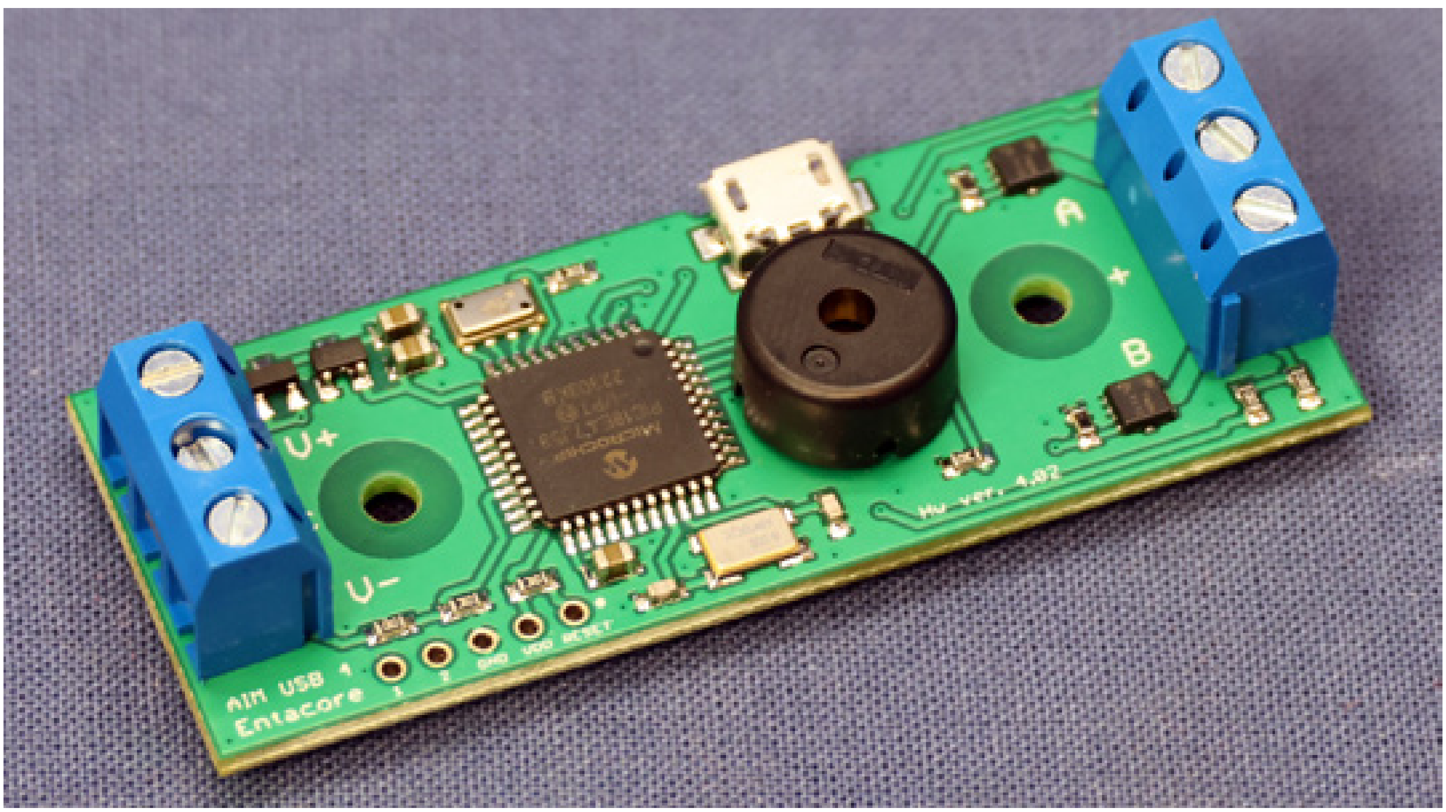
Before the software allows configuration, the current settings must be read from the attached RRC3. If the settings have not been read, all of the configuration options will be disabled (grayed out). Press the “RRC3 Setting Read” button (on the left of the screen) to read the settings from the attached device. The default configurations in the upper half of the screen should be a safe setup on a new device with launch detection at 300’, main deployment at 500’, and drogue deployment at apogee. Select “Event->Timer->1-Shot Comparator” for the OCS (Output Control Sequence); the Trigger Event to “Launch”; the Comparator Operation to “Alt => ACV x 100”; the timer interval to the desired staging delay from liftoff; the ACV (Comparator Value) to the lockout altitude (in increments of 100’); and the OCV (Output Control Value) to 1, for a single 1s pyro firing.



(above) Set the output controls in the Aux Output Controls section to the desired settings. Other options are included across the top of the screen, but do not directly apply to the air start scenario.

There are some small tweaks that can be made to this configuration that makes a pseudo-velocity triggered configuration possible. If the arming altitude is set high enough to act as an altitude lockout, velocity trigger can be achieved by using the Comparator Operation "Vel <= ACVx100" to allow the rocket to slow down to a target velocity before firing the air start. This will require the OCS to be set as Event->Timer->Loop Comparator, and the timer interval set to be long enough for the rocket to be moving faster than the target velocity (or the air start will happen while the rocket is still accelerating). Note, however, that this is not as safe as on something like the Blue Raven due to the lack of angle lockout. It is better to simply fire the air start as soon as possible to reduce the possibility of firing motors when the rocket is far from vertical, despite being above a target altitude.

It is also possible to do ground testing of the pyro channels using the mDAC software by going to the RRC3 Diagnostics tab. In addition, this tab provides an impressive amount of live information about the functionality of the flight computer. This can be useful for both diagnostics as well as for quick battery/continuity tests. Because of the close proximity as a result of the altimeter needing to be connected to the computer, however, ground testing should be done with the utmost caution.



The Entacore AIM USB Altimeter for Model Rockets, shipped and sold at Apogee Components

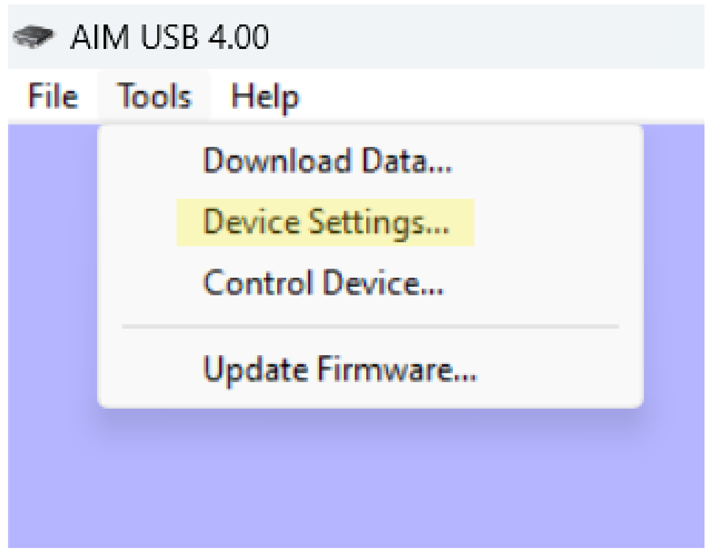
Use of the Entacore AIM USB

The software for the Entacore AIM USB altimeter is simple, but it provides all the functionality that might be required to configure one or both of the pyro channels for air starting based on a time delay or a very simple peak velocity trigger. The Entacore is not the electronics that I would personally recommend if someone specifically is looking for staging electronics. However, it can certainly be capable if desired, as will be shown here.

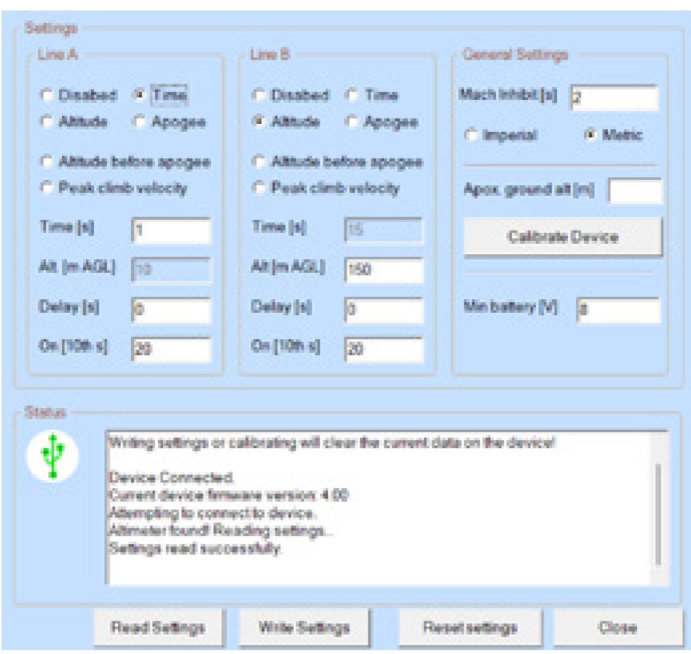
The primary weakness of the Entacore is a conspicuous lack of safety (lockout) features for staging events. This is understandable, given its intended use as a standard dual-deployment altimeter. For a fairly reasonable price, it does offer the ability to trigger air start events in two different ways: time-triggered and peak velocity-triggered.

