

Mentoring TARC for 17 years
Lessons Learned



~~HOW TO WIN TARC~~

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CASE STUDY: MADWEST ROCKETRY



KEY COMPONENTS

- Project Management
- Team Culture
- Technical Expertise
- Ground Support



PROJECT MANAGEMENT

TARC is a long term project - somebody needs to beat the drum and give cadence otherwise the initial enthusiasm will fizzle out and the project progress will stop.

- Schedule meetings
- Organize work-sessions
- Drive fundraising efforts
- Plan launches / rain dates
- Plan and handle purchasing



FINANCIALS

It costs money to build and fly rockets, have a good fundraising plan. Madison West performs 6-8 weeks of raking and yardwork service at the fall and also receives good-heart donations from close and extended families of the club members.



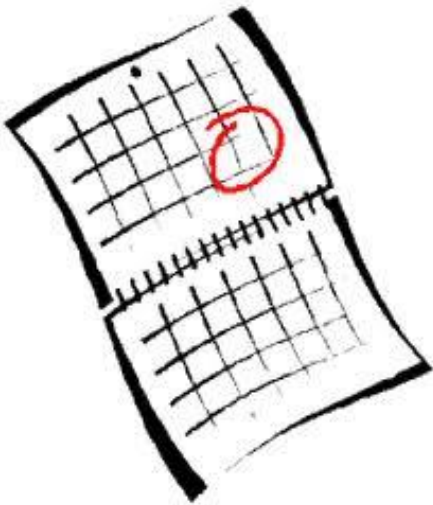
TEAM SPIRIT AND CONDUCT

MadWest students are taught from the very beginning how to work as a team and conduct themselves professionally. Public outreach events are great venue for practicing both (and it's better than be raking ☺).



Outreach events are a great way of building wider community support

TYPICAL WEEK OF MADWEST TARC



| Day | Activity |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Monday | 1 hour organizational meeting (every week, during school hours) |
| Friday | 2-5 hours of workshop time (every week) <ul style="list-style-type: none"> • Building rockets • Repairing rockets • Preparing for launches |
| Saturday | Practice launches |
| Sunday | Outreach events (spring) Fundraising events (fall) |

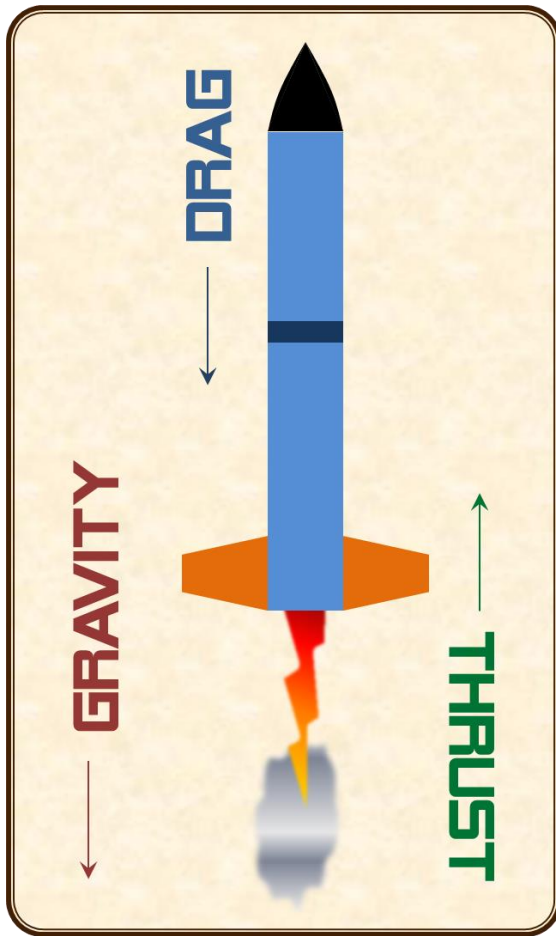
Not every student attends every event or every launch. Teammates shares the responsibilities and workload. The key is to have the events covered and not lose any of the available launch windows.

