PEAK OF FLIGHT

NEWSLETTER

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PEAK OF FLIGHT

TARC Flight Report Sheet

By Tim Van Milligan

Way back in 1995, I created the Apogee Flight Record sheet (https://www.apogeerockets.com/Rocket_Books_Videos/Data_Sheets/Flight_Record_Data_Sheet) that I still personally use when I'm developing new rocket kits (**Figure 1**). The purpose of the document is to have a quick sheet that I can record the important information about how the rocket flew. It was designed as a check-box form that could be quickly filled out after a launch so that none of the important launch information would be forgotten.

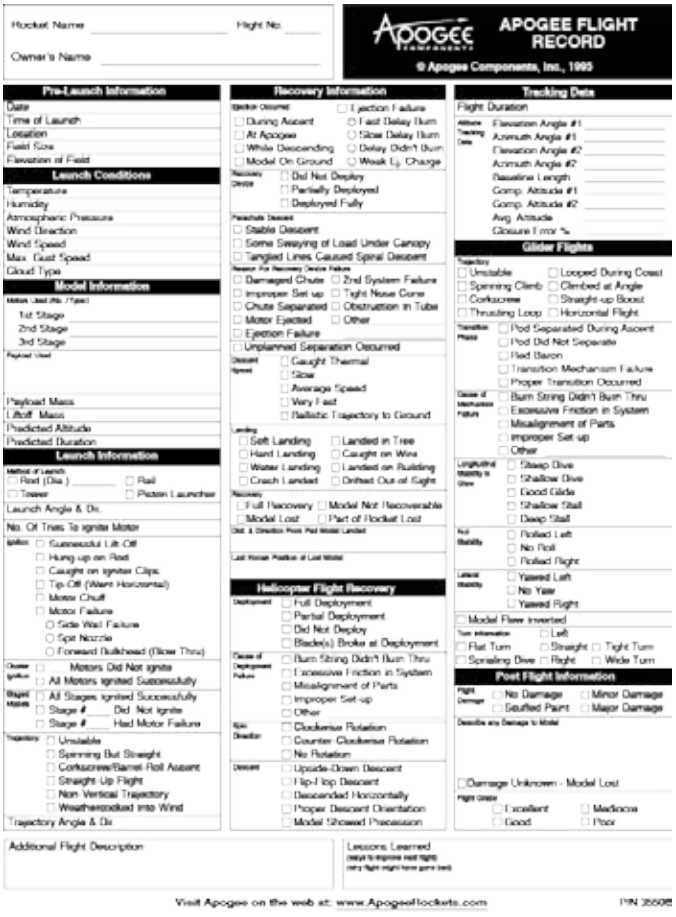

Figure 1: The original Apogee Flight Record data sheet.

The Apogee Flight Record was the basis for the new sheet that I specifically made to help TARC students. The original Apogee Flight Record was designed to collect information on all types of rockets, including gliders and helicopter recovery models. This is not needed for the TARC contest, so I thought I'd try to simplify it. But in the end, I added a lot more check-boxes that I think will be even more useful for TARC rockets.

In this article, I thought I'd explain what the items mean on the new TARC Flight Test Data Sheet. I know that most students are new to rocketry and may not know the meaning of most of the items on the list. And more critical to the mission objective, you should know why it is important to collect the information and how it can be used to make your next flight more successful.

You can download the TARC Flight Test Data Sheet from the Apogee Components website at:
https://www.apogeerockets.com/Rocket-Books-Videos/Data-Sheets/TARC-Flight-Test-Data-Sheet

The TARC Flight Test Data Sheet is used to collect the initial data from your rocket launch. This is termed "raw" data. Raw data is not processed or sorted in any way. It is like jotting down notes on a sheet of paper, although in this case the sheet is designed to prompt you on what I think are the most useful parts of data.

To use it best, you should fill it out on the launch field. There are some portions that can be filled in prior to launch, but most of it should be filled in immediately after the launch. Have a clipboard and a pencil in your hand as the rocket takes off.

Before the launch, have a group huddle and review the various sections so everyone knows what they should be looking for during the launch. Things happen very quickly during the flight, and if you don't remind yourself what you should be looking for, you'll miss it, I guarantee it. I've asked many observers of my flights which direction the rocket was spinning when it took off. Their answer: "It was spinning?"

You'll be kicking yourself later because you'll be missing key information because you weren't prepared to watch for it.

So, when you're holding your pre-launch huddle, be sure to include all the spectators too. Ask them to help you watch for the various events during the launch. It is not cheating to have extra witnesses of the launch, it is SMART!

Hold the pre-launch huddle, even if you plan on videotaping the launch. Most camera operators are not prepared for how fast a rocket takes off, and

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You can subscribe to receive this e-zine FREE at the Apogee Components website **www.ApogeeComponents.com**, or by clicking the link here Newsletter Sign-Up

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therefore most recordings only show the smoke trail following the rocket. Here's a hint: if you're videotaping, you need a camera with an eyepiece, not just a flip-out screen. Trust me on this… It greatly increases your chances of getting a good video of the rocket taking off.

Here's another trick to use to get someone else (like your parents) to retrieve your rocket for you. Start filling out the form as soon as the rocket takes off. When your parents see you huddled together over a clipboard making notes, they'll think that what you're doing is critical, and they will volunteer to get your rocket for you. Let them! Because, in fact, what you are doing when filling out the form is critical! The success of your next launch is more assured when you're recording information than if you were retrieving your rocket.

I would suggest you assign two students to work together and start filling it out as soon as the rocket takes off. As other students come back from their duties during the launch, they can give their insights and perceptions of the launch too.

Before you pack up your launch equipment and make the drive back home, hold one last group meeting to go over the flight. Make sure you've got the Flight Test Data Sheet completely filled out before you leave the field -- even if the launch was a complete success. The flight is still fresh in your mind, so your recollection will be the most reliable at this point. Be sure to include the observations from any outsiders that might have witnessed the launch. Their added insight is always important too. Especially if you've briefed them before the flight and asked them to be on the look-out for certain events too.

Speaking from personal experience, when I was on the Delta II rocket launch team, we would always have an all-hands meeting immediately after every launch. It was a way to make sure that our next launch would meet its mission objectives as well. What you're doing here with this meeting will have the same effect on your project too. You'll get to your goal a lot quicker.

Later, when you get back to school to start working on your next launch, you will probably take the data from this sheet and condense out a summary sheet. For example, you'll probably keep a log of the altitude and the duration of the flights you've made to show your progress on zeroing in on the mission objectives. That is great.