To configure the Entacore AIM USB, download the PC software from the Entacore website (https://entacore.com/electronics/aimusb) and install it on your PC. Windows is the only operating system compatible with the AIM USB software. Plug the flight computer into the computer through the USB port and open the Entacore software. The main screen will be empty except for a menu at the top with three sub-menus from the “Tools” menu, select “Device Settings”. This will bring up a dialog box titled Program Chip that allows for configuring the two pyro channels (named Line A and Line B), configuring the Mach inhibit time, and calibrating the barometric altitude. For this article, we are simply concerned with the pyro channel configuration.

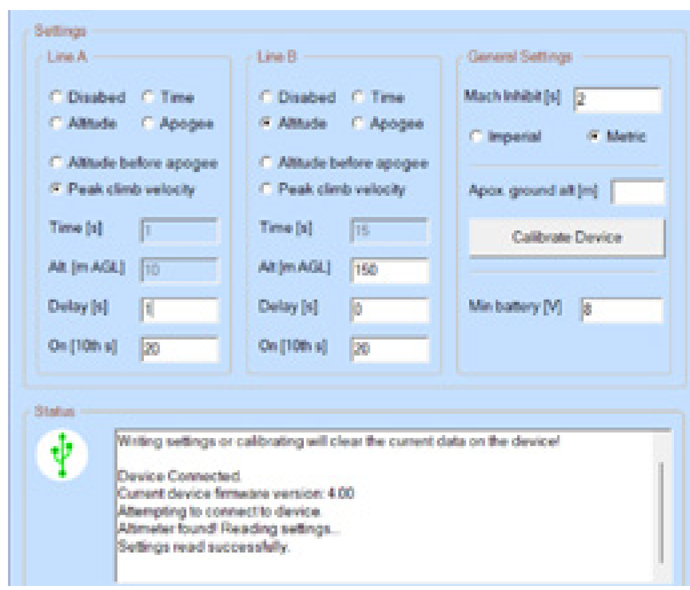
To configure an output for time triggering, simply select the “Time” option and set the desired time after liftoff in the “Time[s]” edit box. The AIM USB allows delays of only whole seconds.
It is also possible to set the amount of time that the igniter will be energized by changing the value in the “On [10th s]” edit box. It is important to note that the amount of time specified here is specified in 0.1-second increments (1/10th of a second). As such, the example configuration will energize the igniters for a total of 2 seconds (20 * 0.1s).



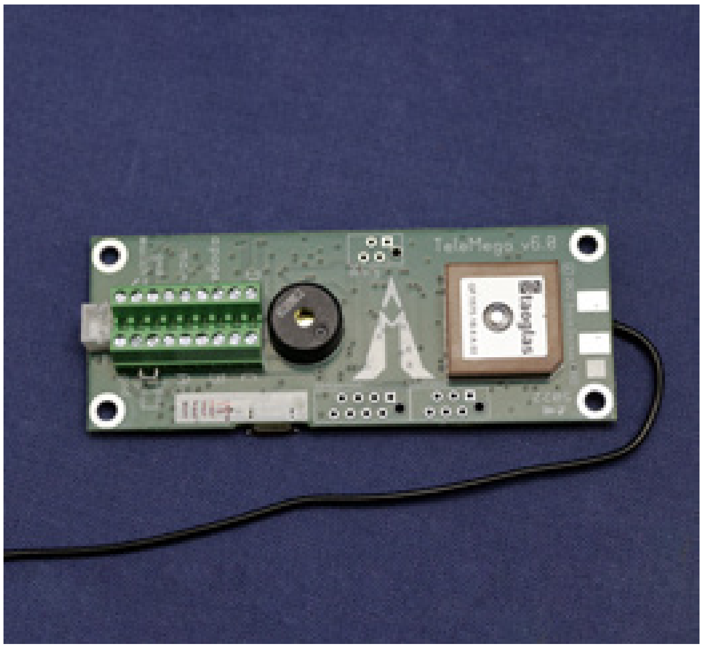
Much of the most useful functionality in the Entacore AIM USB software is in the Tools menu. Recorded data can be downloaded here, the flight computer's firmware updated, and the channels configured by selecting Device Settings.



A time-based configuration will disable the altitude edit box but allow entry of two times "Time[s]" and "Delay [s]". The delay time can always remain at 0 and only the "Time [s]" value be changed.



In a velocity-triggered configuration, both the "Time [s]" and "Alt [m AGL]" options are disabled and the only way to adjust the trigger time is the "Delay [s]" after maximum velocity is detected.



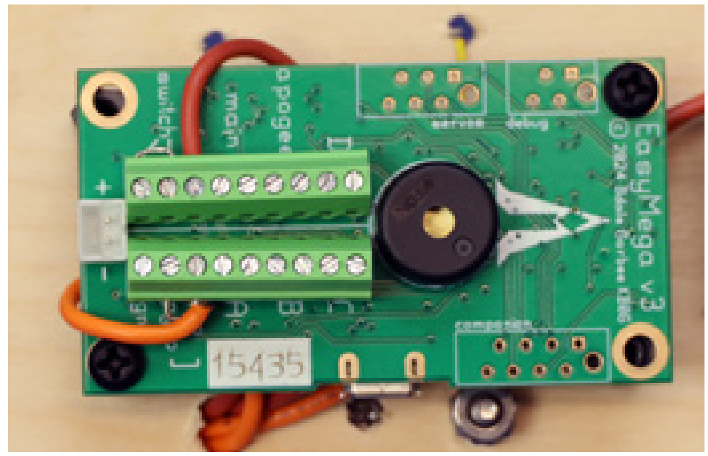
The Altus Metrum TeleMega Altimeter, Sold at Apogee

When the settings have been modified as desired, they must be written back to the flight computer. This is done by clicking on the "Write Settings" button. It will take a short time to complete the writing, but once complete, the status window will display a message about the successful completion.

Configuration for a velocity trigger is very similar. The way that the Entacore specifies the velocity trigger is unique. It uses the peak climb velocity. That is, it will trigger when the estimated velocity of the rocket first begins to decrease. For many motors, this point will be before the actual burnout, so it makes sense to make use of the "Delay [s]" field to trigger a short time (in this case 1 second) after the maximum velocity point.

It is worth repeating that other than the launch detection, there are no safety features to inhibit the pyro channel functionality, so even if the rocket ends up going unstable and pointing toward the ground (or even already impacting it), the Entacore will trigger the channel. Therefore, it should only be used in cases where the initial stability of the rocket is not in question.

Like many flight computers on this list, the Entacore AIM provides a method of ground testing when connected to the computer. This, of course, is handy to test the compatibility of the electronics, battery, and igniters, but the computer connection makes safe deployment testing more difficult.