DON'T REINVENT THE WHEEL

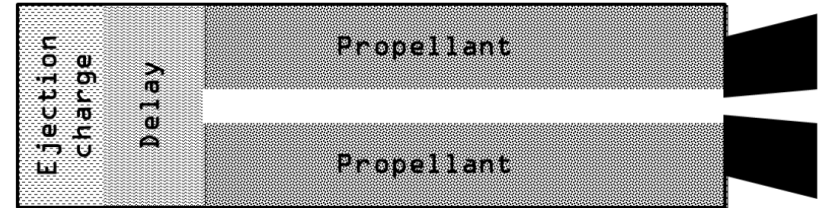
- Get a mentor (if possible)
- Engage veteran students
- Learn from existing designs
- Use Internet and book resources



ROCKETRY-101 SYLLABUS



Acting Forces

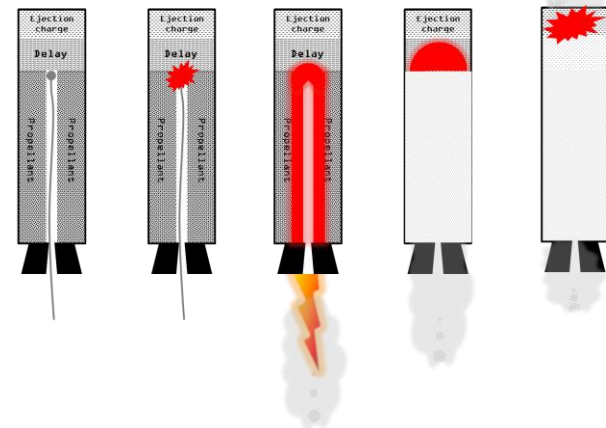


Motor Signature

75F51-13CL

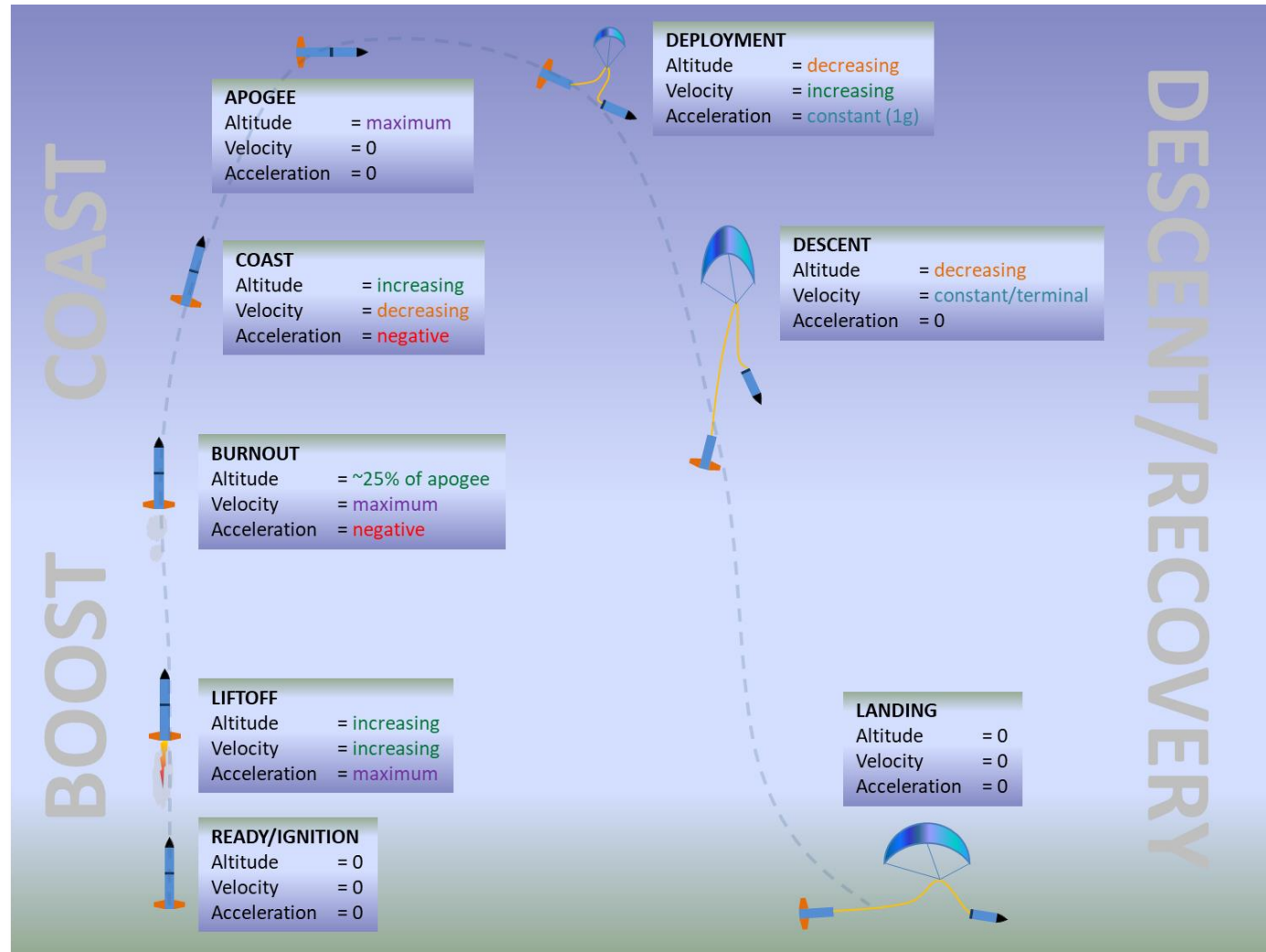
Total impulse [Ns] Impulse class Average thrust Ejection delay Propellant type