But what happens if you've had 10 launches that were getting closer to the objectives and all of a sudden, you've got one that wasn't so good. You'll want to get out your original TARC Flight Test Data Sheets and see what changed and could possibly cause the rocket to stray further from the objectives. So, don't lose the sheets! Save them in a 3-ring binder so you can quickly go back and find the data when you need it.

The Information on the Datasheet

Rocket Name _____ Flight No. _____

TARC Team Name _____

Figure 2: Title section of the data sheet

Why record the rocket name? Because it will help you remember which version of the rocket you've launched. In your progression in the contest, you'll build and launch several different rockets. You want to be sure to keep things sorted so you can better remember which flight you're discussing with your team.

I would highly suggest that you use the same name that you used on the computer design file. So, if your computer RockSim file was called "TARC Design Version 1," use that for your rocket name in this section. It will make more sense later rather than coming back to this data sheet and the name was in honor of your school's mascot, like "The Tiger Spirit."

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The TARC Team Name is on the title block because many schools will have multiple teams in the contest. If you all go out to launch on the same day and your paperwork gets mixed up, you can sort out later which sheet belongs to which flight.

The "Flight No." can be used to record the order in which the rocket was launched. I would suggest you use it to track the number of the flight that was launched on that specific day. For example, say that on both Monday and Tuesday you launched 3 rockets each day. You would have two flight number 1's in the binder. This may sound confusing, except when you try to remember the specifics of the flight. For example, when on Thursday you get together with your group and you ask, "do you remember the first flight we made on Tuesday?" Isn't that more likely to bring up a memory than if you asked: "do you remember flight number 4?" The person will probably respond by asking: "was flight number 4 the first flight on Tuesday?" Yes, it was. But it is easier to remember it by calling it the first flight you made on Tuesday.

Pre-Launch Information
Date
Time of Launch
Location
Field Size
Elevation of Field

Figure 3: Pre-Launch Information section

In the Pre-Launch Information section, you'll record the date and time of launch. This can be used to remind yourself later about the day's events.

The location will probably be generic, like "city football field." But you can be more descriptive if you want, by recording the longitude and latitude of the launch range.

The field size will probably be approximated at this point. That is ok. We just want to record it for future reference. For example, say your rocket drifted away after it was launched. On the next flight, you'll probably want to find a bigger field so that recovery of the rocket can be achieved.

The elevation of the launch site is recorded so you can go back into your RockSim simulations and try to duplicate the flight in computer simulations. By reproducing the flight in the software, you can zero in on the Coefficient-of-Drag (Cd) of your rocket, which you will need to make a better motor selection in the future.

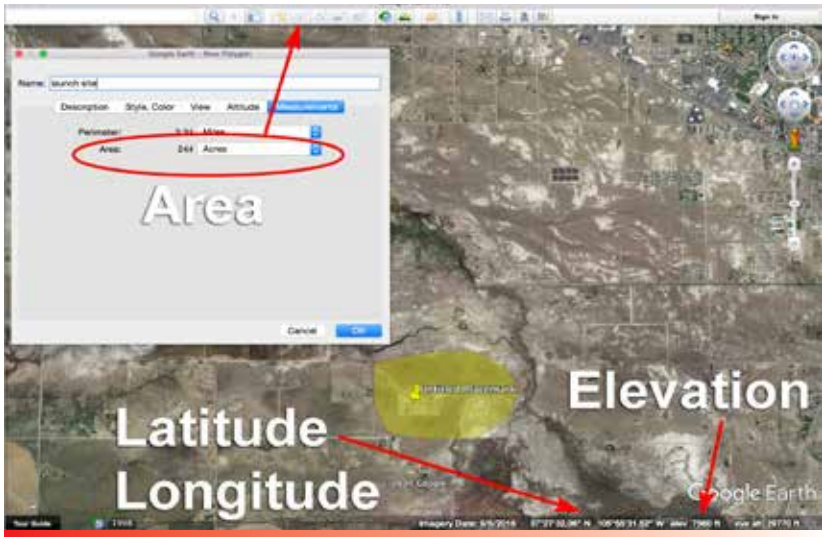

Figure 4: From the free Google Earth software, you can get the location, elevation, and the area of the launch site.

Where do you find the elevation of the field? Good question.

I would suggest downloading and installing the free Google Earth application for your computer. With it, you can get the elevation and the latitude and longitude coordinates of your launch site as seen in the bottom right corner of **Figure 4**.

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You can also use the perimeter feature to find the area of your launch site. Later, you will see how you can use Google Earth to find the distance and direction to the location where the rocket landed. This will be helpful information when you are trying to match the actual performance of the rocket with the computer simulations you performed.

Experiment Information
Changes made to rocket or launch set-up from the last launch? What do you want to test/accomplish in this launch?

Figure 5: Experiment Information

In the Experiment Information section of the TARC Flight Test Data Sheet, you'll record the changes made to the rocket or the launch set-up compared to the last launch you've performed. Why record this information? Because you never know when you might lose a sheet out of your binder where the information is kept. If the previous flight information sheet is missing, you still have a record of what changes you've made for this current flight.

If there were no changes, then write "No changes." If you leave it blank, and you come back to this page ten launches later, it will take you a lot longer to figure out what is different about this launch versus the previous one. You'll save yourself a lot of time and frustration by having something in this section. Try not to leave anything blank if you can help it.

You also might want to see a specific difference in this launch compared to the last one, which might be called your goal. Say the previous launches were arcing heavily into the wind and you wanted to try to reduce that tendency. Then you might say something like: "repositioned the fins to try to reduce the weathercocking." At the end of the flight, you can better draw conclusions to figure out if you were successful or not.

In the launch conditions section (**Figure 6**), you want to record the weather conditions at the time of launch. Again, the reason for this is so that you can try to duplicate the launch in your RockSim simulations. The closer you can come to mimicking the actual launch using the software, the faster (fewer launches) you will get to your mission objectives.

It helps to have a portable weather station with you on the field to take these readings. But if you don't, estimate as best as you can. The most important readings are the temperature and the wind speed. There are all kinds of weather apps for your smart-phone that you might try using too.