The Altus Metrum EasyMega Altimeter, Sold at Apogee

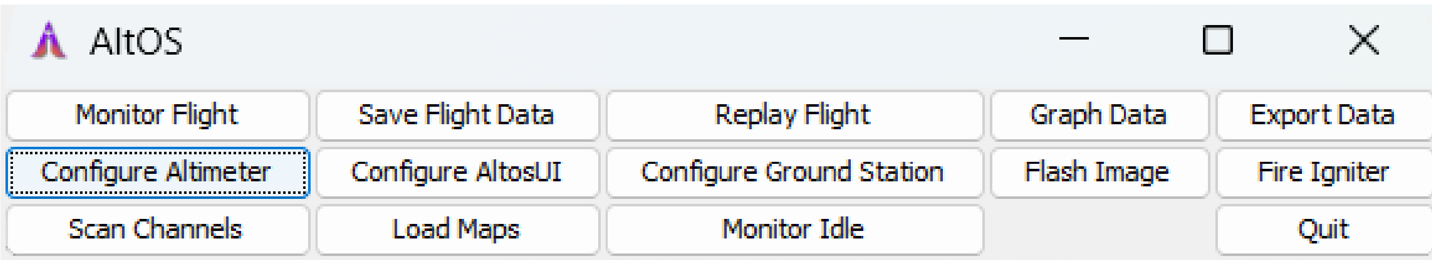
Use of the TeleMega / EasyMega

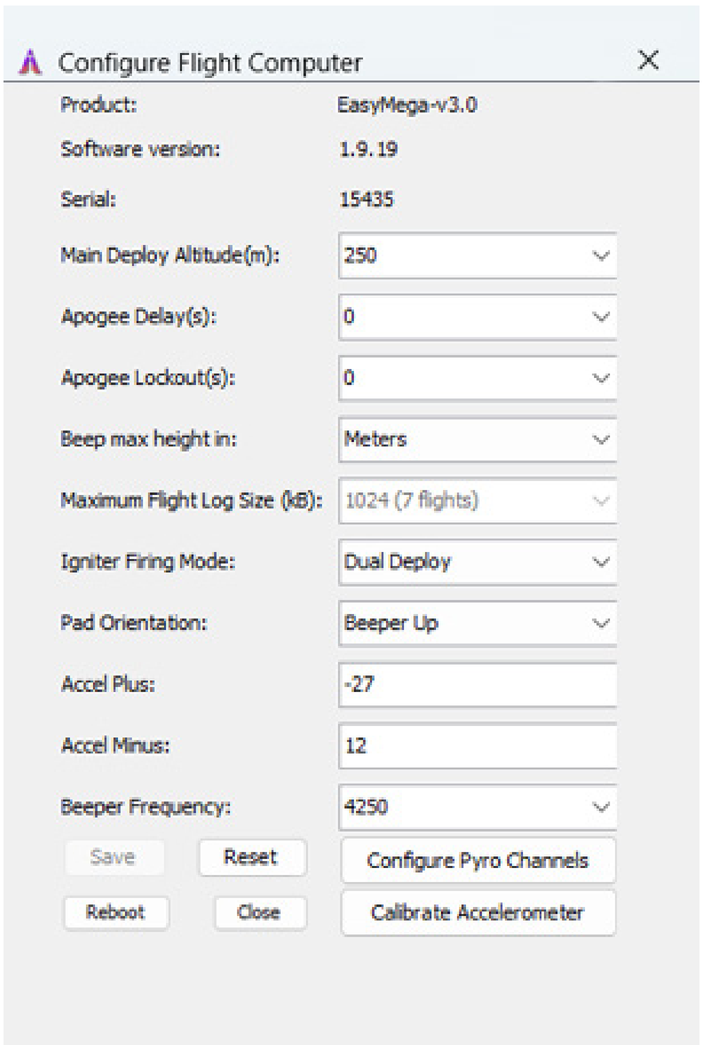
From the standpoint of air starts, there is no fundamental difference between the Altus Metrum TeleMega and EasyMega. The difference is essentially limited to the TeleMega's telemetry capabilities. As such, these two will be considered together. To configure these devices, the AltOS software should be downloaded from the Altus Metrum website (https://altusmetrum.org/AltOS/). This software is available for a wide variety of systems since there are versions for Windows, OSX, and Linux.

The Altus Metrum devices have two channels with minimal programmability intended for more standard dual-deployment uses, and four highly-programmable channels (A through D) with significant flexibility. Plug the flight computer into the computer through the USB port and start up the AltOS software.

The AltOS main window is composed of several rows of buttons that open different functional parts of the software. To configure the device for air starting, open the "Configure Altimeter" window, then click on the "Configure Pyro Channels" button toward the bottom of the dialog. This will open the Pyro configuration window that allows for the configuration of the A-D pyro channels (Main and Apogee channels cannot have custom configurations). There are many ways that the channels can be configured; in fact, channels can be configured for time-triggered, velocity-triggered, and angle-triggered operations with various safety features enabled.

For example, to configure the output to be fired at burnout of the first stage, the "After Motor number" parameter can be selected and set to 1. The configuration can also include a "height above the pad greater" parameter (for altitude lockout) and an "angle





On startup, the AltOS software displays a matrix of buttons which provide ready access to all the included functionality.

Basic flight computer configuration and status are shown on the first configure screen, but detailed control of individual pyro channels is shown in the Configure Pyro Channels dialog

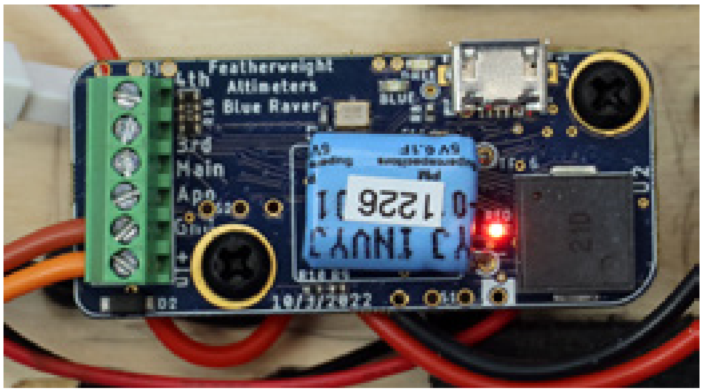
from vertical less than" parameter (for angle lockout). By using "Time since launch greater than" it is possible to do a time-triggered configuration. At the same time "Angle from vertical less than (degrees)" allows for an angle-triggered configuration, and "Ascent rate less than (m/s)" allows for velocity-triggered configurations.

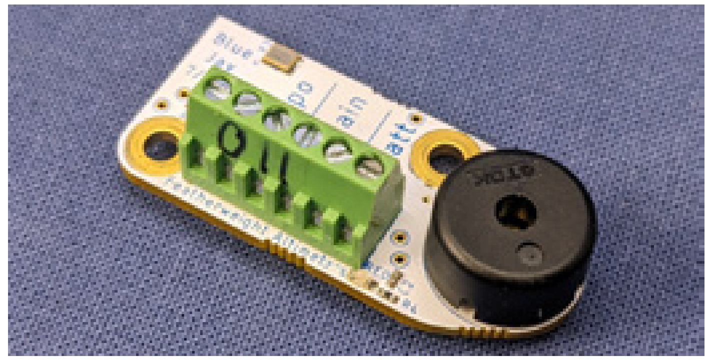
The different settings must be enabled with the check marks and the conditions are then combined such that the channel will only fire if all conditions are true at the same time. The pyro channel firing time can be configured as well, though it applies to all of the pyro channels equally.

The Altus Metrum devices also provide a ground testing functionality. Still, extreme care should be taken when conducting ground tests because they require a direct connection to a computer for non-telemetry models (e.g., the EasyMega). The telemetry models such as the TeleMega are able to trigger ground tests remotely and can be, therefore, much safer.

Use of the Blue Raven/Blue Jay Plus

The two Featherweight Altimeter devices, the Blue Raven and the Blue Jay Plus, are designed for use with mobile devices such as smartphones and tablets. This allows for easier access to information and reconfigurability while at the field. Because there is no direct connection though, they both require a battery to be con-



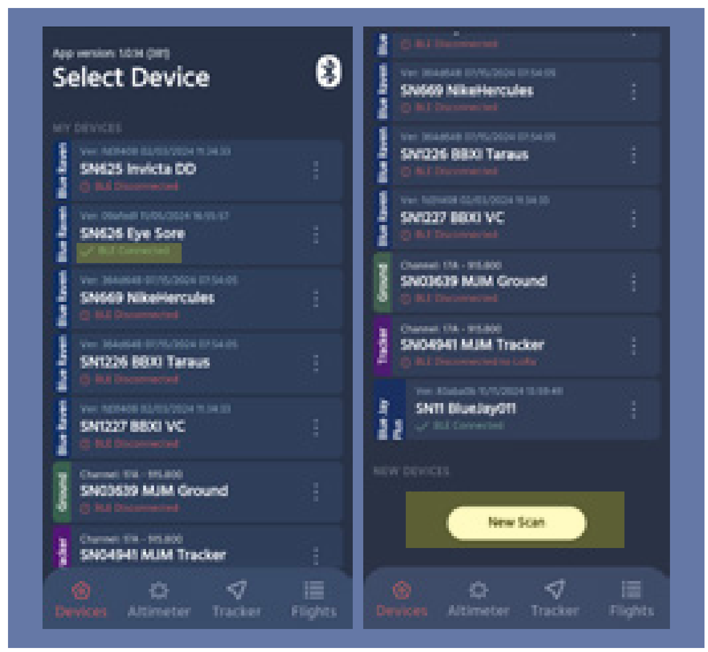


Left to Right: Featherweight Blue Raven Altimeter, Blue Jay Altimeter, Shipped and Sold at Apogee Components

nected when configuring, unlike the previously described devices. One limitation of the Blue Jay Plus that must be kept in mind is that its pyro channels are limited in the amount of current they are able to reliably handle and so are limited to firing e-matches (such as the Firewire and Firewire mini). As such, standard Aerotech and Estes motor igniters are not supported by the Blue Jay Plus hardware. The configuration capabilities, however, are very much the same between the Featherweight offerings.

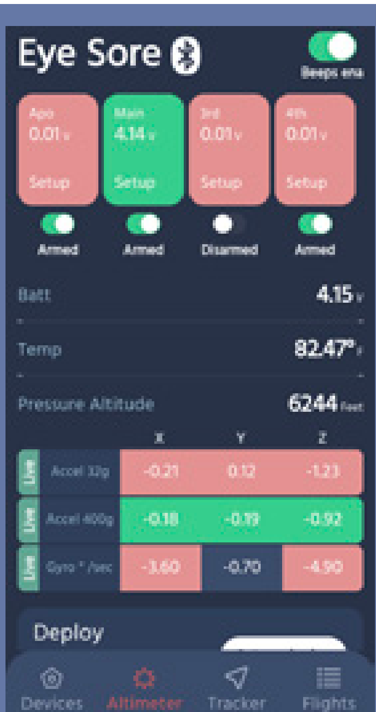
To program the Featherweight altimeters, they are paired with a phone or tablet through bluetooth. Opening the Featherweight UI app (which is available through Google Play or the Apple Store), the first important screen is the Device screen which displays previously connected devices, currently connected devices, and allows for forcing a new search for devices. In most cases, the altimeter will be detected as soon as it is powered up and the system will connect to it automatically. If this doesn't happen, the "New Scan" button at the bottom of the screen will force this to happen.