READY IGNITION BOOST COAST EJECTION



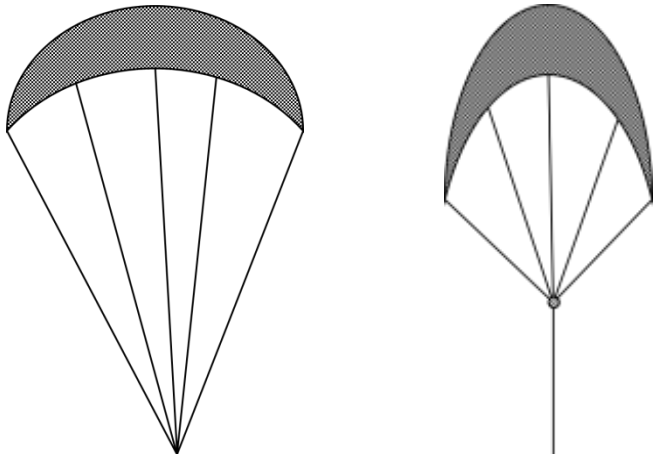
Propulsion Basics

ROCKETRY-101 SYLLABUS

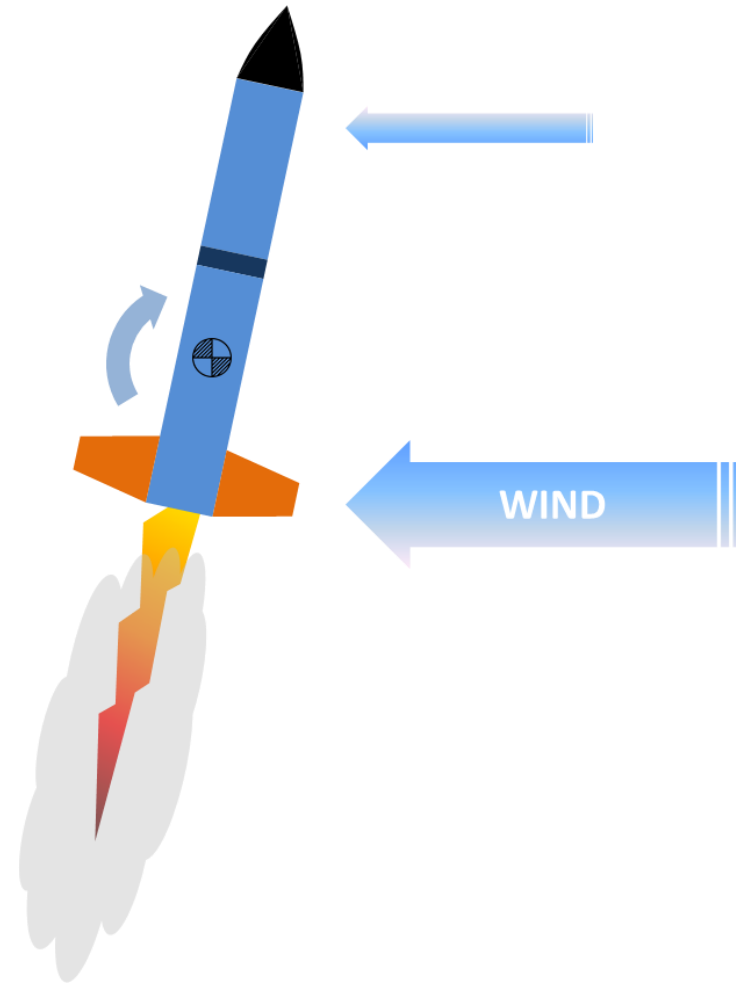


Phases of Rocket Flight