Launch Conditions
Temperature
Humidity
Atmospheric Pressure
Wind Direction
Wind Speed
Max. Gust Speed
Cloud Type

Figure 6: Weather conditions on the day of the launch

Model Information
Motors Used (Number and Type:)
Type of Altimeter:
Color of Rocket:
Distinguishing Features:
Payload Used: ☐ Eggs ☐ Simulated Eggs
Empty Mass
Payload Mass
Ballast Mass
Liftoff Mass

Figure 7: Model Information

The model information (**Figure 7**) is important because you want to document this model and how it differs from previous rockets you might have built for the contest. I suggest you put a print-out of the RockSim configuration into the binder stapled to the Flight Test Data Sheet for additional reference. Adding a photo of the rocket is also a good idea too. But this section on the sheet is specifically where you'll record the last-minute condition of the rocket.

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For the motors used, remember to include both the motor designation (called "Type") and the manufacturer, such as Aerotech F50-7. Sometimes there are two different manufacturers that make the same motor type so be sure to include the manufacturer. Some teams also like to include the "Lot number" of the motors. This is a specific number that the manufacturer puts on the motor to indicate what day it was made. If there is a problem with a motor, they'll go back to their records and pull up any information about the motors that were made on that day and try to figure out how it was different.

If you are using a cluster of motors (more than one ignited at the same time), be sure to include the number of motors from each type. For example, 2X Estes D12-5. The 2X is shorthand writing and means "two times," as I used two Estes D12-5 motors instead of just one.

There are three different altimeters approved for use in the contest. But sometimes you might want to use a different one for testing purposes. So be sure to include that information here.

The color and distinguishing features are recorded just in case you lose the rocket. If you do, you might go to the land-owner of the field and say: "I lost a red rocket that had a decal with our school mascot on it. If you find it, please give me a call."

Incidentally, you should write your contact information on each rocket, in the case it gets lost. If you put the word: "Reward" on the rocket, you'll probably get it back even faster. On my rockets, I write: "Reward! If found, please call 719-535-9335." That will reach me here at Apogee Components.

For your payload used section, you can quickly check off if you used real eggs, or simulated eggs for the flight. I suggest simulated eggs in the form of modeling clay for most of your flights. If you break real eggs, it can get messy.

The mass of the rocket is critical, so be sure to bring a portable scale with you to the launch field so you can get final weights right before launch.

The one mass you may not be familiar with is the one called "ballast mass." Ballast is extra weight carried on board that makes the rocket heavier. A heavy rocket doesn't fly as high as a lightweight one. So, if your previous rocket flew too high, and you didn't make any other physical changes to the rocket, you can add ballast mass to the model so it doesn't fly as high.

I like to use modeling clay for ballast mast. It is a little sticky, so you can press it to the inside of the tube and most times it will stay in place. You can also use sand as ballast too.

Launch Information
Method of Launch: ☐ Rod (Dia.) _____ Length _____ ☐ Rail Length _____
Launch Angle & Direction.
No. of Tries to Ignite Motor
Launch: ☐ Successful Lift-Off ☐ Hung-up on Rod ☐ Caught on Igniter Clips ☐ Tip-Off (Went Horizontal) ☐ Catastrophic Motor Failure ○ Side Wall Failure ○ Spit Nozzle ○ Forward Bulkhead (Blow Thru)
Trajectory: ☐ Straight-Up Flight (no spin) ☐ Spinning But Straight ☐ Corkscrew/Barrel-Roll Ascent ☐ Unstable ☐ Non-Vertical Trajectory ☐ Weathercocked Into Wind
Flight PathTrajectory Angle & Direction:

Figure 8: Launch Information

The first section of the launch information is where you can record whether you used a launch rod or rail to launch the rocket. For either method, record the length of the device so you can go back into RockSim later and use the information to try to duplicate the launch.

If you use a launch rod, there is a space to record the diameter. It isn't so important, but I like to have the information. If the diameter is small, the rocket can sway around and take off at an angle that you didn't intend. Just keep that in the back of your mind if you're trying to figure out why it didn't go in the direction you wanted.

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Next, you want to record the launch angle and direction that the launch guide (either the rod or the rail) is pointed.

To get this information, take out your smartphone and open the compass app. Point the phone in the direction that the rail is aimed, and write down the direction. You can also get the latitude and longitude of the launch pad. This will also come in handy when you retrieve the rocket because you can note the coordinates where you picked it up so you can find the distance traveled.

Figure 9: From your phone, you can get the direction the launch rod was pointed toward, as well as the GPS coordinates of the pad.

At this point, you're ready to launch. The form includes a place where you can record the number of tries it took you to get the rocket to ignite. It's not especially important to the mission, but it helps you to remember that you should follow your launch checklist to make sure you have the igniter installed correctly.

Figure 10: With the same compass application on your smartphone, you can measure the angle from vertical that the rail was tilted.

Once the rocket fires, things start happening faster. If things go as expected, there isn't a lot of information to record. Hopefully, you'll just check the box that says, "Successful Lift-Off." This means the rocket exited the launch rod and started its journey into the sky.

Everything else in the "Launch" section of the data sheet is an undesirable occurrence.

"Hung-up on Rod" means the rocket fired successfully, but it didn't exit the pad and actually get into the sky. Usually, this means the launch lugs were misaligned and there was too much friction for the motor to overcome.

"Caught on Igniter Clips" means the wires from the launch controller entangled the rocket and prevented it from leaving the rod. The most common occurrence in this category is that the wires get looped over the top of a fin.

"Tip-Off" is the term we use when the rocket exits the rod and immediately makes a horizontal turn and doesn't go "up." Tip-off can be caused by a couple of things. One issue is if the wires from the launch system don't release from the rocket at ignition.

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In that case, they are dragged upward by the rocket and yank the rocket in an unpredictable direction like playing a game of crack-the-whip.

Another possible cause of tip-off is when the launch rod is swaying around in a breeze. If the rocket leaves the pad when the rod is moving around too much, it will leave in a direction you didn't intend it to go.

A brief but sudden gust of wind could be another cause of tip-off. You just never know when a microburst of wind may happen…

Finally, you may have a motor failure. We call these Catastrophic Motor Failures, or "CATO" for short. Most people just say in hillbilly dialect: "the rocket done blowed up." But know that true CATO's are rare. Model rocketry is actually a very safe activity. However, there are usually three types of CATO's.

The first is the "Sidewall failure." You'll notice it by the fire from the motor that comes out the side of the rocket and burns the tube and a probably a fin too.

Second is the "Spit Nozzle." Like the name suggests, the nozzle on the back end of the motor comes flying out, like a watermelon seed that you spit out of your mouth. It ricochets off the blast deflector and scuttles across the ground.