The Altimeter tab includes real-time information about the status of the altimeter and will be used to check that the altimeter is in a valid state prior to launch. It also provides access to the majority

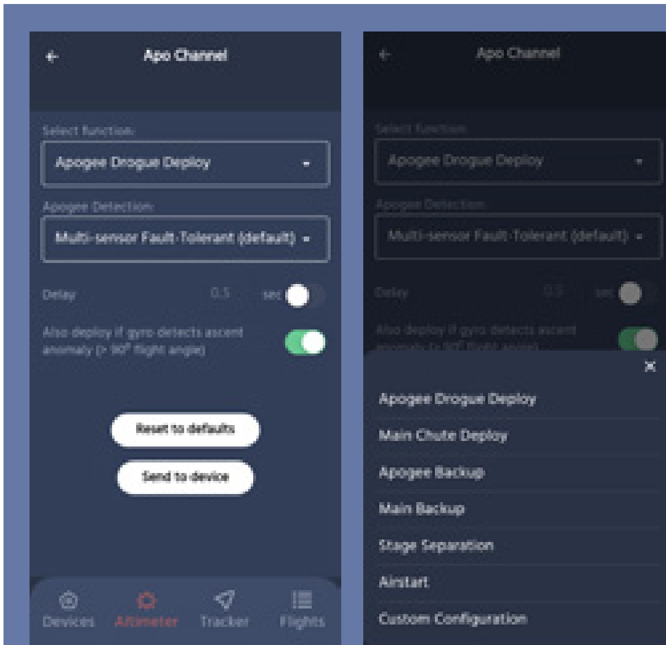


The device screen shows all previously connected devices in a list, and highlights the actively selected device. At the bottom, there is the New Scan button that lets you force a scan in case a new altimeter is not detected when it is powered up.

of the functionality that the Blue Raven and Blue Jay provide, such as Ground Testing, Simulations, and, of course, configuration. Any value that is displayed in a red box represents a value that is outside the expected (or desired) range, while values in a green box are within the expected range and are, therefore, valid. It should be noted that while the altimeter is moving, the acceleration values are likely to move in and out of validity as the altimeter is looking for a constant gravitational acceleration. When the rocket is moving (even just vibrating) this is unlikely for the acceleration to be consistently in range. The status of the pyro channels is represented across the top with green channels having continuity and red channels having no continuity. It is also worth noting that each pyro channel can be individually armed. The default air start configurations on the Featherweight altimeters will power up disarmed and **must** be manually armed prior to flight for the channel to ignite the motor. This auto-disarm functionality can be changed in the configuration.



The altimeter screen here shows a Blue Raven ready to launch. Only the main channel has an installed igniter and it shows good continuity and is armed. The battery voltage is good, and all the sensors are within believable ranges.



Here the Apo channel is configured as an Apogee Drogue Deploy, no delay. There are lots of config types to choose.

To configure a pyro channel on the “Blue” altimeters, tap on the pyro channel to bring up the config screen (there is also a “Deploy Logic” button further down that will get you to config as well). The top option box on the screen selects the basic type of configuration that is desired. The Blue Raven and Blue Jay Plus both provide fully custom configurations (with a huge amount of functionality) but will generally use simplified configurations that allow for a more obvious setup. By default, the Apo and Main channels will be configured for deployment at apogee and main deployment, but all of the available channels can be configured in any way desired. For basic air starting configurations, select the “Airstart” type.

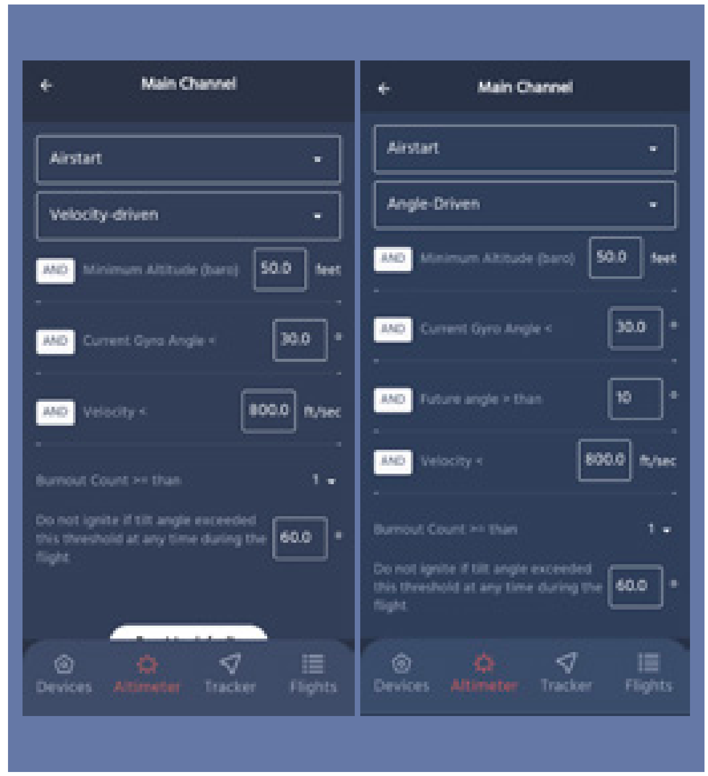
By default, the Blue Raven and Blue Jay Plus provide two standard sub-types of air start configuration: velocity-driven and angle-driven. These two subtypes both offer complete safety lockouts but provide differing approaches to timing the motor for altitude optimization. Basically, the velocity-driven configuration will fire the channel as soon as the velocity drops below a configured target velocity and the angle-driven version is designed to target as soon as the future angle from vertical (the angle predicted for 3 seconds in the future) is greater than the configured value.

Time-based air starting (with safety lockouts) is possible as well if the Custom Configuration option is selected. A basic configuration may use the “Time after Launch” condition in addition to altitude, and current gyro angle to implement such an event. By selecting the AND button on the left, that condition will be included in the final configuration.

Due to the complexity of custom configurations, they should only be used if absolutely required as the built-in “standard” configurations, are much quicker to use and check for correctness. However, the flexibility of the Featherweight altimeter custom configurations allows for unrivaled programmability. It might be noted that the Stage Separation configuration could also be used for time-based air starting but it does not include safety features such as altitude or angle lockout, and so is not a particularly safe option.

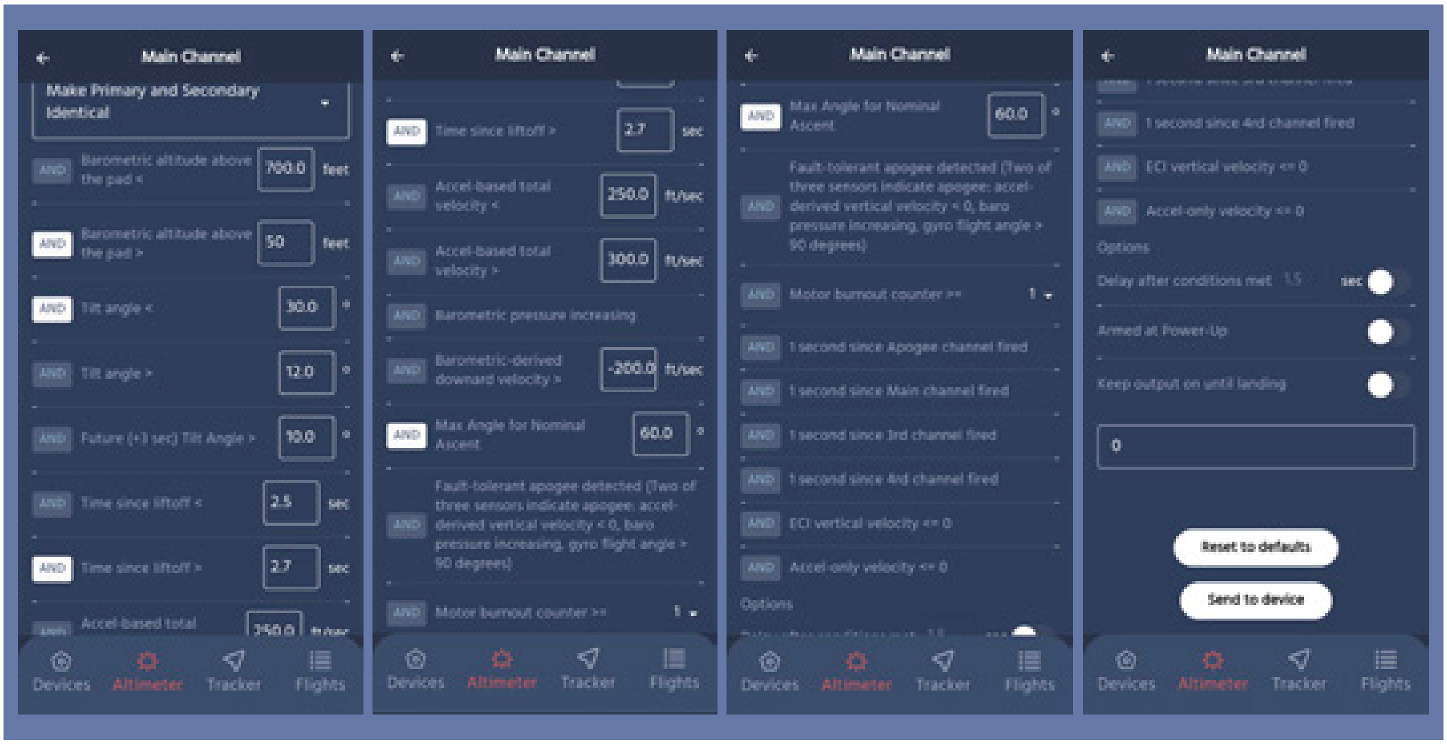
Both of the Featherweight flight computers support ground testing using bluetooth for initiation of the test. This allows for separation test to be completed safely. During the test, data is recorded on the flight computer, including things such as voltage and current, while the video recording capabilities of the mobile device are used to record high-speed video. These running together allows for interesting possibilities for synchronized data analysis. The ground testing functionality, as is typical for ground testing, allows for testing of only a single pyro channel at a time.