ROCKETRY-101 SYLLABUS

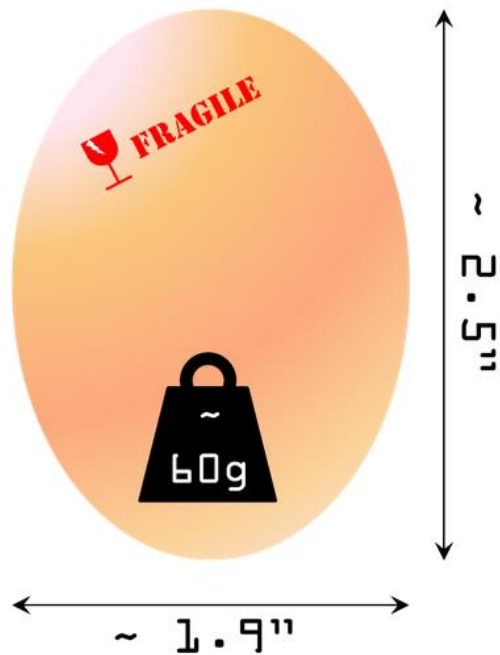


Descent Time Control

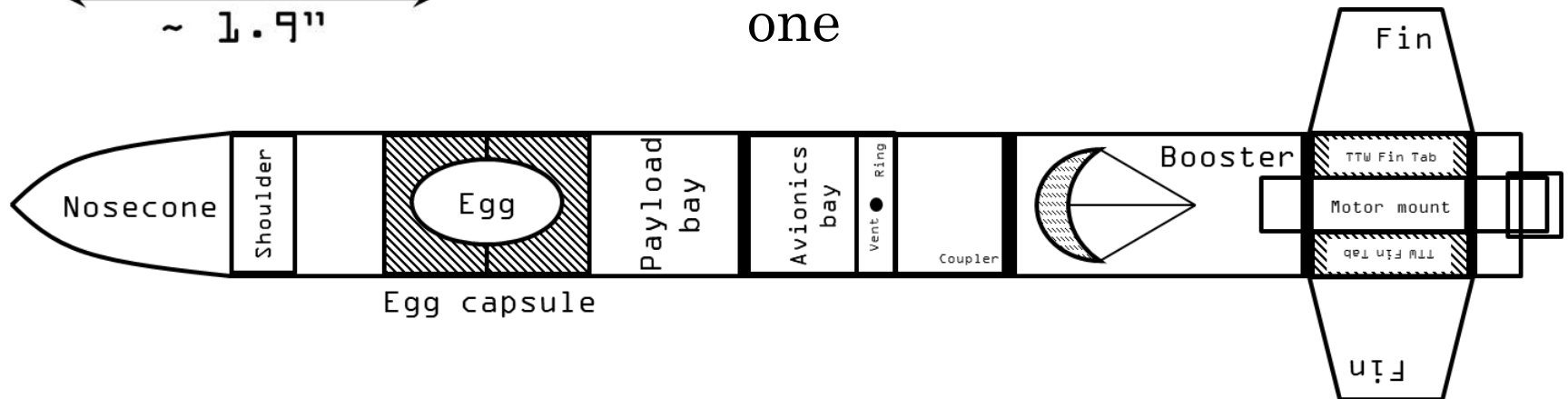


Stability and Weathercocking

DESIGN FOR MISSION GOAL

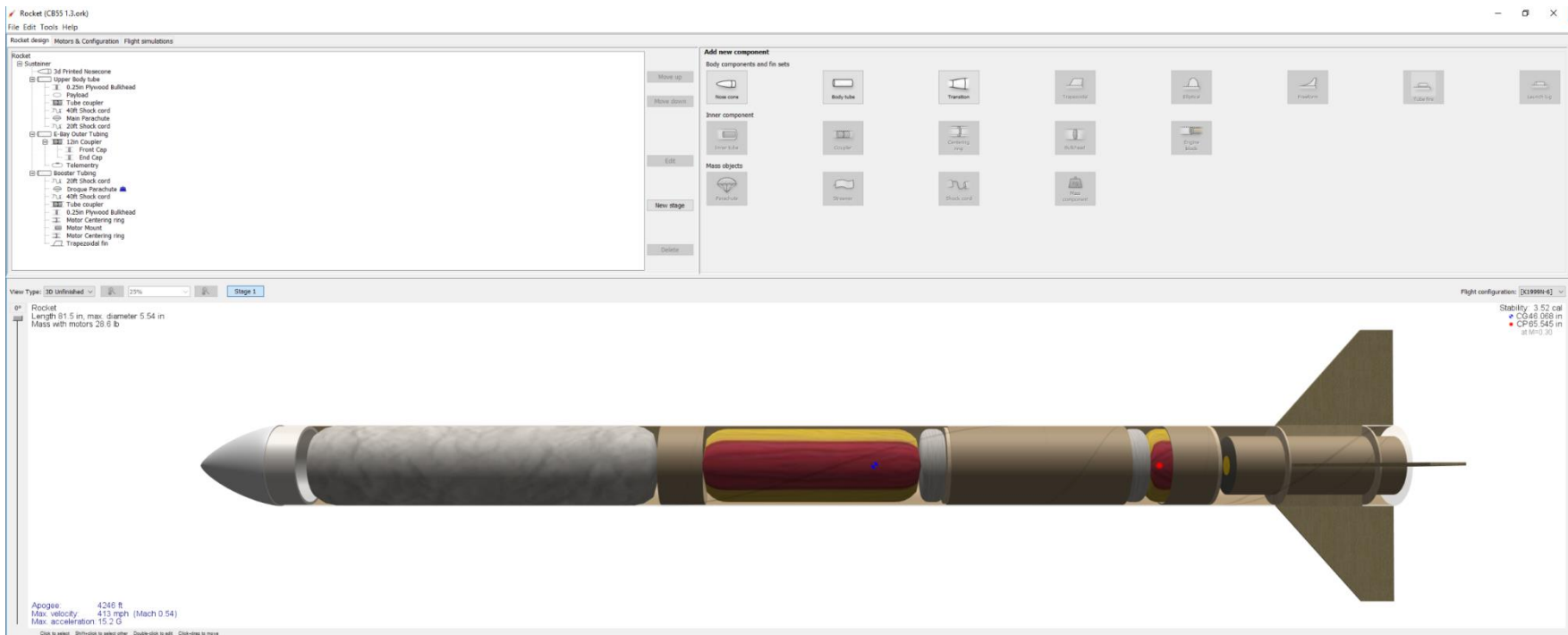


- Build the rocket around the payload (eggstronaut)
- Add only what's necessary
- Keep the design simple
- Aim for easy production
- Keep cost in mind
- You will need more than one