Finally, a forward bulkhead failure is when the fire from the motor comes out the front end and torches everything inside your rocket. We also call these a "blow through" because it blew fire through the middle of the rocket.

The first thought from most modelers is that there was something wrong with the rocket motor. That may not be the situation at all. Remember, "true CATO's" are rare and model rocketry is very safe.

So, what happened? There is a lot of user involvement in the launch, and the CATO is more likely to be user induced than a true failure of the motor itself.

A lot of motors are "loadable" or "reloadable." That means the user assembles them, which opens a lot of chance for incorrect assembly. I'd say a large majority of failures at ignition are user error. Make sure to follow the assembly process carefully. Get a seasoned rocketeer to look over your shoulder and give you pointers too.

In the case of single-use motors, where they are pre-assembled by the manufacturer, there is still the chance of mishandling and subjecting the motor to harsh impacts. Don't drop your motors on the ground, it isn't good for them… The motors are essentially balloons with a tough outer shell. You can cause micro-cracks in the wall of the motor case by dropping them hard on the ground. And then when the pressure comes up in the motor at ignition, the walls of the case pop open spewing the hot gas out the side of the rocket.

Additionally, black powder motors do not tolerate temperature or humidity cycling. The paper case can expand and contract due to high swings in temperature or humidity. Store them in a place where they would be as comfortable as you would be if you had to sleep there.

Using the wrong igniter can also cause problems, although this is a little rarer. It is usually where you have a different igniter that what came with the motor, and it has a huge pyrogen tip on it. If the pyrogen produces too much hot gas too quickly, it could over pressurize the case and cause it to burst. It's rare, and you probably won't see it in TARC rockets because the nozzles are too small to put an igniter with a big head into it.

The point is, most CATO's are caused by the rocketeer. I know this isn't much consolation, as we often tend to want to blame someone else for when things go wrong. Rocketry and space travel, as you will come to learn through the TARC program, is very unforgiving of user mistakes. Therefore, you should also use a checklist when launching your rockets.

If you call the manufacturer about the exploding motor, I guarantee you that they will ask you a dozen hard questions dealing with how you

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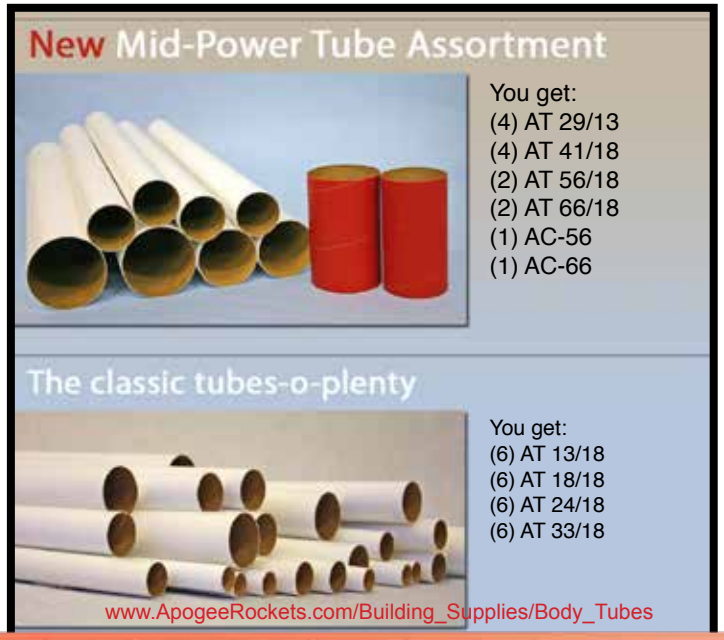
handled the motor once you purchased it. It's often embarrassing to have a rocket fail to launch, so handle the motors with respect and care.

In the "Trajectory" section, hopefully you'll check the box where the rocket went straight up. But chances are that there will be some spin to the rocket, so in that case, check the box where it was "Spinning but Straight." I would also write down the direction of the spin as seen from observers on the ground - either clockwise or counterclockwise. If your rocket is spinning, you have a fin canted slightly on the rocket or they have slightly different airfoils in them. If you're sanding your fins, be sure that they are all identical, or it will induce a spin.

But sometimes spin is good. For example, a spinning bullet flies straighter than one that doesn't rotate. So, you "might" want spin. This is something you'll have to experiment with when you are designing and testing your TARC rocket.

A corkscrew, also called a "barrel roll", is different than a simple spinning rocket. You'll notice it in the smoke trail left behind by the rocket as it takes off. It will look like a twisting corkscrew.

In this case, the rocket is spinning, but it is moving sideways at the same time. It can have a couple of causes. If your rocket has multiple engines, an imbalance of thrust can cause the spin. In other words, one motor is pushing harder than the other, causing the rocket to tilt a little bit to one side. But this tilt causes one fin to produce more lift and cause the rocket to roll (spin). This spin reorients the rocket to a different trajectory. It sounds complicated, but what it looks like is a corkscrew path.



The same thing can happen in a single-motor rocket where just one fin is attached crooked or has a different airfoil than the others. It can also be caused by the motor being tilted to one side. This is called "misaligned thrust."

The cork-screw flight is more or less straight, which is a good thing from a safety standpoint. But it is a very high-drag flight and the rocket never reaches its potential altitude. If your rocket is cork-screwing, you've got to go back and fix it, or you'll never reach your mission objectives. If it is cork-screwing, it doesn't even make sense to try to mimic the flight in RockSim after the launch. Just make sure to concentrate on your building skills and put the next rocket together better.

"Unstable" flight is a big problem. In this case, the rocket never takes a straight or predictable path. It zig-zags all over the sky, and everyone is running for cover. It can be unsafe. Obviously, you'll need to fix this on your next rocket. But at this point, now you must figure out what caused the issue. Hopefully, it's something simple like a fin coming off the rocket. But if the rocket looks okay, you need to go back to your computer simulations and try to design a new rocket that is more stable. See the back-issues of the Peak-of-Flight newsletter on designing a stable rocket.

A "Non-Vertical Trajectory" is different from unstable. Here the rocket is taking a definite path, but not in the direction you aimed the launch rod. Additionally, the direction is not turning the rocket into the wind. It goes in a direction sideways with respect to the wind direction, or downrange with the wind. Just not "into" the wind direction.

Non-vertical trajectory might have been caused by the "tip-off" issue discussed previously. But sometimes it is starting out straight and goes a little way before veering off course.