A further outstanding feature that the Blue Raven and Blue Jay support is simulated flights. When running a simulation, the Featherweight UI interface on the phone allows the configuration of acceleration and burn time for one or more stages with the staging being triggered, potentially, by the configured pyro channels. This



Main channel will fire as soon as the velocity drops below 800 ft/sec, so long as at least one burnout has been detected, the altitude is above 50 feet, the current angle from vertical is less than 30 degrees, and the tilt angle has never been greater than 60 degrees.

In the angle-driven case, there are two conditions that must be met for the channel to fire, the velocity must be below 800 ft/sec and the future angle must be greater than 10 degrees. Similar lockout conditions are provided as the velocity-driven case where altitude and tilt angle are used to validate the safety of firing the motor.



allows for testing of the complete flight profile and all the events in a safe way. It must be noted, however, that the physical pyro channels are active during a simulation run. If igniters are connected, THEY WILL FIRE, during a simulation. This has the distinct advantage of allowing an all-up test of the hardware, but it also requires care as running a simulation on a fully prepped rocket could lead to a deployment on the ground or, worse still, the ignition of a motor.

A custom configuration allows lots of conditions, only five of which are used here to safely trigger a channel 2.7 seconds after liftoff is detected.

Conclusions

Across the board, I would prefer that any rocket using electronic staging also have electronic deployment. If a rocket is simply air starting peripheral motors, an argument could be made that the motor deployment using the central motor is safe with no electronic backup. In the case of staging, however, the result of an ignition failure is likely to be a rocket coming in ballistic should no electronic backup be provided. This is an unacceptable result that should be actively expected and avoided.

In a similar vein, I prefer electronics with as many safety features as possible when in control of an air start motor. A multi-stage flight that fails to stage because of an altitude or angle lockout, is frustrating… but vastly preferred to a flight that “successfully” lights a motor in an unstabilized attitude leading to near horizontal flight or even powered flight toward the ground.

Ultimately, the question that needs to be answered is “Which electronics should I get?” As mentioned at the beginning, I can’t answer that question with a single device. Nor can Apogee, as a company, can’t answer that question. As Tim often points out, the stated goal is the most important component of answering such a question.

One needs to consider the modeler’s unique needs and desires. All of the electronics outlined in this article will allow one to light a motor with the rocket already in the air. But, all of the devices have different features and limitations. The electronics that are best for any one modeler might be unsuitable for another due to size, cost, flexibility, or ease of use. It may be that using a combination of electronics (say one device for staging and another for recovery) leads to a cleaner installation. And, some projects may be dependent on the availability of high-resolution data logging while other projects will see absolutely no benefit from it.

Special-purpose electronics such as the Simple Timer make lighting a motor in flight simple, while highly flexible devices like the Blue Raven allow precise control of flight events. Neither of these approaches is wrong, or even "better" in any objective way.

My current favorite flight computer is, without a doubt, the Blue Raven. I was initially incredulous regarding the value of a Bluetooth connection to my phone, but I was quickly won over. For my job, and in my personal hobby projects, I need ready access to flight data to help me understand what is and is not working on rockets I'm developing. The Blue Raven makes this extremely easy. This last NARAM, I flew a three-stage Black Brant XI model with two Blue Ravens. Because of the size constraints, I couldn't have done it with any other electronics on the market at that time (the Blue Jay—only recently released—would have been an even better option). The result was a complex and expensive flight. In a rocket two times the size, I likely would have strapped in 2 Simple Timers, and been done with it. But that would have left me without the data that made it possible to analyze the flight failures I had.

Here at Apogee Components, we are always happy to talk to our customers about which electronics might be best for their application. There are more electronics coming onto the market all the time, and that can lead to confusion. Hopefully, this article has provided some insight into a less "typical" application of the electronics available and will provide a foundation for the exploration of electronics in future projects

About the Author:

Martin has been designing and building rockets for as long as he can remember. After originally toying with the idea of pursuing a career in Aerospace Engineering, he decided to double major in Computer Science and Fine Arts, spending a decade working in K-12 math & science education. He joined Apogee Components as the Product Designer in 2022.

SUBMITTING ARTICLES TO APOGEE

We are always looking for quality articles to publish in the *Peak-of-Flight* newsletter. Please submit the "idea" first before you write your article. It will need to be approved first.

When you have an idea for an article you'd like to submit, please use our contact form at **https://www.apogeerockets.com/Contact**. After review, we will be able to tell you if your article idea will be appropriate for our publication.

Always include your name, address, and contact information with all submissions. Including best contact information allows us to conduct correspondence faster. If you have questions about the current disposition of a submission, contact the editor via email or phone.

CONTENT WE ARE LOOKING FOR

We prefer articles that have at least one photo or diagram for every 500 words of text. Total article length should be between 2000-4000 words and no shorter than 1750 words. Articles of a "how-to" nature are preferred (though other types of articles will be considered) and can be on any rocketry topic: design, construction, manufacture, decoration, contest organization, etc. Both model rocket and high-power rocket articles are accepted.

CONTENT WE ARE NOT LOOKING FOR

We don't publish articles like "launch reports." They are nice to read, but if you don't learn anything new from them, then they can get boring pretty quick... Example: "Bob flew a blue rocket on a H120 motor for his certification flight." As mentioned above, we're looking for articles that have an educational component to them, which is why we like "how-to" articles.

You can see what articles and topics we've published before at: **https://www.apogeerockets.com/Peak-of-Flight?pof_list=archives&m=education**. You might use this list to give you an idea or two for your topic.

Here are some of the common articles that we reject all the time, because we've published on these topics before:

- How to get a L1, L2, or L3 Cert
- Building cheap rockets and equipment (pads & controllers)
- How to 3D print parts, or a Rocket Kit
- How to Build a cheap Rocket Kit
- Getting Back Into Rocketry After a Long Hiatus

ARTICLE & IMAGES SUBMISSION

Articles may be submitted by emailing them to the editor. Article text can be provided in any standard word processor format, or as plain-text. Graphics should be sent in either a vector format (Adobe Illustrator, SVG, etc.) or a raster format (such as jpg or png) with a width of at least 600 pixels for single column images or 1200 pixels for two-column images. It is preferable for images to be simple enough to be readable in a two-column layout, but special layouts can be used.

Send the images separately via email as well as show where they go by placing them in the word processor document.

ACCEPTANCE

Submitted articles will be evaluated against a rubric (available here on our website). All articles will be evaluated and the results will be sent to the author. In the evaluation process, our goal is to ensure the quality of the content in *Peak-of-Flight*, but we want to publish your article! Resubmission of articles that do not meet the required standard are heavily encouraged.

ORIGINALITY

All articles submitted to Peak-of-Flight must not run in another publication before inclusion in the *POF* newsletter, but it may be based on another work such as a prior article, R&D report, etc. After we have published and paid for an article, you are free to submit them to other publications.

RATES

Apogee Components offers **$300** for a quality-written article over 2,000 words in length. Payment is pro-rated for shorter articles.

WHERE WILL IT APPEAR?

These articles will mainly be published in our free newsletter, *Peak-of-Flight*. Occasionally some of the higher-quality articles could potentially appear in one of Tim Van Milligan's books that he publishes from time to time.

Cloud of Bats Rocket Plan

by Martin Jay McKee

Do your recent scratch-build endeavors lack tedium? Do you find that too few club members are fleeing vermin at launches these days? Do you wish that you could do the work for a dozen flights for only one? Then have we got a plan for you!

Introducing, the Cloud of Bats!