DON'T TRUST COMPUTER ENTIRELY

- Use OpenRocket to get the initial design
- Leave altitude reserve (it's easy to fly lower)
- Be conservative about stability (2 calibers is a good start)
- Expect weight increase when fully built



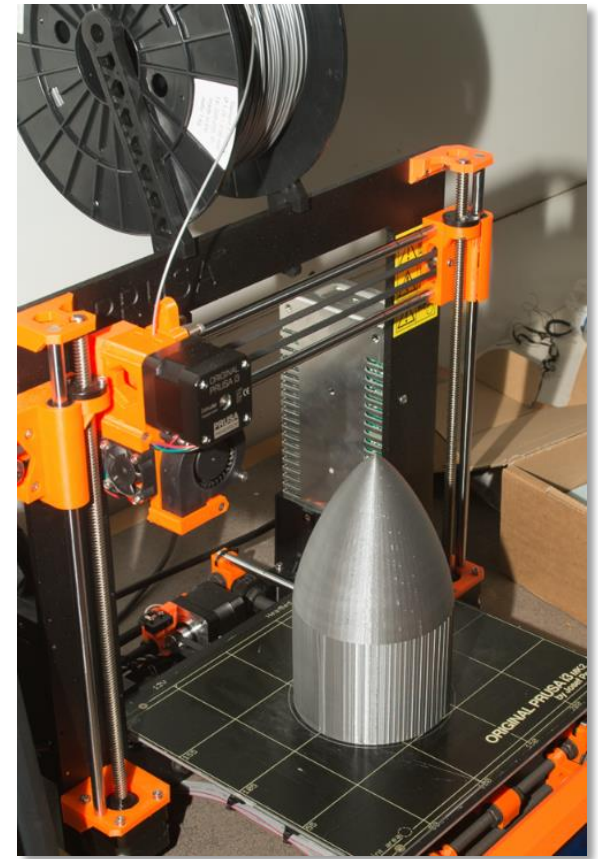
WORKSHOP PERKS & PERILS

○ Perks

- Machinery
- Chemicals
- 3D printers

○ Perils

- Machinery
- Chemicals
- Poor judgement



MadWest rents a workshop space that provides place for teams to work, brainstorm and socialize.

BUILDING ROCKET IS A PROCEDURE

- Create a design
- Prove it by simulations
- Produce part list
- List the building steps
- Follow the recipe
- Correct as necessary

It takes several times longer to build the first one because you are discovering issues and learning (often from your own mistakes). One the first rocket of a kind is built, the rest goes much faster.



BUILD MULTIPLE ROCKETS

- Rockets get easily damaged
- Even if repairable, inactive rocket cannot gather more data that same day and time is lost
- It takes about 2-6 work sessions to build a rocket and 17 seconds to lose one
- Each rocket will suffer from material fatigue, keep building new ones during practice season.



WHEN TO GIVE UP ON A DESIGN

- Students are prone to dismissing a given design instead of working out the quirks and learning how to use it properly (e.g. rail-bites)
- Usually the design is fine, just needs a few tweaks to perform perfectly
- On the other hand, sometimes students cling to a wrong design for emotional reasons
- Material fatigue can cause sudden loss of performance even though the design is solid



CANCEL LAUNCH?

- Launch windows are one the most limited resources
 - Don't cancel by forecast
 - Launch cancelation reasons are:
 - limited visibility
 - undrivable roads
 - winds over 20mph
 - That's it.
-
- Layer up, move around, eat hot food, engage in heated discussions.
 - Don't expect any help from weather – it was not designed that way.



WISCONSIN FOUR SEASONS

almost winter

winter

still winter

tornado season



GROUND SUPPORT

- Parents are perfect candidates for ground support roles (car pools, grill operators, chat facilitators)
- Ground support helps the teams to deal with difficult weather condition or tough launch days.