Sorting out the non-vertical trajectory issue can be a challenge. I'd start with an analysis of the fins on the rocket. Are they stiff, or can they flex a little bit? Flexible fins (usually really thin and made from paper or plastic) can start to "flutter" (to shake or vibrate) when the rocket reaches higher flight speeds. This flutter can cause the rocket to veer off course. In extreme situations, it can completely rip the fins right off the rocket. If the fins come off, I guarantee you the rocket will go unstable. In either case, you'll need to go back to your design and make the fins thicker and made from of a stronger material.

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"Weathercocking" is the term given to the flight path of a rocket as it gradually turns into the wind. Like a weather-vane, the rocket wants to point its nose into the wind.

Weathercocking is normal for a stable rocket. It is annoying because the rocket doesn't go straight up like you want. The stronger the wind, and the more stable the rocket, the more the rocket will go horizontally. Because it goes horizontal, the altitude is reduced and the rocket can also be heading downward when the ejection charge pushes out the parachute. On windy days, you need to be prepared for weather cocking by reducing the delay time of the rocket motor slightly so it pops the chute out right at the apogee point.

There are a couple of things you can do to limit weather-cocking. First is to increase the lift-off speed of the rocket. The faster the rocket takes the less the wind affects it. You can increase the speed by choosing a motor with a higher average thrust, and by flying from a longer launch rail. You can also intentionally cause the rocket to spin so that it flies straighter. I'm not a big fan of reducing the size of the fins in order to make the rocket less stable. But that is also an option to reduce the amount of weather cocking in the rocket.

Finally, try to estimate the path angle and direction of the rocket as it ascends into the sky. Again, your smartphone can give you the direction, but you may have to estimate the path angle as measured from vertical the rocket takes. I'm sure there is even a phone app that can help you, but I don't know of one off the top of my head. Since this happens so fast, you need to be quick about making a notation on the form. Therefore, I suggest you have two people that are dedicated to data recording for the flight. You'll be glad you had them both.

The next section of the TARC Flight Record Data Sheet is where you'll record recovery information.

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Recovery Information

Ejection Occurred:

- ☐ During Ascent
- ☐ At Apogee
- ☐ While Descending
- ☐ Model On Ground

☐ Ejection Failure

- ○ Fast Delay Time
- ○ Slow Delay Time
- ○ Delay Didn't Burn
- ○ Weak Ej. Charge

Recovery Device Deployment

- ☐ Deployed Fully
- ☐ Parachute Stripped off of Rocket
- ☐ Partially Deployed
- ☐ Slow Deployment
- ☐ Parachute Did Not Deploy
  - ○ Damaged / Melted Chute
  - ○ Improper Set-up / Folding
  - ○ Motor Ejected Out of Rocket
  - ○ Ejection Charge Failure
  - ○ Tight Nose Cone
  - ○ Obstruction In Tube
  - ○ Other

Parachute Descent

- ☐ Stable Descent
- ☐ Some Swaying of Load Under Canopy
- ☐ Tangled Lines Caused Spiral Descent

Descent Type

- ☐ Normal Descent
- ☐ Ballistic Trajectory to Ground

Figure 11: Recovery Information that you'll want to record

This is to document the phase of the flight that occurs after the ejection charge goes off.

First, you want to record where during the flight the ejection occurred. Most observers on the ground that have never watched a rocket before will assume that if the ejection and deployment occur in the air, then it was a good flight. So, when you hold your pre-launch huddle, ask them to watch more closely because it does make a difference to the goals of the mission where during the flight the chute is popped out.

If the ejection occurs while the rocket is traveling upward or while the rocket is descending, then you didn't do a good job of picking the delay or not correctly setting the delay (by drilling into the delay propellant) if the motor has an adjustable delay.

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For the least amount of stress on the parachute and on the rocket, we desire the chute to be deployed right at apogee (the highest point in the trajectory). Even if you might have a reefing device on the parachute (like the ChuteRelease at https://www.apogeerockets.com/Electronics-Payloads/Dual-Deployment/Chute-Release), you still probably want the ejection to occur very close to the apogee of the trajectory. It makes things more controllable.

The rocket ejecting the chute while on the ground is probably the worst situation, as it points to a major problem. Did the rocket go unstable or lose a fin on the way up? Did you forget to drill the hole to select the proper delay on your reloadable rocket? Did you forget something on your checklist? You need to determine why the rocket impacted the ground before the ejection occurred.

Ejection Failure

In the same box, there is also a section to document an ejection failure should one occur. Ejection failure means that the chute didn't come out properly. It could also mean it came out too soon or too late. In this sense, it wasn't that you didn't properly select the right motor delay, but something doesn't seem quite right. For example, you might have used a single-use (meaning you didn't physically perform any modification to the delay propellant) composite-propellant motor with a 5-second delay. But when you flew it, the ejection of the nose seemed early, and you estimate about 3 seconds. This would be a fast delay time, and you'd mark it off in the check circle.

It doesn't necessarily mean the motor malfunctioned. There could be other contributing factors. For example, the motor might have misfired on the first launch attempt. This is called a "chuff." It seemed to want to start but didn't quite catch - probably because the igniter wasn't fully inserted in the motor. It sat and sputtered and coughed before self-extinguishing. But what happens during that brief chuff is that a little bit of the delay propellant burns up. On the next launch attempt, when the motor does finally ignite, the delay propellant is shorter, meaning the delay time is shorter too. And then it appears that the rocket ejected too early. This is another reason to count the number of attempts it took to ignite the rocket motor. You'll come to realize that multiple attempts can impact the flight when it does take off.

Long delay times can also occur although this is usually due to the subtle mixing issues that occur when the delay propellant was made. For the manufacturer, making propellant is a lot like baking a cake, and the ingredients can vary slightly from batch to batch. Some batches might burn slightly longer than others. It is a tough process making propellant. The motors are allowed to be up to 10% off in the delay time and still be within specification.

Sometimes, and this is also extremely rare, the delay propellant will stop burning completely. This only happens with composite propellant motors. You will notice this because the trailing smoke doesn't come out of the rocket after the thrust stops. If the delay snuffs out, the rocket will come down ballistically and crash hard.

The usual cause of the delay stopping is an extreme drop in pressure inside the motor. The propellant needs pressure to continue burning, and if the pressure drops dramatically, the delay can snuff. If it does happen, it is usually with very short burn motors that burn so quick that pressure can drop quickly. I wouldn't worry about it happening to your TARC rockets because you won't be using high thrust motors like that.