With just a couple of recent additions to the Apogee staff, the office has become a hotbed of (good-bad) ideas. Acting as sounding boards for one another, we have started coming up with more and more elaborate (and difficult) rocket ideas. We decided some months ago to attempt to build more holiday-related rockets to bolster our social media visibility and so we started planning for a Christmas rocket. As those discussions were happening, it was mentioned that the October Odd-Rocket launch at our local club (SCORE) was coming up just before Halloween and that it would be cool to create something for that as well. We had just recently done a build-and-fly event with gliders so we've had gliders on the brain and it didn't take long to connect gliders and Halloween with

Cloud of Bats Rocket, Fully Assembled with Bat Gliders

Part Number	Build Quantity	Description	Purchase Quantity
10100	2	AT-24x18" Tube	1
10141	2	AT-41.6x18" Tube	1
10544	Optional	BT-60 Ebay Kit	1 (Optional)
13009	1	AC-24 Coupler	1
13019	1	AC-41.6 Coupler	1
13032	1	CR-18/24	1
13037	1	CR-24/29	1
13057	1	1/4" x3" Launch Lug	1
14099	2	1/8" x 3" x 18" Balsa	2
14098	2/3 Per Bat	1/16" x 3" x 18" Balsa	2/3 Per Bat
15016	3	CR-24/41.6 Cardstock	1
20069	1	PNC-41.6 Nosecone	1
24049	1	"E-Size" Engine Hook	1
29093	1	24" Nylon Parachute	1
30326	1	300# x 10' Kevlar	10
Available from Amazon or other Retailers	n/a	0.020" (0.5mm) Thick Acrylic	n/a
Available from Amazon or other Retailers	n/a	Stencil Material	n/a

bats. Several ideas were concocted in quick succession including a coffin-shaped rocket with internal gliders and standard parasite gliders. But my thinking went more toward bats as a creature – they live in colonies. So I wondered, what's the collective noun for bats in flight? Well, there are multiple, but the one I liked the best was "cloud." And, for a cloud, a single parasite glider wasn't going to cut it. How about three, or nine…, or eighteen!? So that was it. My plan was to design a small glider that looked like a bat and a carrier rocket that could hold at least a dozen of said gliders. How hard could it be?

T-3 weeks to the launch.

Little Brown Bat (Myotis lucifugus)

For no reason other than a silly dedication to the gag, the gliders are dimensionally and aesthetically based on the Myotis lucifugus species of bats, commonly known as the Little Brown Bat. They have a distribution over much of the northern sections of North America. Nevertheless, they are now officially endangered due primarily to white-nose syndrome, a fungal disease that has decimated their population. In addition, they also face the threat of habitat loss… an unfortunate one-two punch.

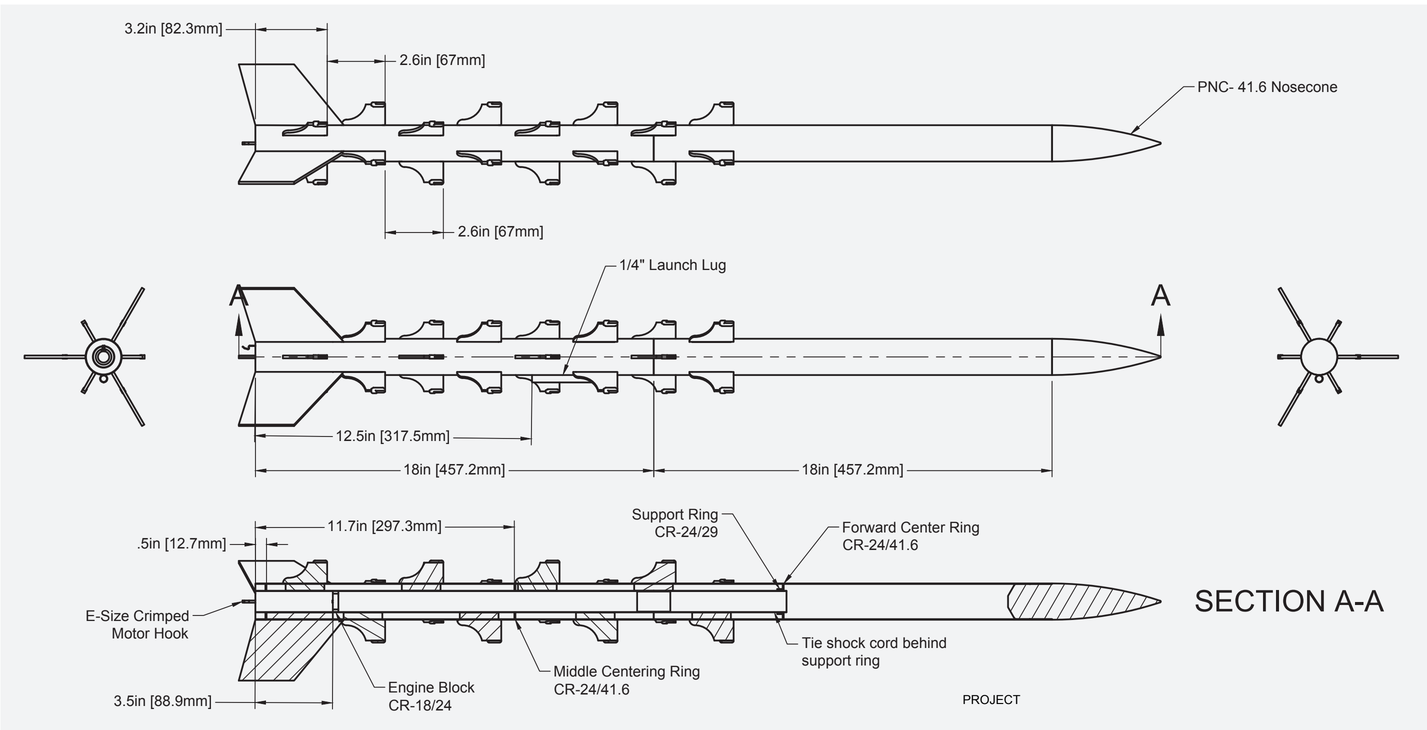
Despite their recent reduction in numbers, the Little Brown Bat is one of the most recognizable bats in North America. It is a small insect-eating bat of the Myotis genus, a genus commonly known as the "mouse-eared" bats. Named for its dark brown fur, the Little Brown Bat is a highly adaptable species often found near water sources such as lakes, rivers, and ponds, where it feeds on insects such as mosquitoes, beetles, and moths.

A Little Brown Bat during hibernation (By U.S. Fish and Wildlife Service Headquarters)

Notes on the Cloud of Bats

The final design of the Cloud of Bats rocket is a BT-60 size rocket with a 24 mm motor mount and mounting locations for 24 (two dozen!) of the bat gliders. For its maiden flight, it only carried 12 bats as it was an extremely busy day and we did not wish to halt launching too long with the full two-dozen bats strewn about the field. However, it flew exceptionally well on the relatively mild Aerotech D13. If I were rebuilding the plan, however, I would probably build it with electronic deployment as motors with short enough ejection charges are simply not available. Any flight is going to go well past apogee before the recovery system deploys if the Cloud of Bats is flown with a full load.

The construction of the carrier rocket is fairly standard except it was designed with through-the-wall fins. With three stabilizing fins and twenty-four bat standoff fins, that's a whole bunch of fin slots to cut. It would absolutely be possible to build it with surface-mounted fins, however, as this is not a rocket that is well suited to high thrust or high impulse flights anyhow. The rocket was built with slots mostly because they are so easy for us with the ability to laser cut them, and it made building everything in alignment much quicker. The fin marking guide included along with the plan can be used to mark the assembled tubes, and the fin templates have the



Cloud of Bats Rocket, Releasing Bats Gliders During Flight

Dimensional Drawing of the Cloud of Bats Rocket

tabs marked so the tabs can either be retained (to build the rocket as our model flew) or removed for surface mounting.

To provide additional support and rigidity, the motor mount tube goes through the entirety of the aft body tube and into the forward body tube. On the dimensioned drawings, it is constructed from one full-length (18”) AT-24 body tube, and an additional 6” section of AT-24, with a standard AC-24 coupler joining them. The motor mount tube can be constructed from any combination of lengths as long as the final length is 24” and there is space at the aft end for the motor to fit. There are also three centering rings on the motor mount tube, due to its length, but the centering rings are primarily intended to provide rigidity while the tube is installed. With through-the-wall fins, the entire body tube becomes very rugged.

The gliders themselves are constructed from a 3D-printed body, balsa wood wings, and a clear plastic vertical stabilizer. They were specifically designed to be easy for us to mass-produce in-house but they aren’t exactly difficult to build as long as you have access (or know someone who does) to a resin 3D printer. The wings have the traditional scalloped “bat” shape, so they are non-trivial to cut out by hand, but they aren’t particularly difficult either. And,

Bat Gliders are Mounted to the Main Rocket Body

the gliders are actually pretty stable without the vertical stabilizer (thanks to the sweep combined with dihedral). They do fly better with them and the vertical stabilizer shifts the balance point back, so not including them will require more clay to trim the gliders. It is best to cut out the vertical stabilizers with scissors as a hobby knife tends to slip on the thin acrylic.

The glider bodies have a slight curve designed into the back end of the wing slots to ensure that they each have a slightly raised elevator. The bats should all end up quite close to correctly balanced if built as designed. They should only require a small amount of clay to get them to glide well and to correct for lateral imbalance due to differing weights for each wing. Although it is possible to fly the Cloud of Bats without trimming the gliders (we did, due to lack of time to trim all 12 bats!), the flight will be significantly more impressive with the bats all trimmed for a clean glide.

The Cloud of Bats rocket has the highest stability margin with 12 bats mounted. With more than that the center of pressure moves forward significantly more quickly than the center of gravity. Even fully loaded, however, it is stable with a standard E12 motor given only the recommended 15g of clay in the nose.