ROCKET LAUNCH IS A PROCEDURE

- Develop a step by step procedure for launching the rocket
- Write it down in a form of a checklist
- Always follow the checklist to the letter
- Do not skip steps even if you think you know what you are doing
- Data recording is a part of the launch procedure



LAUNCH DAY THUMB RULES

| Parameter | Value |
|----------------|-----------|
| Rocket | Stewart V |
| Liftoff weight | 632g |
| Motor | CTI F79SS |
| Delay cut | by 7s |

Keep the best flight settings with each rocket and update accordingly

| Adjustment | Effect |
|----------------------------------|------------------------------------------------------------|
| 1gram of ballast | decreases apogee by 3ft, shortens flight duration by 0.08s |
| Tilt the launch rail 1° downwind | for each 4mph of windspeed |

Know the corrections for windspeed, altitude and flight duration



STREAMLINE YOUR PROCEDURES



- Streamline and standardize the launch procedure
- Consider design details that will allow you to launch more often (equals collecting more data)
- Train all team member in all aspects of the launch, but allow them to specialize
- Practice coordination of activities

THE GOAL IS TO COLLECT DATA

- Keep meticulous data records, back them up
- Record launch conditions, flight results and anomalies
- A copy of data records travels to every launch as a reference material
- Develop and record correlations

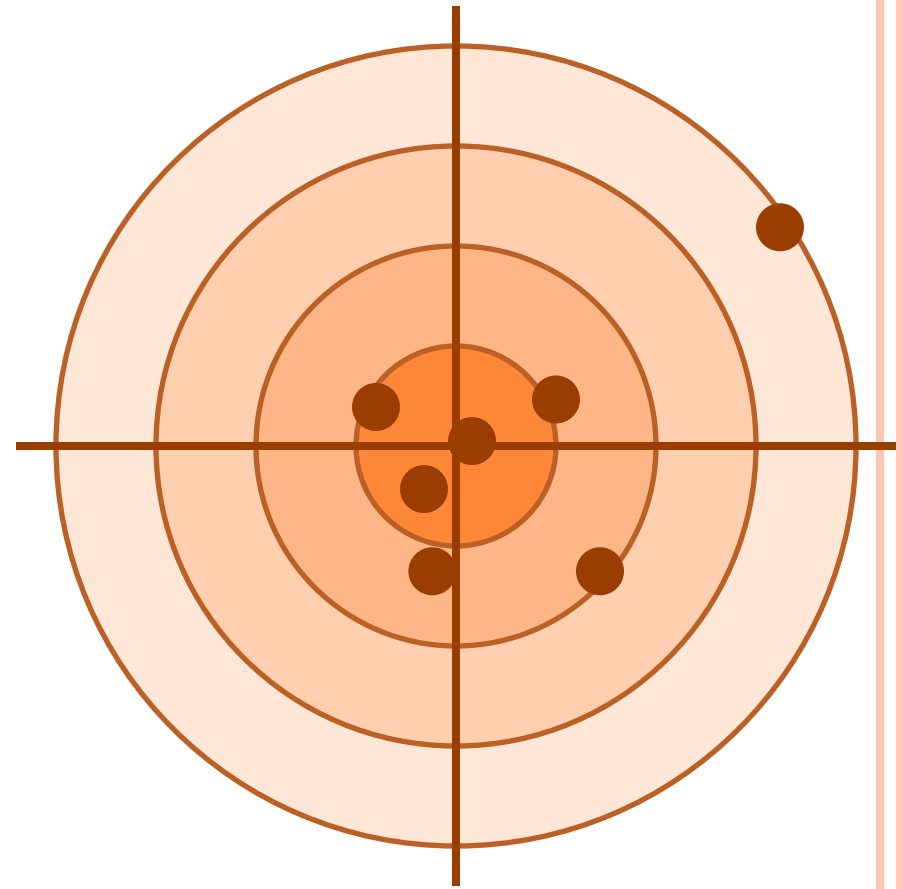
Date: 01/23/2021 Temp: 32F Wind: 12mph

| Rocket | Motor/ delay | Liftoff weight | Altitude | Time | Wind |
|--------|-----------------|-------------------|----------|-------|------|
| #13 | F51-8 | 634g | 802 | 53.12 | 12 |
| #9 | F79-7 | 591g | 786 | 41.23 | 13 |
| #8 | F51-8 | 640g | TREE | :-(| :-P |