A weak ejection charge can happen on occasion, but as before, it can also be user error. You'll notice that the ejection charge did fire, but the nose barely moved. If it doesn't come off, the rocket will come in ballistically.

If your parachute is not prepped properly, meaning it is too tight in the tube, it could prevent the nose from sliding off easily. Take your time prepping the chute, and follow your checklist to prevent folding errors.

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Additionally, the nose cone must have the proper fit. It can't be too tight, obviously, or that could prevent it from moving forward. Too loose can also be an issue, as air can flow around the shoulder instead of pushing it off. Test the fit of the shoulder by tilting the rocket upside down. It should stay in the tube when inverted. But if you start to wiggle the rocket, it should start coming out. That is the criteria that I use to test the fit of the nose cone on the tube.

Recovery Device Deployment

Once the chute is out of the rocket, it needs to fully open. Hopefully "deployed fully" will be the check-box you'll mark on the data sheet. Everything else below that check-box is "bad news."

Parachute Stripped off Rocket

The parachute stripping off the rocket is where the rocket stays in one piece, but the canopy of the chute is floating away on its own. The obvious thing to check it to make sure you attached it to the rocket (been there… done that…).

Another common failure is the shock cord coming loose. Add to your pre-flight checklist to tug hard on both ends of the shock cord to make sure that it has not weakened from the previous flight. If it comes loose, the rocket is going to come down in two pieces, and one will be coming down really fast.

Sometimes the lines aren't on strong enough for the velocity that the rocket is moving at when the chute is pushed out. This is something you should be aware of: make sure the chute is strong enough to survive the opening speeds. If not, use a stronger parachute, or find a different way to fold the parachute so it opens slower at high speeds.

Partially Deployed

Partial deployment is when the chute is out in the air but fails to fully inflate. It is usually because the lines are twisted, or the fabric has melted to itself. Either way, it is user error. So, go back and review/update your checklist concerning the folding of the chute in the rocket.

Slow Deployment

A slow deployment is where the chute eventually opens completely, but it took so long that the rocket lost a lot of altitudes. Now it will land much quicker than you had planned, and you won't meet the mission objectives. The cause of slow openings is something happened with the suspension lines. They were tangled, and eventually, that freed themselves so that chute could fully inflate.

Parachute Did Not Deploy

If your chute did not open at all, you'd check the box indicating this, and then determine the reason in the circle check-offs below.

Damaged / Melted Chute

The most common is a damaged or melted parachute. Always inspect the parachute prior to launch to make sure it is free of damage and that all the shroud lines are on tight. Make sure there is enough wadding in the tube to prevent the heat of the ejection charge from hitting the chute. But it shouldn't be so much that it obstructs the tube and doesn't push off the nose cone.

Improper Set-up / Folding

It is important that you fold the chute, not just wad it up and shove it into the tube. Shoving it into the tube makes it act like a plug, and it is slow to move out. If it is slow leaving the tube, it is going to have more heat damage. It needs to slide freely in the tube, which is best accomplished by meticulous folding. Follow the same procedure from one flight to the next, even when things get rushed. Parachute failures are the most common mishaps in rocketry, and most of them are preventable.

Motor Ejected Out of Rocket

If the motor ejects out of the rocket, you'll also find the rocket going in ballistically. This

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occurs when you don't restrain the motor in the rocket correctly. Make sure to test and make sure the motor can't move either forward or backward prior to putting the rocket on the launch pad. This should be part of your pre-flight checklist.

Ejection Charge Failure

Ejection charge failure could be as simple as forgetting to pour in the black powder when you're prepping the reloadable motor for flight. Or you may have improperly assembled the reloadable motor. It is rare that the motor ejection charge will fail if everything is put together properly.

Tight Nose Cone

A tight nose cone, which we discussed before, can also prevent the parachute from deploying out the rocket. Make sure when you make your pre-flight checklist to confirm that the shock cord isn't wedged between the side of the shoulder and the inside of the tube. That can also make the fit very tight.

Obstruction in Tube

Be sure there are no obstructions in the tube that could cause the parachute from being pushed out. For example, it is common for the chute to snag on the shock cord anchor that may be glued on the inside of the tube. You'll want to check the inside of the tube prior to loading the chute to make sure everything is clear and it can't get snagged on anything.

Other Causes

The checkoff for "other" is for some condition that isn't addressed by the categories listed above. I don't know what that is, but I've seen a lot of strange things happen in rocketry. Just at our last launch, I saw two rockets collide mid-air, which I thought I'd never see in my lifetime. Fortunately, it was a glancing blow and both rockets continued just fine. But that just proves that weird things can happen. There is space by the "other" check off for you to write in what happened.

Parachute Descent

In the parachute descent section, the desired outcome is the first checkbox: "Stable Descent." This means the chute was fully open and came down nice and straight. This is desirable because "stable" is the most predictable when it comes to determining the descent rate of the rocket.

"Some Swaying of Load Under Canopy" is typical for a chute when there is a breeze blowing. Unfortunately, swaying and oscillating means the descent rate is constantly changing. It is slow when the canopy is perpendicular to the ground, and high when the edge of the chute is tilted up.

Another way to prevent swaying of the canopy is to cut a spill hole in the middle of the canopy. This gives the air flowing into the chute a controlled exit point and stabilizes the canopy. The downside of a hole in the middle of the cloth is it that the chute will fall faster because its surface area is reduced. So, if you plan on having a spill hole in the chute, you'll have to use one that is slightly larger in diameter.

Be careful not to make the spill hole too large. A big hole can cause the chute to have problems opening at slow speeds because air isn't filling up the cloth canopy fast enough. You'll have to play with the spill hole size to find out the optimum area that allows for easy opening and yet diminishes any swaying.

Tangled Lines Caused Spiral Descent

Swaying can also be caused by the lines on the chute not having equal length. This has the same effect as having shorter lines and the chute will start oscillating. The tangled or twisted lines tilt the canopy to one side and cause it to start saying back and forth along with creating a spiraling descent pattern. It really helps to use a swivel (https://www.apogeerockets.com/Building_Supplies/Parachutes_Recovery_Equipment/Swivels/) on the suspension lines to help control the amount of twisting of the lines.