The carrier rocket was painted in a simple yellow-orange gradient and then the decals were applied. The bats, on the other hand, ended up with fairly involved paint. First the bats were painted in a light brown. Then a medium brown was added for texture on the body. Once dry, a stencil was applied to mask the arms, legs, and body, and dark brown was sprayed onto the wings. Finally, black paint was airbrushed onto the nose and ears. Most of the time spent in constructing this rocket was spent painting the 36 bats that we built (to make sure we had enough, in case of damage or loss).

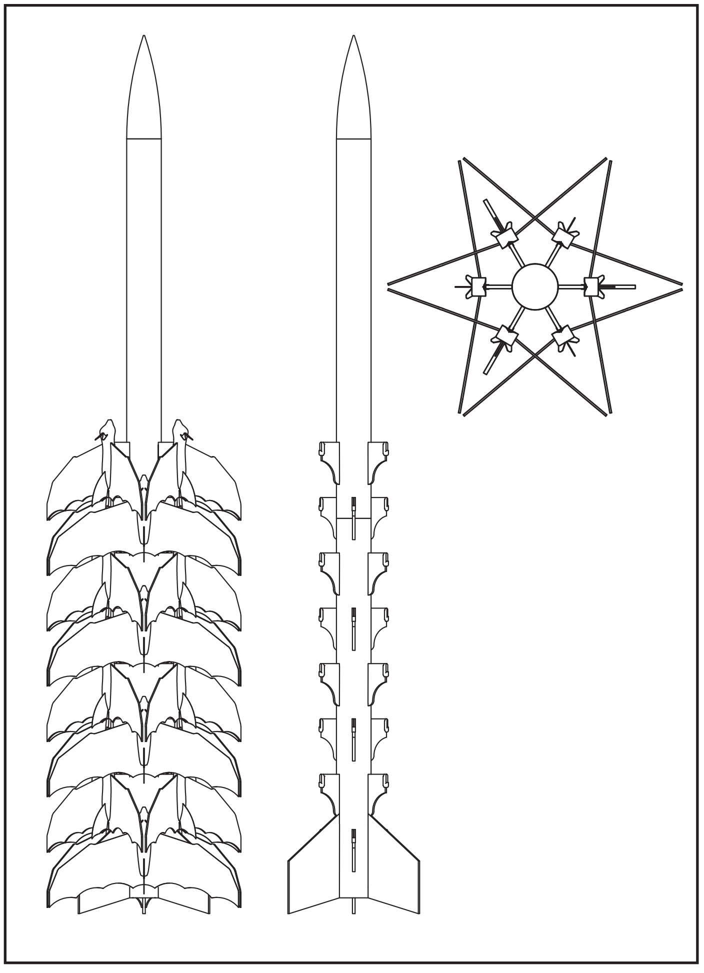
The decals were applied to the carrier rocket in a scattered pattern and were printed on clear decal paper. Vinyl was used for the prototype but clear waterslide decal paper would work just as well.

As mentioned before, one suggested modification would be to add electronics to deploy the parachute at apogee rather than relying on motor ejection. A simple approach to this is to use our BT-60 Ebay Kit and simply slide the assembled sled into the rocket beneath the parachute, with the shock cord cut in half and tied to either end of the sled. This has the added advantage of moving the center of gravity forward and, therefore, making a flight with all 24 bats mounted more stable. Of course, a cleaner solution would be to build the electronics into the rocket according to the instructions of the ebay kit.

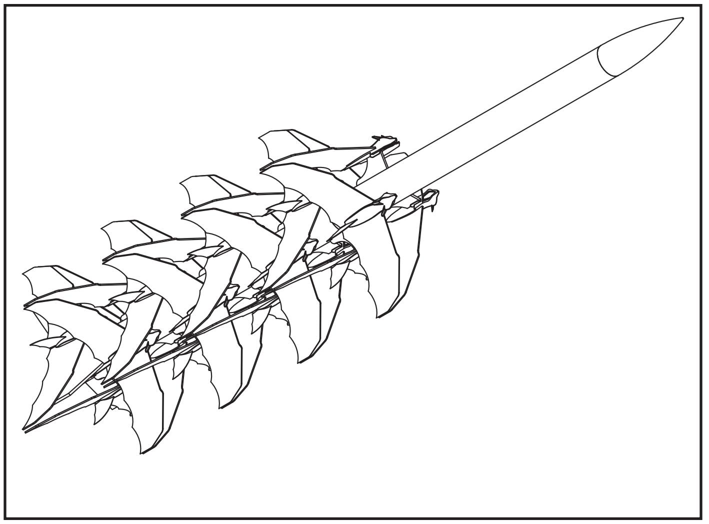
Always remember that the more bats are loaded and the higher you fly the Cloud of Bats, the longer it will take to track down all the gliders. While we didn't actually make the Odd-Rocket launch (due to weather, the Cloud of Bats was done), when we did finally fly it at the following launch, it took over two hours to recover ten out of the twelve gliders flown. And that was on a field with around 100 fliers. How many you are willing to fly is up to you. It should always be flown with a full rows of (three) bats each so that it is symmetrical and balanced. **Twenty-four bats is a lot!**

Rocket Diagrams

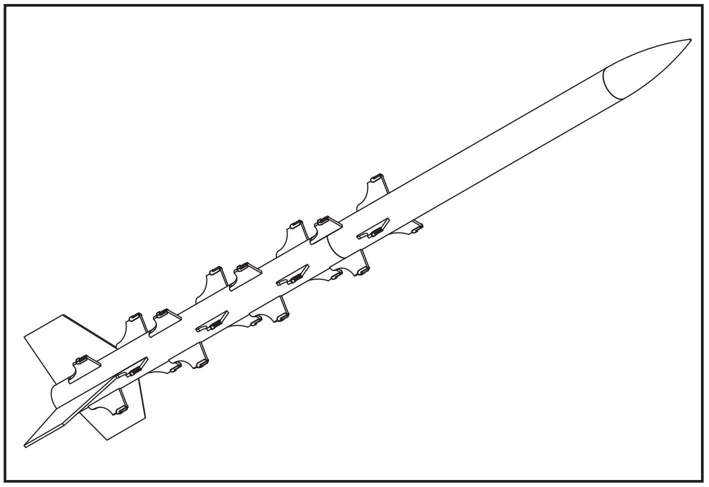
Use These Diagrams as Reference Material



(Left to Right) Side View — Loaded and Unloaded + Top View



Cloud of Bats Rocket Loaded Angled Isometric View



Cloud of Bats Rocket Unloaded Angled Isometric View

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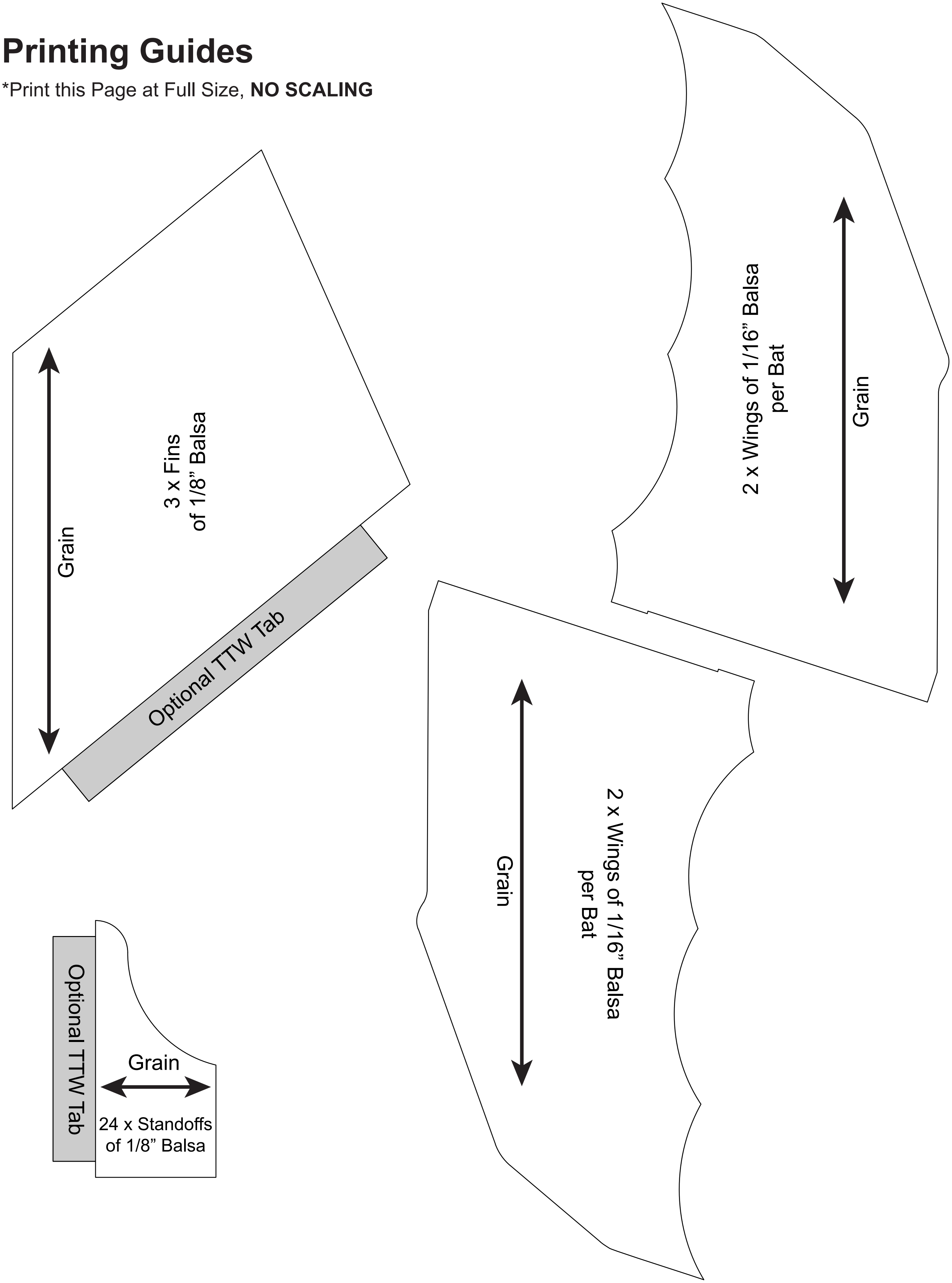