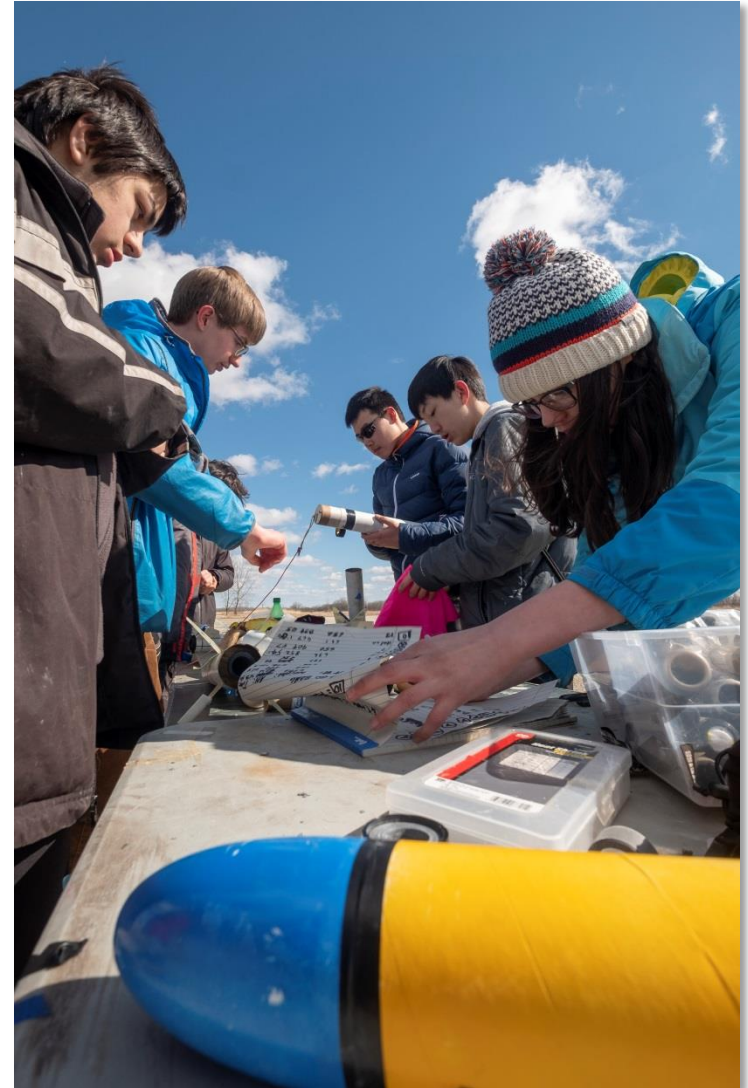
STATISTICAL APPROACH

- Not all scores will be perfect (if any)
- The goal is to tighten the spread (more practice helps)
- Learn how weather affects altitude and flight duration
- Keep detailed records of all flights
- Record optimal launch settings for each rocket
- Follow your launch procedures to the letter



QUALIFICATION STRATEGY

- Be ready to qualify early in season (end of February)
- Choose a day with stable weather and low winds
- Consult your data records, set the best starting point
- Follow your launch procedures
- Make a few adjustment flights to lock on target
- Do not overpractice – rockets are prone to material fatigue
- If you get a good score, repeat the flight right away
- Watch for afternoon thermals



YES, THIS IS SUPPOSED TO BE TOUGH



- There will be bad flights and you will land a few in a tree - build multiple rockets to be ready
- There will be outlier scores - practice a lot to tighten the spread
- There will be cancelled launches – plan accordingly
- Propellant may be sold out – buy your reserves early

FINAL THOUGHTS

- Set a pace and keep it
- Gel the team (they are in for a long haul)
- Get community involved
- Follow your procedures
- Record all data
- Develop and use correlations
- Expect complications
- Weather won't be helping
- Control what you can
- Understand what you cannot control
- Always be a step ahead