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www.apogeerockets.com/Rocket-Kits/Skill-Level-2-Model-Rocket-Kits/SkyMetra

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Descent Type

The descent type is a broad category to give you a quick synopsis of what the descent was like. The worst case is a "Ballistic Trajectory to the Ground," and it will probably mean a destroyed rocket. If the chute comes out, even partially, I'd say to check off a "Normal Descent," even if it wasn't as you had planned for.

Unplanned Separation Occurred

This section of the form can be used to document what (if any) parts came off the rocket anywhere during the flight. You also want to list why you think the separation occurred. For example, on one rocket a local TARC team flew, they were using the removable plastic rivets (https://www.apogeerockets.com/Advanced_Construction_Videos/Rocketry_Video_231). During the flight, the force of ejection was so hard that the tube split at the holes in the paper tube. So that would be considered an unplanned separation. And for the reason why the team would have put down that the paper tube tore at each of rivet holes. This information could then be used to figure out if rivets should be used, and if they were in the proper place on the tube.

☐ Unplanned Separation Occurred
What Separated / Why?

Landing
☐ Soft Landing ☐ Landed in Tree
☐ Hard Landing ☐ Caught on Wire
☐ Water Landing ☐ Landed on Building
☐ Crash Landed ☐ Drifted Out-of-Sight

Was Rocket Recovered?
☐ Full Recovery
☐ Model Lost
☐ Model Not Recoverable
☐ Part of Rocket Lost

Distance & Direction From Pad Model Landed

Last Known Position of Lost Model

Figure 12: Continuation of the recovery section on the data sheet.

Landing

The landing section on the Flight Test Data Sheet should be one of the easiest to understand.

The difference between "soft landing" and a "hard landing" is the amount of damage the model suffered. If the parachute opened it didn't have any damage, I'd say that was a soft landing. If it had structural damage, like a broken fin but was repairable, then I'd say it was a hard landing. It is a bit subjective, and you can use your own judgment. A crash landing is worse than a hard landing, and in my opinion, the damage is so major that either the rocket was completely destroyed or a large section of it had to be replaced because it was unusable.

The other check boxes should be self-explanatory: the rocket landed in a water, landed in a tree, got hooked on a wire, landed on a building, or just drifted out of sight.

Incidentally, if the rocket lands on a power line, do not try to retrieve it. Don't throw things at it either. Just call the local power company to come get it. They would rather you stay safe and not damage their property. You might also hit them up for a donation to your team too.

Was the Rocket Recovered?

This section is used for later reference when you are reviewing all the flights you made. You may be wondering why your summary sheet doesn't have any altitude data associated for flight number 2. This section, when you review it will quickly, may remind you why that might be.

If the model got caught in a tall tree or powerline, you want to check the box that the rocket wasn't recoverable-even though technically it wasn't lost. You just couldn't get to it to retrieve the data from the altimeter.

If part of the rocket was lost, like the payload section containing the altimeter, there is a space provided for you to indicate what was missing after the flight.

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Distance and Direction the Pad Model Landed

Why do you want to record the distance and direction of the landing point of the model? Because you can try to mimic this in RockSim so you can zero in on the Coefficient of Drag that you'll need in order to predict the performance of future flights. In RockSim, you can see how far the rocket drifted based on the wind speed that you put into the software. You can compare that to the actual distance the model landed from the launch point.

When whoever retrieves your rocket picks it up (you did con your parents into hoofing it out and picking it up for you, right?), make sure to instruct them to record the GPS coordinates from their smartphone where the rocket was when it landed. Show them how to take a screenshot of the image on their phone's screen and then have them text or email it to you so you have an exact record of it.

Once you get back home, open the Google Earth software and place a pushpin at both the launch point and the landing point. Then using the "path" tool, draw a line in the software connecting the two pushpins and not the distance between them, like **Figure 13**.

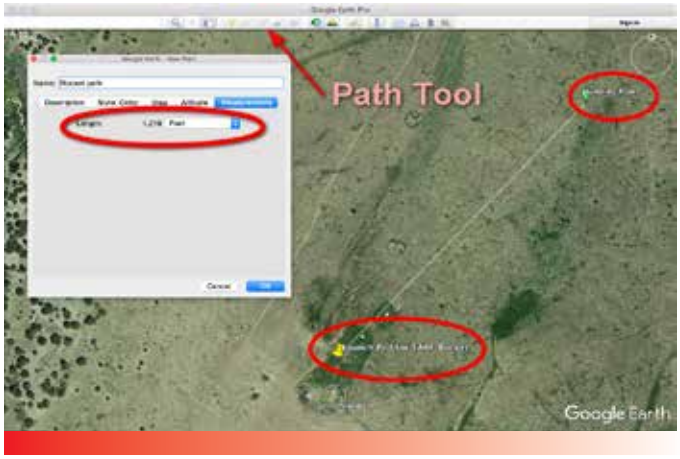

Figure 13: Using the Google Earth software and its path tool, you can find the exact distance between the launch and landing points.

Last Known Position of Lost Rocket

As the rocket is drifting out of sight (we hope not, but it happens), get out your smartphone and using the compass app, get a direction that the rocket was traveling with the wind. This can be plotted on the Google Earth map like what was described for the landing point. Draw a line on the map to show where the rocket was heading. You may be able to use Google Earth image to find a road that can help you get closer to the suspected landing point at a later date and hopefully find your lost rocket. Any piece of information you can record right after the launch may help you to track it down later.

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Post Flight Information

After you get everything back, it is time to record that information that you really need to know. The Peak Altitude is taken directly from the altimeter. Everyone is going to want to know if you reached the goal of the contest, and this is the first thing they'll look at.

Post Flight Information
Peak Altitude
Deployment Altitude
Flight Duration
Total Score
Condition of Payload
Calculated Descent Rate
Flight Damage ☐ No Damage ☐ Scuffed Paint ☐ Minor Damage ☐ Zippered Tube ☐ Major Damage, but Repairable ☐ Rocket Destroyed ☐ Damage Unknown - Model Lost
Description of any Damage
Additional Flight Info / Description:

Figure 14: The Post Flight Information gives you an indication of how well your rocket performed.

Why record the Deployment Altitude? Because you need it to figure out exactly how fast the rocket is falling with the parachute you have. This is called the descent rate, and a place for jotting down that number is found a few lines down on the sheet. If you need a longer descent rate, you need a bigger parachute, right?

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Without knowing the descent rate of your rocket and the parachute, you will have a harder time figuring out what to change to get the descent time you need for the competition. So in my opinion, this is a crucial number to record.