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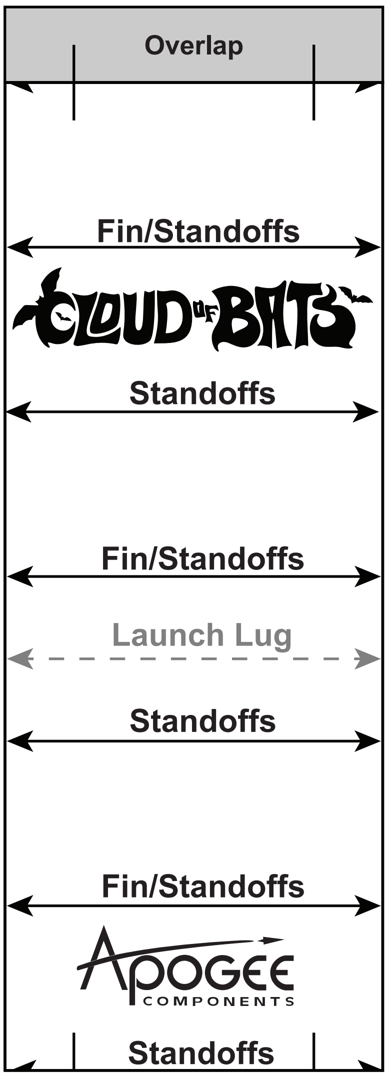

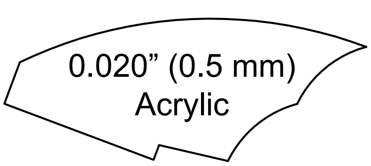

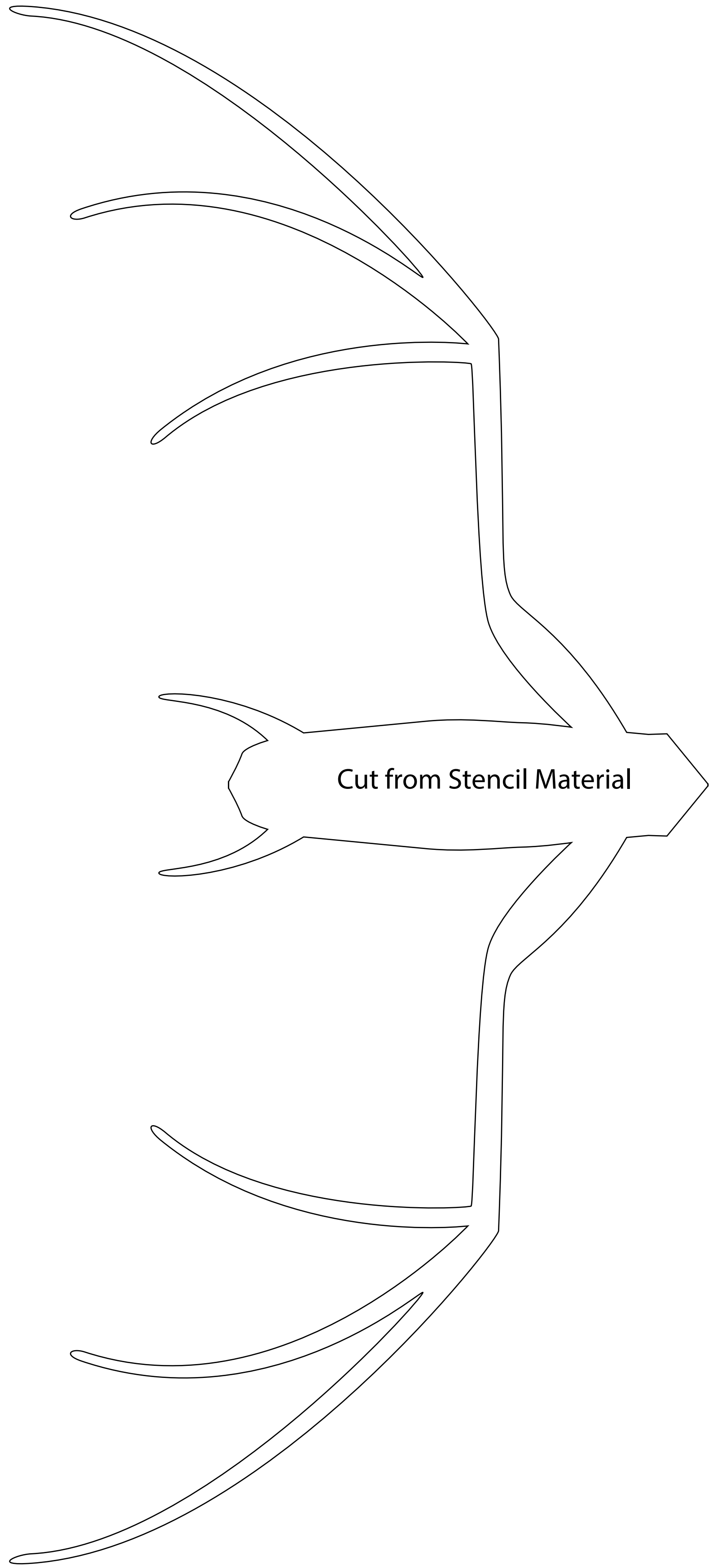

Cloud of Bat Rocket Decals

*Decals Should Be Printed at 100% Size, No Scaling
| Each Individual Bunch of Bats is its own Decal

3d Print Files

3d Print Files can be found within the Rocket Plans section of the Apogee Rockets Website.

You can find this on our website at:
https://www.ApogeeRockets.com/downloads/rocksim_files/Cloud-of-Bats-Plan.zip

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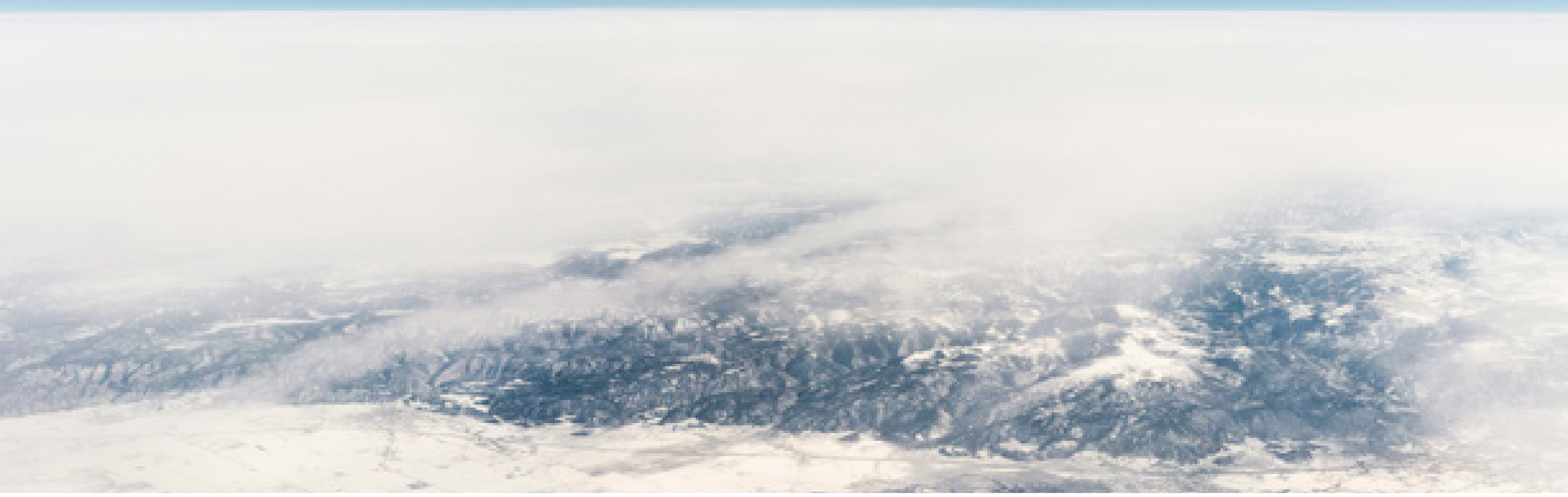

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