However, finding the deployment altitude is tricky. You'll need to use a "recording altimeter" to figure it out. That is an altimeter that specifically records the position of the rocket from lift-off to landing, not just the peak altitude of the flight. Of the current contest approved TARC altimeters, only the Perfectflight Pnut (https://www.apogeerockets.com/Electronics-Payloads/Altimeters/PerfectFlite-Pnut-Altimeter) is a recording altimeter. Once you download the data from the altimeter, you can figure out what altitude the rocket was when the parachute opened. See Peak-of-Flight Newsletter #208 (https://www.apogeerockets.com/education/downloads/Newsletter208.pdf) for information on how to get this data from the altimeter.

While the Jolly Logic AltimeterOne and AltimeterTwo altimeters are not currently approved for official contest flights, they can be used for your practice flights. And they do have some advantages in that they have an extra sensor on them called an accelerometer. With it, you get a lot of extra data, including the speed of the rocket - both going up and coming down.

You can simply read off the descent speed of the rocket right from the altimeter without having to do data manipulation as described in Peak-of-Flight Newsletter #208.

Flight Duration

The flight duration will be taken manually from someone timing the rocket. You can use your smartphone for this, but I prefer a real stopwatch because the buttons are easier to click. They give you a tactile feeling when you push on them, so you don't have to look down and away from the launch to start the timer going. But that is just my personal preference.

The "Total Score" depends on the formula that is being used for the event. It might change next year, so I didn't put the formula on the flight record data sheet. You can figure it out when you get back to your base of operations after the flight.

The "Condition of Payload" can be used to indicate whether the eggs survived the launch. You can mark it as "OK" or "cracked." It is up to you.

Flight Damage

The flight damage of the form is used to record the condition of the rocket after the flight. If the rocket can be flown again immediately, I'd record it as "No Damage."

Of course, you'll often have scuffed paint after the launch because the rocket was drug along the ground by the wind. So, mark it on the sheet if you want.

"Minor damage" in my opinion is things like a slightly crumpled tube. Such as around the open end of the tube where the shoulder of the nose cone is inserted. Because the shoulder, when inserted, will provide the structural rigidity for the tube, it would be okay to fly it without any repair. At most you might try to smooth out any creases with your fingernails to try to smooth it out.

Another minor damage might be a smooshed fin tip. Again, the rocket will probably fly fine without any type repair. I'd even consider a cracked fin fillet as minor damage. Just get out some water-thin CyA (super glue) and wick it into the crack to fix the damage and the rocket is ready to fly again.

A zippered tube is common too. It is when the shock cord slices into the end of the tube, splitting it downward. It could be minor damage or major damage depending on how long the zipper is. It is a subjective call for you as the rocket owner whether you think it is minor or major damage.

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For me, "Major Damage, but Repairable" is when the rocket will need to go back into the workshop to be fixed. If you can't fix it on the field in under an hour, I would say it suffered major damage.

If the rocket can't be salvaged, or if more than half of its components should be replaced in order to fix it, I'd mark the flight damage as being "Rocket Destroyed." These TARC rockets are somewhat weight sensitive, so you don't usually want to put in extra stiffeners (like a tube coupler to patch a crumpled body tube). You'll probably be replacing components in their entirety if you get significant damage. At some point, you'll have to say, "let's build a new version of the rocket." My own personal criteria is how much time it will take to make the repairs. For other people, it is how much money they'll have to spend to build a new rocket rather than repairing the damaged one.

If the rocket got lost, you will check the box "Damage Unknown - Model Lost." That's really all you can do till you can get the model back, right?

If there was damage, you can jot down in the space provided on the data sheet. You might also take a quick photo of the rocket with your phone's camera to document the slight damage.

This could come in handy if you decide to make another flight with the same rocket immediately following the one you just documented. When the second flight comes back, you may be wondering if the damage you see on the rocket was caused during the first flight or the second one. The photo after the first flight will give you the evidence you need to make that determination.

Additional Flight Info / Description

There is a little extra space on the sheet where you can jot down any other observations you might have made during the flight. Like I mentioned before, a lot of crazy things could happen during the launch that are completely unexpected. If that happens, be sure to write it down. It might be something like: "Tom's dad picked up the rocket and while he was walking back he tripped and fell down. We think that is what caused the eggs to be broken." You never know…

www.apogeerockets.com/Building_Supplies/Launch_Lugs_Rail_Buttons/Rail_Buttons

Lessons Learned
(Ways to improve next flight)
(Why flight might have gone bad?)
(What do you want to test next time?)

Figure 15: The "Lessons Learned" section of the flight report.

Lessons Learned

The lessons learned section is just as important as anything in the flight report. It is where you stop and think about what just happened with the flight and compare that to what you wanted to achieve. There are a few questions that you can use to start the process going. These are: "Ways to improve next flight," "Why flight might have gone bad?", and "What do you want to test next time?"

You might discover that your checklist is missing a few steps, and you'll want to also write those down while they are still fresh in your mind.

While you are filling out this flight record data sheet immediately after the launch, I would suggest that you also get your team together at the beginning of the next group session to review this information again. You might remember something about the flight that you didn't write down.

Video of the Launches

I would also suggest that you make a video recording of each launch too if you have the equipment and the time. Sometimes you don't notice things are happening during the launch because there is so much excitement and distractions from other people on the launch range. A good video recording might pick up some of the events that you missed with your own eyes.

This is almost always that case with my own flights of the prototype rockets that I build. I go through them frame-by-frame to pick up the smallest details of the launch. You'd be surprised at what you'll learn by taking a few minutes to review the launch video.

Conclusion

Most TARC teams that I've watched just collect the peak altitude and the duration aloft of the rocket. They are at a huge disadvantage, in my opinion. What I hoped to teach you with this article is that good data is your friend when it comes to the TARC contest. It will provide you with the hard evidence you need to make good

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decisions on which direction you need to take with your rocket design and motor selection. There is so much you can record from the flight, and while it adds another task to your project, it is well worth the effort. In the long run, having this data will help you get to your mission objectives in a shorter amount of time.

If you are recording other data about the flight that isn't on the TARC Flight Record Data Sheet, please let me know. I might be able to include it in an updated version.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward an M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http://www.apogeerockets.com) and also the author of the books Model Rocket Design and Construction, 69 Simple Science Fair Projects with Model Rockets: Aeronautics and publisher of the "Peak-of-Flight" newsletter, a FREE e-zine newsletter about model rockets. You can email him by using the contact form at https://www.apogeerockets.com/Contact.